Web-based Learning: Cognitive Styles and Instructional Strategies

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Abstract

This paper reports a study, which investigated whether different instructional strategies might interact with individual's cognitive style in learning. A web-based learning package was designed employing three strategies, Interactive Concept Maps, Illustration with Embedded Text and Text-Only. Group Embedded Figure Test was administered to 178 university students to identify their cognitive style as field dependent or field independent. Findings showed that no significant difference in performance was found between field dependents and field independents in Concept Maps and Illustration with Embedded Text treatment condition. However, a significant difference was found between field dependents and field independents in the Text-Only treatment condition. Also significant interaction was found between cognitive style and treatment type.

Keywords

Individual differences; web-based learning; instructional strategies; multimedia learning

Introduction

The advent of the World Wide Web has changed the way of teaching and learning. Owing to its unique features, educators are now relying more and more on the Web as a vehicle of delivering instruction. One of the main features of the Web is the non-linear structure of hypermedia and the flexibility of presenting information. Such feature permits instructional designers to account for individual differences. However, it is still unclear as to what instructional strategies promote effective instruction for differences in performance that may be attributed to individual differences in the context of web-based learning. For this reason, writers have called for conducting more studies in how individual differences influence learner performance in such environment (e.g., Chen, Czerwinski & Macredie, 2000; Abidi, 2009; Abd Halim, Bilal Ali, & Yahaya, 2011).

Indeed, in response to that call, several researchers (e.g., Graf, 2003; Harris, Dwyer & leeming, 2003; Gauss & Urbas, 2003; Akdemir & Koszalka, 2008; Inan, Flores, Ari & Arslan-Ari, 2010) attempted to examine which individual differences may actually influence web-based learning. One individual difference, which has emerged as important, is cognitive style.

Chen and Macredie (2002) suggested that Witkin's field dependence has emerged as one of the most widely studied cognitive style in different educational settings. Witkin and Moore (1974) used the term, field independence, to describe individuals who are individualistic, internally directed and accept ideas through analysis. On the other hand, field dependent individuals prefer working in groups, are externally directed, influenced by salient features and they accept ideas as presented. Owing to these characteristics, previous studies showed that field independent learners often performed significantly better than field dependent learners in a computer and web-based learning environments (Ford, 1995; Ford & Chen 2000).

However, Witkin, Moore, Goodenough and Cox (1977) theorize that field dependent learners and field independent learners may perform equally well when learning material is highly structured and organized and the needs of field dependent learners are met. They added that field dependent learners may learn most efficiently when given guidance that emphasizes key information and draws attention to necessary cues.

As a response to the theory of Witkin et al., (1977) researchers have started to identify and examine different instructional strategies as an aid to field dependent learners in the context of web-based learning. Such instructional strategies investigated include: hierarchical, linear and network structure (e.g., Graff, 2003); learner/program control (e.g., Wang & Beasley, 2002); contextual organizers (Meng & Patty, 1991; Graff, 2005); and navigational techniques (Chou & Lin, 1998; Graff, 2005). Most of these studies revealed that navigation through hypermedia materials and the form in which they are presented to learner have been identified as important to many users. Owing to the loss of face to face interaction between the instructor and learner in web-based learning environments, Lord (1998) believed that learning materials need to be crafted with careful attention to the mental processes and cognitive style that the user is likely to employ.

As a contribution to the research effort in this area, the present study investigated the effect of ICMs (Interactive Concept Maps) and IET (Illustration with Embedded Text) as learning strategies on students learning with different cognitive styles in a web-based learning environment. Concept mapping is a visual knowledge representation technique. It was first developed by Joseph Novack of Cornell University (1983) based on Ausubel's theory of meaningful learning. Jonassen (1996) described concept maps as an effective way of stimulating prior knowledge by making it explicit and requiring the learner to pay attention to the relationship between concepts and sub-concepts. Shum (1990) stated that there is a need to reduce cognitive overload for the user by designing a better system of cues and concept maps that would aid user's navigation through the hypermedia materials and thereby help to refute claims that hypermedia materials are only suitable for certain types of learners. A meta-analysis on studies which used concept mapping as a learning strategy, conducted by Horton, McConney, Gallo, Woods, Senn, & Hamelin (1993) revealed that concept mapping raised student achievement on the average by 0.46 standard deviations, as well as a strong improvement in student attitude.

As a visual presentation of information, IET has been also widely investigated in contrast to TO (Text Only). Mayer (2003) states that the promise of hypermedia learning is that it will be able to foster deeper learning in students when hypermedia instruction is designed in ways that are consistent with how people learn, and thus can serve as aids to human learning. Mayer proposed a multimedia instructional strategy in which words are mixed with pictures. In his research on instructional design methods across different media, Mayer found that students learn more deeply from well-designed multimedia message where printed words are placed near rather than far from corresponding pictures. This is called spatial contiguity effect (Mayer, 2003). Perhaps this is true in the case of field dependent learners since they have difficulty imposing organization in an unstructured material, Witkin, et al. theorize that field dependent learners may learn equally well as their counterparts when learning materials are highly organized.

Although a good deal of research has examined the effect of visual presentations on learning (e.g., Walsh, 2003; Bruke, 2007), few have investigated the effect of different visual presentations on specific cognitive styles. Literature shows that field dependent learners tend to use less efficient strategies for attaining concepts. Therefore, illustrations used in presenting visual concepts should be designed to assist field dependents in their learning.
The present study was an attempt to find whether the use of Interactive Concept Maps and Illustration with Embedded Text would advantage field dependents learning compared to field independents in a web-based learning environment. Technically, two conditions of presentations of information were employed in the study: highly supported conditions (Interactive Concept Mapping and Illustration with Embedded Text) and low supported condition (Text-Only). Our hypotheses were formulated as follows:
a) More effective learning will be evident when the information is presented through Interactive Concept Mapping and/or Illustration with Embedded Text (highly supported condition), in contrast to Text-Only presentation (low supported condition).
b) The effect of high supported condition will be relatively stronger in the case of field dependent individuals (that is, an interaction between instructional strategies and individual differences).

Methods

The sample of the study consists of 178 first-year university students enrolled in a course called Becoming Information Literate offered by the School of Education, University of South Australia. The Group Embedded Figure Test (GEFT) was administered in order to assess participants' level of field dependence. The estimate of reliability of the GEFT is .82 (Witkin, Oltman, Raskin & Karp, 1971). The GEFT requires one to locate simple geometric figures embedded in more complex patterns within specified time limits. A median split was used to place participants into cognitive style groups. Participants scoring below the group median of 14 were classified field dependent; those with scores greater than the median were classified field independent.

Materials

A web-based learning package was designed for the Becoming Information Literate students. The package content focused on how car-braking system works. Owing to the fact that field independent learners outperform field dependent learners in various learning settings due to their different characteristics (Ford & Chen 2001), two instructional strategies, ICMs and IET were employed in the package to present the same subject. These strategies were meant to assist field dependents in their learning. The same subject matter was also presented using TO (text only) as a control variable.

The web-based learning package was designed using a combination of computer applications (Macromedia, Inspiration, Photoshop and Microsoft FrontPage). The ICMs were constructed in an interactive way so that students can build up concepts gradually until they get the whole picture of the subject matter. For further explanation, each concept was accompanied by both pictures and text. In order to avoid cognitive overload on the part of the students the text accompanied was presented in chunks. Similarly, the IET presentation was constructed using the same computer applications. However, the subject matter was only presented by diagrams and text. That is, text was placed near rather than far from each part of the system depicted by the diagrams allowing learners to get the concept in both picture and text simultaneously.

Procedures

The study went through the following steps:

Introduction: Participants were given a brief explanation of the purpose of the experiment. They were asked to use the web-based learning package.

Pre-tests: Prior to using the package, participants were given the Group Embedded Figure Test (GEFT) in order to identify their cognitive styles as either field dependent or field independent. The second test was a web-based open-ended question that was asked to determine the subject's prior knowledge with the subject.

Web-based learning package: After taking the pre-tests, participants were asked to use the package to learn the subject matter. This package presented the same subject matter using the three instructional strategies: ICMs, IET, and TO.
All students learned the subject matter using only one of these three strategies. For example, the package presented the subject matter to one group using ICMs and presented to another group using IET.

Post-test: After completing the lesson, students were given an immediate web-based post-test, which consists of a performance test with the same question as the pre-test and a number of transfer questions to verify any increase in understanding at the end of the instruction.

Data were analysed with the Statistical Package for the Social Sciences (SPSS). Analyses of data included, means, standard deviations, and ANOVA analysis. A significance level of $p < 0.05$ was adopted for the study.

Results

One-way ANOVA was run in order to examine the effectiveness of the three instructional strategies used in the web-based learning package. Table 1, shows the means of student's performance in ICMs, IET, and TO.

Table 1. Means scores in ICMs, IET and TO

Treatment	N	Mean	Std. Deviation	Std. Error
Concept maps	63	7.95	2.027	.255
Illustration with text	44	6.57	2.654	.400
Text	71	4.70	2.691	.319
Total	178	6.31	2.833	.212

As shown in Table 2, One-way ANOVA yielded a significant difference in performance between students who undertook the three treatments. Students showed high performance, M = 7.95 in ICMs treatment followed by IET treatment, M = 6.57 and the least was the TO treatment, M = 4.70. This result confirms the first hypothesis stating that more effective learning will be evident when the information is presented through ICMs and/or IET, in contrast to TO presentation.

Table 2. One-way ANOVA analysis for students' performance by treatment

Sum of Squares	df	Mean Square	F	Sig.
Between Groups	355.941	2	177.970	29.259	.000
Within Groups	1064.441	175	6.083		
Total	1420.382	177			

A 3 x 2 ANOVA was conducted to determine whether type of treatment and cognitive style of students influenced their performance. As shown in Table 3, the result of the analysis indicated that there is a main effect for the type of treatment, $F = 32.2$, $df = 2$, $p < .05$ on student performance. The mean of performance for the treatment of ICMs, IET and TO was respectively M = 7.93, M = 6.75, and 4.76. Results also indicated a main effect of cognitive style (field dependence), $F = 5.99$, $df = 1$, $p < .05$ with field independents (M = 5.74) performing better than field dependents (M= 3.33) in the TO treatment. These findings support the second hypothesis.

Table 3. 3 x 2 two-way ANOVA for the effect of the three treatments and cognitive style on students' performance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Treatment	248.049	2	124.025	25.163	.000
Cognitive style	24.339	1	24.339	4.938	.028
Treatment * Cognitive style	32.542	2	16.271	3.301	.040

a R Squared = .270 (Adjusted R Squared = .246)

However, as shown in Table. 4, this effect disappeared in both conditions, ICMs and IET. The mean of performance of field dependents and field independents in the ICMs treatment was respectively M = 7.82, M = 8.08 and was M = 6.68, M = 6.81 in the IET treatment.

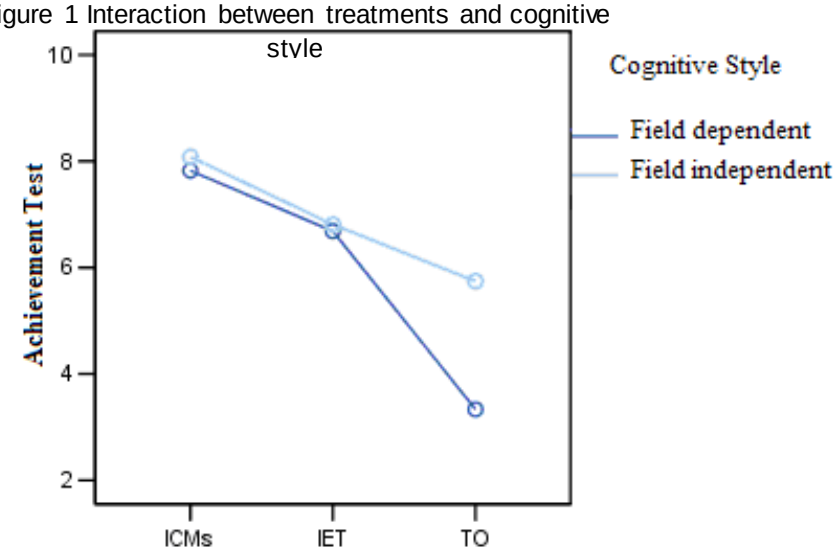
Table 4. 2x2 two-way ANOVA for the effect of treatment (concept maps and illustration with text) and cognitive style on students' performance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Treatment	33.988	1	33.988	6.710	.011
Cognitive style	.866	1	.866	.171	.680
Treatment * Cognitive style	.106	1	.106	.021	.886

a R Squared = .082 (Adjusted R Squared = .052)

However, when the analysis was run on the three treatments (see Table 3), the main effect for cognitive style got qualified by a significant cognitive style by treatment interaction, $F = 3.301$, $p < .05$. Conversely, this effect as shown in Table 4 disappeared when the analysis was only run on both ICMs and IET treatment together. This explained that ICMs and IET are effective instructional strategies in reducing disparity in performance between field dependents and field independents in contrast to TO (see Figure 1).

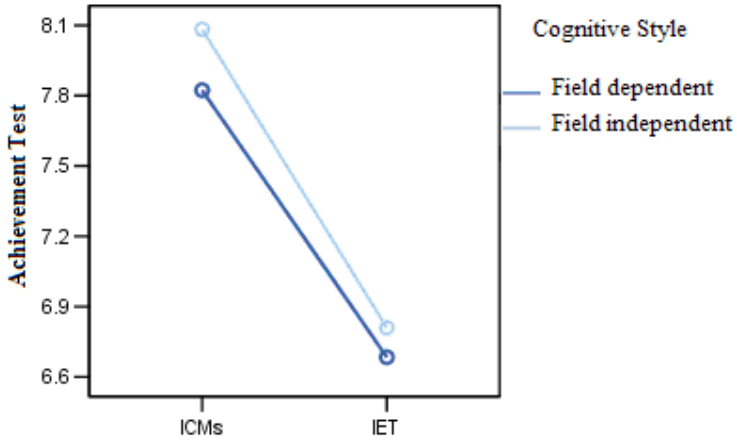
Figure 1 Interaction between treatments and cognitive style



Further, a 2 x 2 repeated measures two-way ANOVA was conducted only on the ICMs and TO treatment to determine whether treatment and participants' cognitive style influenced their performance. Results of the analysis indicated a significant performance by treatment

interaction, F = 55.31, p < .05. However, the analysis yielded a non-significant performance by cognitive style interaction, F = .514, p > .05. This explains that the TO treatment did not reduce the difference in performance which was found between field dependents, M = 1.04 and field independents M = 2.15 in the pre-test. Interestingly, the findings showed a significant interaction, F = 5.3, p < .05, between performance, treatment and cognitive style which means that participants performance changes by treatment and type of cognitive style. In other words, field dependent participants who undertook the ICMs treatment performed as good as field independents in contrast to the TO treatment where field independents performed better than field dependents. Similarly, another 2 x 2 repeated measure two-way ANOVA was run on both the ICMs and IET. The findings of the analysis indicated a significant performance by treatment interaction, F = 4.23, p < .05. However, a non-significant performance by cognitive style interaction, F = 1.21, p > .05, was found. Also the interaction between performance, treatment and cognitive style was not significant, F = .073, p > .05, which means that both treatments equally reduced the disparity in performance between field dependents and field independents (see Figure 2).

Figure 2 Interaction effect between treatment (ICMs and IET) and cognitive style



Discussion and Conclusions

Findings of the present study showed that both ICMs and IET were equally effective in reducing disparity in performance between field dependents and field independents in a web-based learning environment. No significant difference was found between field dependents and field independents on the post-test in both treatment conditions in comparison with the TO treatment condition where a significant difference on both the pre-test and post-test results was found between the two types of cognitive style. ICMs showed superiority over IET as both field dependents and field independents showed higher post-test results when using ICMs in contrast to IET. A possible explanation to this result would be that ICMs provided field dependent learners with a clear overview of the learning material and helped them visually see the interrelationship between concepts and sub-concepts. Perhaps ease of navigation was another advantage field dependent learners enjoyed with ICMs. Chou and Lin

(1998), in their study on the effect of navigation map types and cognitive styles on learners' performance in a computer-networked hypertext learning system, concluded that based on field dependents characteristics, concept maps should be available to field dependents as they provide global overviews of the learning content.

IET has also proven to be an effective way of assisting field dependents in their learning and perform as well as their counterparts. Perhaps placing text near rather than far from the corresponding pictures or diagrams assists learners in processing information. Mayer (2003) contend that when corresponding words and pictures are presented near each other, learners are more likely to be able to hold corresponding words and picture in the working memory at the same time. This situation enables the process of integrating visual and verbal model, a key step in active learning. This is reasonable since field dependent learners perceive things in a global manner, and would enjoy the increased structure provided by the illustration with embedded text in contrast to text alone.

The results of the present study seem to support what is asserted in literature, namely, owing to its features, the web in general and hypermedia in particular, if instructionally designed well and used properly, can be more effective in assisting all types of learners in processing information. That is, reducing differences in the academic performance among students with different cognitive styles. Witkin et al. (1977) suggest that, in comparison with field independent people, field dependent people have more difficulties dealing with confusion, complexity, and dimensions that are often present in hypermedia systems. Thus, extra guidance may be useful in assisting field dependent people in hypermedia learning where there is no face-to-face interaction with instructor. Therefore, the support provided in present web-based learning package (ICMs, IET) may provide sufficient structure and support to overcome the limitations of field dependent students to impose effective structure on their learning since field dependent people tend to have trouble in relatively unstructured learning environments.

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