Understanding the Impact of Individual Differences on Learner Performance Using Hypermedia Systems

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ABSTRACT

In recent studies, there has been focus on understanding learner performance and behaviour using Web-Based Instruction (WBI) systems which accommodate individual differences. Studies have investigated the performance of these differences individually such as gender, cognitive style and prior knowledge. In this article, the authors describe a case-study using a large student user base. They analysed the performance of combinations of individual differences to investigate how each investigated item influenced learning performance. The data was filtered to validate the data mining findings in order to investigate the sensitivity of the results. Moving data threshold was used to evaluate their findings and to understand what could affect the performance. The authors found that certain combinations of individual differences altered a learner's performance level significantly using Data mining techniques. They conclude that designers of WBI applications need to consider the combination of individual differences rather than considering them individually in measuring learners' performance.

KEYWORDS

HCI, Hypermedia Systems, Individual Differences, Learner's Performance, Web-Based Instruction

1. INTRODUCTION

Individual learner differences using Web-Based Instruction (WBI) programs have gained increasing attention in the design and development of hypermedia learning systems. There have been numerous research studies on the effect of hypermedia systems on learners' performance using WBI programs (Alhajri, Counsell, & Liu, 2013a; Alhajri, Counsell, & Liu, 2013b; Calcaterra, Antonietti, & Underwood, 2005; Chen & Liu, 2008; Chen, Fan, & Macredie, 2006; Farrell & Moore, 2001; Mitchell, Chen, & Macredie, 2005a; Reed & Oughton, 1998; Workman, 2004). When learners use hypermedia systems they may make progress at their own pace and develop their own learning paths (Alhajri, Counsell, & Liu, 2013b; Chen, Fan, & Macredie, 2006). Users should have a flexible interface which accommodates their needs, be easily able to identify relevant content and navigational support, as well as move around freely (Calcaterra, Antonietti, & Underwood, 2005; Mitchell, Chen, & Macredie, 2005a; Alhajri, Counsell, & Liu, 2013c; Alhajri, Counsell, & Liu, 2013d). In a number of recent studies, the focus has been on understanding learners' performance and behaviour using these systems and investigation of a learner's performance of these differences individually.

In this article, we investigate the performance of student participants based on their individual differences using a specially designed WBI program (Alhajri, Counsell, & Liu, 2013c) which accommodate their learning needs. This design help learner making progress at their own pace and develop their own learning paths (Alhajri, Counsell, & Liu, 2013b; Chen, Fan, & Macredie, 2006). We investigated the learning performance of learners by combining three individual differences (henceforward called a 'Multi-ID' approach) after acquiring knowledge. Additionally, we used three attributes ('gain' score which is the difference in participant score obtained post-test minus the score obtained pre-test, number of pages visited and time spent using the system) as a vehicle for measuring learner performance. Data mining techniques, using k-means clustering method, is also used to uncover the relationships between measurement attributes which provides a deeper and better understanding of performance level for the combined individual differences (Multi-ID). The data then was filtered to validate the data mining findings in order to investigate the sensitivity of the results for further exploration of understanding the relationship between such attributes. This deep investigation of the results was done by providing data threshold of g-score greater than zero vs. less than or equal to zero. We then re-run the clustering method in order to evaluate our findings and to understand what could affect the original conclusions of learners' performance. ANOVA test is then conducted to understand how the performance level was affected after moving the threshold by comparing the two clustering tests.

The remainder of the article is structured as follows. First, we present previous work and an appraisal of studies directly relevant to our findings. We then describe the methodology used to conduct the three investigations. The findings of our investigations are then discussed. Finally, conclusions and possibilities for future work are identified.

2. LITERATURE REVIEW

2.1. Individual Differences

Previous studies have demonstrated the importance of individual differences as learners' differences in the design of WBI programs (Alhajri, Counsell, & Liu, 2013b; Al-Hajri & Al-Hunaiyyan, 2011). Such differences can have a significant effect on interactions using WBI. Individual differences can range from cognitive styles (Workman, 2004; Kim, 2001); to prior knowledge (Mitchell, Chen, & Macredie, 2005a; Calisir & Gurel, 2003; Hölscher & Strube, 2000) to gender differences (Beckwith, Burnett, Wiedenbeck, & Cook, 2005; Roy, Taylor, & Chi, 2003; Schumacher & Morahan-Martin, 2001) to age differences (Ford & Chen, Individual differences, hypermedia navigation and learning: an empirical study, 2000; Weiser, 2000). In this article, we explore individual differences through three perspectives, namely gender, prior knowledge and cognitive style. Regarding age differences, this article was conducted on a higher education institution with ages of range between 18 to 25 years old:

1. **Gender:** Some studies indicate that females and males show different behaviour and demonstrate different perceptions and attitudes (Alhajri, Counsell, & Liu, 2013b; Roy, Taylor, & Chi, 2003; Chen & Macredie, 2010). Gender is the most obvious individual difference between users. Many studies have been conducted on gender differences in the use of hypermedia systems which has a significant variable in the learning process. However, there is a distinct lack of studies investigating their performance while interacting with WBI programs. Alhajri et al. (Alhajri, Counsell, & Liu, 2013b) investigated the effect of individual differences and how that could influence learner performance. Results indicated that performance could be affected by the interaction of individual differences on learner's behaviour using a WBI program;
2. **Prior Knowledge:** Learners with different levels of prior knowledge (e.g., novices and experts) benefit differently from hypermedia learning systems (Calisir & Gurel, 2003; Wildemuth, 2004). Many studies have related prior knowledge to different levels of perception in using hypermedia

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