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# Investigating attributes affecting the performance of WBI users

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ABSTRACT

Numerous research studies have explored the effect of hypermedia on learners' performance using Web Based Instruction (WBI). A learner's performance is determined by their varying skills and abilities as well as various differences such as gender, cognitive style and prior knowledge. In this paper, we investigate how differences between individuals influenced learner's performance using a hypermedia system to accommodate an individual's preferences. The effect of learning performance is investigated to explore relationships between measurement attributes including gain scores (post-test minus pre-test), number of pages visited in a WBI program, and time spent on such pages. A data mining approach was used to analyze the results by comparing two clustering algorithms (K-Means and Hierarchical) with two different numbers of clusters. Individual differences had a significant impact on learner behavior in our WBI program. Additionally, we found that the relationship between attributes that measure performance played an influential role in exploring performance level; the relationship between such attributes induced rules in measuring level of a learners' performance.



## 1. Introduction

A learner's performance is determined by their varying skills and abilities as well as various personal features such as gender, preferences and background knowledge of the course content. Such differences, known as "individual differences of learners", have been found to be important factors in the development of non-linear learning systems (Calcaterra, Antonietti, & Underwood, 2005; Mitchell, Chen, & Macredie, 2005). In a hypermedia system, (a non-linear learning system) learners are permitted to learn in their own way and to decide on their own paths through the material (Large, Beheshti, & Rahman, 2002). In this way, they learn at their own pace and construct their understanding of subject matter actively (Chen & Macredie, 2002; Littlejohn, 2002).

In this paper, we used a WBI program to accommodate preferences of individual differences using mechanisms provided in Chen, Fan, and Macredie (2006) and Chen and Liu (2008) where individual differences such as learner's prior knowledge and cognitive styles, more specifically field dependent and field independent were considered. In particular, we group the WBI users into clusters based on their characteristics using three important attributes in measuring their performance: gain score is defined as post-test minus pre-test (g-score), total number of topics pages visited by the participants (t-pages) and total time, in seconds, that each participant spent visiting the topic pages in the WBI program (t-time). Hierarchical and K-Means clustering algorithms were used to explore different numbers of clusters to strengthen our results. Investigation will focus on the following three key aspects. Firstly, learners were pre-identified using the intersection of the three individual differences (by combining gender, cognitive style and prior knowledge when identifying a learner). Secondly, we investigated the impact of the behavior of individual difference' intersection on learner performance. Thirdly, we explored the relationship between attributes used to measure learner's performance to induce rules for performance level.

The paper is structured as follows. Section 2 presents related work. Section 3 describes the methodology used to conduct our study and the techniques applied to the analysis of the corresponding data. The findings of our analyses are then discussed in Section 4. A data mining approach provides the basis of our analyses exploring the relationship of attributes that affect the performance of the individual. Finally, conclusions are drawn and possibilities for future work are identified in Section 5.

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## 2. Background

Many studies argue that no single style will result in better performance. Thus, learners may have different backgrounds, especially in terms of their knowledge skills and needs, so may show various levels of engagement in course content (Wang, 2007). However, learners whose browsing behavior was consistent with their own favored styles obtained the best performance results (Calcaterra et al., 2005; Mitchell et al., 2005). The lack of studies investigating the performance of individual after interacting with WBI programs accommodating user preferences is noteworthy.

### 2.1. Individual differences

Previous studies have demonstrated the importance of individual differences as a factor in the design of web-based instruction. Such features can have a significant effect on user learning in web-based instruction and may affect the way in which they learn from, and interact with, hypermedia systems. These range from cognitive styles (Kim, 2001; Workman, 2004) to prior knowledge (Calisir & Gurel, 2003; Hölscher & Strube, 2000; Mitchell et al., 2005) to gender differences (Beckwith, Burnett, Wiedenbeck & Cook, 2005; Roy, Taylor, & Chi, 2003; Schumacher & Morahan-Martin, 2001).

#### 2.1.1. Gender

Most studies indicate that gender is a significant variable in the learning process. This implies that males and females might need different levels of support when they interact with the Web. Some studies have found that males are more actively engaged in browsing than females because they tended to perform more page jumps per minute (Large et al., 2002; Roy et al., 2003). They suggested that males out-perform females in their ability to retrieve information from the Web since they are more experienced users; they formulated queries with fewer keywords, spent less time on individual pages, clicked more links per minutes than females and have more positive attitudes towards online technology in general.

#### 2.1.2. Prior knowledge

Learners with different levels of prior knowledge, from experts to novices, benefit differently from hypermedia learning systems (Calisir & Gurel, 2003; Wildemuth, 2004). Many studies argue that there are different levels of perception in using hypermedia learning systems requiring different ways to navigate (Calisir & Gurel, 2003; McDonald & Stevenson, 1998; Shin, Schallert, & Savenye, 1994).

#### 2.1.3. Cognitive styles

Field dependence and field independence are probably the most well-known division of cognitive styles. The differences between field-dependent and field-independent learners are:

**Field independent** learners have an impersonal behavior. They are not interested in others and show both physical and psychological distance from people. They tend not to need external referencing methods to process information and are capable of restructuring their knowledge and developing their own internal referencing methods. Thus, field independent learners are generally analytical in their approach.

**Field dependent** learners have interpersonal behavior in that they show strong interest in others and prefer to be physically close to people. They make greater use of external social influences for structuring their information. Field dependent learners are more attentive to social cues than field independent learners. Thus, field dependent learners are more global in their perceptions (Witkin, Moore, Goodenough, & Cox, 1977).

#### 2.1.4. Hypermedia and program design elements

Hypermedia provides a flexible approach which helps users to work with the information from different viewpoints. *Additional support* can be provided to help novices in hypermedia learning. Thus, graphical overviews and structural cues are powerful and beneficial in providing navigation guidance to novices to ease potential disorientation problems (Chen et al., 2006). Moreover, field dependent users look at examples, while field-independent users frequently examine detailed descriptions (Chen & Liu, 2008). As for the *content structure*, findings in Chen et al. (2006) indicate that experts focused on locating detailed information while novices tended to get an overview only. A field independent user performs well in terms of analytical thought; they tend to focus on information and browse fewer pages to directly get to relevant topics for completing their tasks. On the other hand, field dependent users have global perceptions to process information. They tend to build an overall picture by browsing more pages (Goodenough, 1976). For field dependent students, a global picture of the subject can be assisted with pop-up windows. In this case, a pop-up window can be used to show additional topics for field-dependent students who would like to get a global picture of the subject content (Chen & Liu, 2008). Thus, information that is related to tasks is put in the main window containing the topic instructions for field independent and field dependent users, while further information is displayed with a pop-up window for field dependent users.

As for *Navigation tools,* Chen et al. (2006) showed that index tools were helpful for experts. On the other hand, map and menu tools were beneficial for novice learners in hypermedia learning systems. Moreover, in the study of Lin and Chen (2008), 101 individuals were examined and their cognitive styles identified by the Cognitive Styles Analysis (CSA) by Riding (1991). Results showed that field independent individuals favored an alphabetical index and a search engine whereas field dependent individuals preferred to use a map to build the entire perceptual fields. Thus field independent users often prefer an alphabetical index to locate specific information, whereas field dependent users often use a hierarchical map to get a global picture of the subject content (Chen, 2010; Chen & Liu, 2008; Chen & Macredie, 2010; Farrell & Moore, 2001).

Lee, Chen, Chrysostomou, and Liu (2009) investigated the relationships between cognitive styles and users' learning behavior in web-based learning programs. They found that a cognitive style, more specifically field dependent and field independent, could be reached by some rules. "These rules can be applied to replace the CSA or other cognitive style tests and work as criteria for automatic identification of the students' cognitive styles" (Lee et al., 2009). In other words, they found that field independent learners prefer non-linear navigation which we provide it by index approach because field independent learners are tend to be more analytical (Ford, Wood, & Walsh, 1994) and they are very task oriented (Witkin et al., 1977). Such a finding is in line with those of Lee, Cheng, Rai, and Depickere (2005). On the other hand, they found that