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Learning from web-based instructional systems and cognitive style

Martin Graff

Martin Graff is a lecturer in psychology at the University of Glamorgan. He has published in the field of cognitive style and computer-based learning. His research interests include cognitive style and individual differences, learning from hypertext and e-learning. He is currently undertaking a major evaluation project on e-learning in South Wales colleges. Address for correspondence: School of Humanities and Social Sciences, University of Glamorgan CF37 1DL UK. Tel: 01443 654071; fax: 01443 482138; email: Mgraff@Glam.ac.uk

Abstract

Two of the principal issues, which have been addressed in assessments of the benefits of web-based instructional systems, are firstly, whether the segmentation of information provided by the web structure aids users in apprehending the interrelationships between the units of information featured in the web. Secondly, whether providing the user with an overview of the web system assists in facilitating his/her learning. It is suggested in the present study that these two issues may be more effectively understood by a consideration of an individual's cognitive style. Fifty participants were assigned to one of two web-based instructional systems featuring information on the subject of psychological ethics. The information in one of the web systems was segmented to a greater degree than the information in the other. Half the participants using each web system were given an overview of the system and half were not. After a given time using the system, participants were tested on the information from the web. The findings suggest that cognitive style and segmentation had an effect on performance, although the provision of the overview had little effect. The results are discussed in terms of a consideration of cognitive style in the design of web-based instructional systems.

Introduction

The fundamental characteristics of web-based instructional systems are their non-sequential arrangement of information content, and their facility for allowing the linking of information, which is conceptually related. Therefore, it is conceivable that such systems provide the potential for presenting instructional information more effectively than traditional linear methods of delivery, because the interrelationships between units of information can be explicitly illustrated within the web structure.

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However, there are also disadvantages to web-based instruction. For example, several researchers have suggested that the segmenting or fragmenting of information in web-based systems may have the consequence of causing a loss to its general meaning. (Whalley, 1993; Laurillard, 1996). Furthermore, difficulties in using web-based systems have been identified by Gygi (1990) who suggests that such hypertext structures suffer from a lack of what have been called "discourse cues", which are a set of standard indicators about how information is organised, eg chapters and sections, as is the case with traditional print-based media.

The question to consider therefore is whether instructional information should be segmented, as is the case in web-based systems, in order to illustrate the various conceptual interrelationships between units of information, or whether this segmentation causes a loss to the overall meaning of the information, ultimately making it less clear.

Disorientation

In addition to the segmentation issue outlined above, web-based instructional systems may debilitate the learning process because users have to perform multiple tasks simultaneously. They have to navigate through the web system in addition to reading and understanding the contents of the information it contains. Performing both tasks concurrently demands a high level of cognitive load (Sweller, 1988, 1994). Focusing on navigating through the web will leave the user fewer mental resources with which to process the instructional material. Alternatively, focusing more on the instructional material, and less on navigating may ultimately cause the user to experience a feeling of dissorientation. The more disorientation the user experiences, the more he/she will need to attend to navigating and less to processing the content, thus reducing the amount of learning that can take place.

Disorientation in a web-based environment has frequently been compared to feeling lost in physical space (Hammond and Allinson, 1987), and therefore it is conceiveable that the provision of an overview depicting the layout of the web, similar to a map in a physical environment, may be beneficial to users. Research has illustrated that providing such an overview makes web-based learning environments easier to use, directing readers to different aspects of the system and facilitating learning (Dee-Lucas and Larkin, 1995; McDonald and Stevenson, 1999). However, the relative benefit of providing such an overview may depend upon the individual user's feeling of disorientation. In other words, an overview will be more facilitative to users who feel disorientated than to those who do not.

Cognitive style

Further investigation of whether segmentation of information facilitates learning, and the relative benefit of the provision of an overview, may also be usefully addressed by considering individual differences in user characteristics. One categorisation of such which would appear to be relevant to consider here is cognitive style. The underlying rationale as to why cognitive style may be pertinent to the relative success with which individuals learn from web-based systems is outlined below.

Cognitive style differences are manifest in an individual's relative ability to impose his/her own idea of structure on learning materials. Some individuals have this ability, while others need to have more explicitly structured learning environments available to them (Riding, 1991; Riding and Douglas, 1993; Riding and Al-Sanabani, 1998). Because web-based instructional systems feature the potential for displaying different pieces of information on different pages, the need for an individual to understand the overall structure becomes increasingly important. Therefore, a user who possesses a cognitive style enabling him/her to understand the structure of the system should derive greater benefit in terms of learning.

Cognitive style is also related to an individual's ability to detect his/her spatial location or orientation in space. This has been documented as far back as Witkin's pioneering research (Witkin and Goodenough, 1979) into perception of the upright, when it was suggested that individual differences existed in spatial orientation ability. This would be an important means of knowing one's position within a web-based environment and the lack of such an ability may cause an individual to experience disorientation. As suggested above, the more disorientation the user experiences while using a web-based system, the more he/she will need to focus on navigating and less on processing the information content. Ultimately then, the more disorientation experienced, the more difficult it will be to learn the information. Therefore, in order for effective learning to take place, an individual will need to be aware of his/her location within a web-based environment.

One of the most useful conceptualisations of cognitive style to emerge in recent years is the wholist-analytic (WA) and verbaliser-imager (VI) style constructs proposed by Riding (1991). Wholists typically view ideas as complete wholes, but are unable to separate these ideas into discrete parts, whereas analytics are able to apprehend ideas or concepts in parts, but have difficulty integrating such ideas into complete wholes. Verbalisers are superior at working with verbal information, whereas imagers are better at working with spatial information.

Wholist-analytic style and web-based instruction

It is suggested that the wholist-analytic dimension of cognitive style may be relevant to the success with which individuals learn from web-based systems for the following reason. The segmentation of information in web-based learning systems may exacerbate an analytic individual's tendency to see information in parts, which may ultimately debilitate learning performance. This effect was observed by Riding and Grimley (1999), who noted that analytics did not learn as well as wholists from using a multimedia presentation of information. They explained this by the suggestion that the presentation was constrained by the constricted viewing window of the computer, which meant that only small units of information were presented at any one time. This ultimately increased the tendency of analytics to process the information content in discrete parts, thus affecting their learning performance. Analytics therefore should learn most effectively from web-based systems featuring less segmentation, whereas the segmentation of information should make little difference to wholists.

The provision of an overview of a web-based system should theoretically be more facilitative to wholists, because they strive to see the full extent of the system. Analytics on the other hand don't strive to do this and consequently should not benefit from an overview. Douglas and Riding (1993) noted that the provision of an advance organiser, giving users a conceptual overview of an instructional system was of benefit to wholists in terms of learning performance, yet made little difference to analytics. However, using a hypermedia environment, Ford and Chen (2000) noted that although wholists made more use of an overall topic map than analytics, this resulted in no difference in learning performance.

Verbaliser-imager style and web-based instruction

The importance of a consideration of the verbaliser-imager cognitive style to the success with which individuals learn from web-based systems is explained as follows. Verbalisers are superior at working with verbal information (Riding and Taylor, 1976; Riding and Dyer, 1980; Riding and Calvey, 1981; Riding and Douglas, 1993) and theoretically should be superior at reading and understanding the information content of a web-based instructional system. However, because verbalisers are less effective than imagers at keeping track of their spatial locations, this may adversely affect their learning in more complexly arranged segmented web systems. Conversely, it is equally possible that the performance of imagers may diminish through not engaging with the content of the information as effectively as verbalisers. Therefore, it is possible that verbalisers and imagers will direct attention to the tasks of reading and processing the information content, and tracking location, with different emphasis and this may be manifest in their learning performance.

Furthermore, the provision of an overview of the web, should be more beneficial to verbalisers than images. This is because, as mentioned above, verbalisers do not monitor their spatial location in the web structure as effectively as imagers and should therefore find the overview of more benefit.

Learning and cognitive style

Finally, it is important to note that learning may be assessed in several ways. On one level, learning may be demonstrated by recall of discrete items of information, while on another level, an individual may be required to recall how discrete items of information are interrelated. It is possible that individuals with different cognitive styles may perform differently at each of these types of learning, with analytics being superior at recalling single discrete items of information, and wholists superior at recalling information, which requires reference to be made to the whole of a subject domain. Accordingly, it is important to measure learning by both methods in a study comparing performance between individuals of different cognitive styles.

Aims

The aims of this study are as follows. Firstly, to investigate the extent to which segmentation of information aids learning performance in individuals possessing different cognitive styles. Secondly, this study aims to enquire whether the provision of an

overview of a web system facilitates learning in individuals with different cognitive styles.

Method

Web structures

Two web structure conditions were employed in this study. These were a "short page" condition consisting of twenty-three pages (Web structure 1, see Figure 1) and a "long page" condition consisting of eleven pages (Web structure 2, see Figure 2). Each structure contained identical material on the subject of psychological ethics. However, struc-

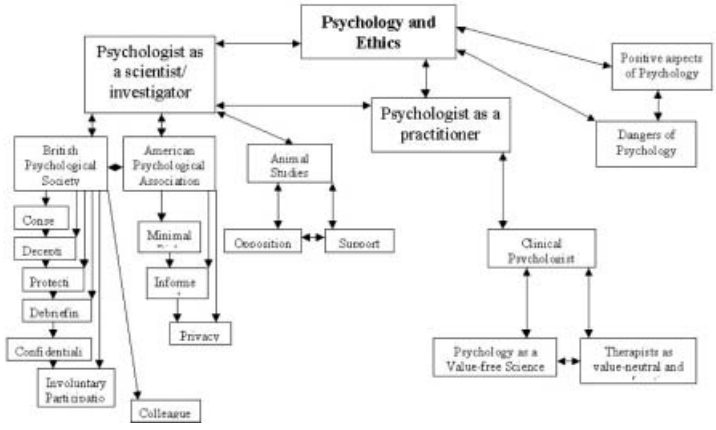

Figure 1: Web structure 1—short page condition

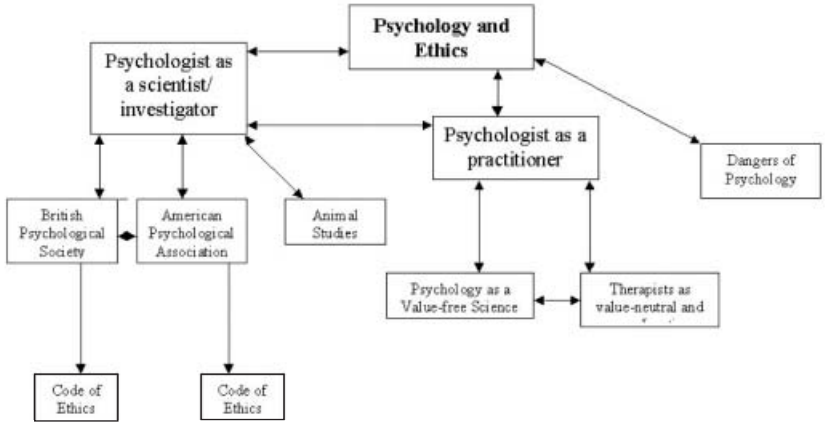

Figure 2: Web structure 2—long page condition

ture 2 contained more words per page than structure 1, therefore participants needed to scroll down the page in order to view all of the information. Structure 1 therefore was the more segmented condition. Within each of these conditions, half the participants received an overview of the system in the form of a map of the web structure and half did not.

Cognitive styles analysis

The Cognitive Styles Analysis (Riding, 1991) is a computer presented test used to determine an individual's position on the wholist-analytic and verbaliser-imager dimensions of cognitive style. It consists of three subtests. The first contains items relating to the verbaliser-imager style, the second set of items relates to the wholist dimension of style and the third set of items relates to the analytic dimension of style. The test taker is required to react by pressing either a "true" or "false" button in response to each question item. The computer then calculates an individual's score for each style dimension by comparing response times between the verbaliser and imager items for the verbaliser-imager (VI) score and the wholist and analytic items for an individual's wholist-analytic (WA) score. The WA and VI scores can then be used to categorise individuals into types namely "verbalisers" or "imagers" and "wholists" or "analytics." This process is described under "data analysis" below.

Test-retest reliability of the Cognitive Styles Analysis as reported by Peterson, Deary, and Austin (2003) is as follows: for the verbaliser-imager scale ($r = 0.70$ $p < 0.00$) and for the wholist-analytic scale ($r = 0.81$, $p < 0.00$).

Participants

Participants in this study were fifty, psychology first year university students, (9 males and 41 females). The mean age was 23.24 with a standard deviation of 7.49. Ages ranged from 18 to 46.

Procedure

The general design of this study was a 2×2 between subjects design. As described earlier, the conditions were web structure in terms of page length and provision or absence of an overview. Participants were randomly assigned to one of these conditions and were given approximately ten minutes to read through the structure navigating through the pages in any manner they wished. They were then requested to answer recall questions and an essay question on information contained in the web structure.

Data analysis

For the purpose of data analysis, wholists were individuals scoring ≤1.26 on the WA scale and analytics were individuals scoring ≥1.27. Similarly, imagers were individuals scoring ≤1.03 on the VI scale and verbalisers were individuals scoring ≥1.04.

Recall questions were scored by matching participant responses against the correct answers. One point was given for a partially correct answer and two for a more comprehensive answer. The essays were scored in terms of the level of detail particpants

used. High scores were awarded for essays high on detail and low scores were given to essays with a low level of detail. The level of detail was judged according to a predefined rubric.

Results

Learning—effects of web structure

Figure 3 displays the mean scores for recall and essay scores for wholist and analytic cognitive styles performing in each structure condition. A 2×2 MANOVA was calculated for wholist-analytic cognitive style and web structure. No significant main effects were observed here for recall or essay scores for web structure or cognitive style, although a significant interaction effect was evident for the essay scores $F(1,46) = 3.59$ $p < 0.05$. Analytics achieved superior scores in the long page condition whereas wholists were superior in the short page condition. Figure 4 displays the mean scores

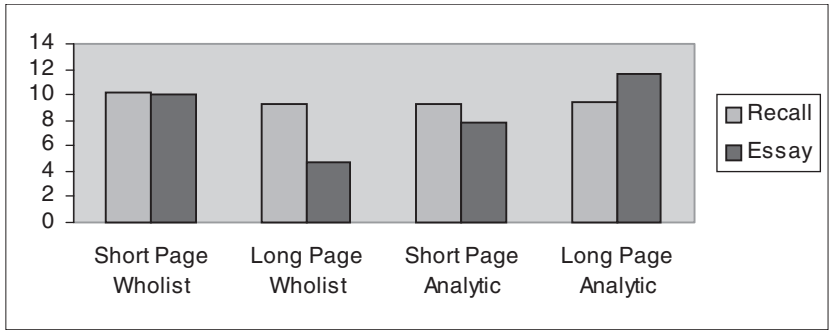

Figure 3: Wholist-analytic style, web structure and learning performance

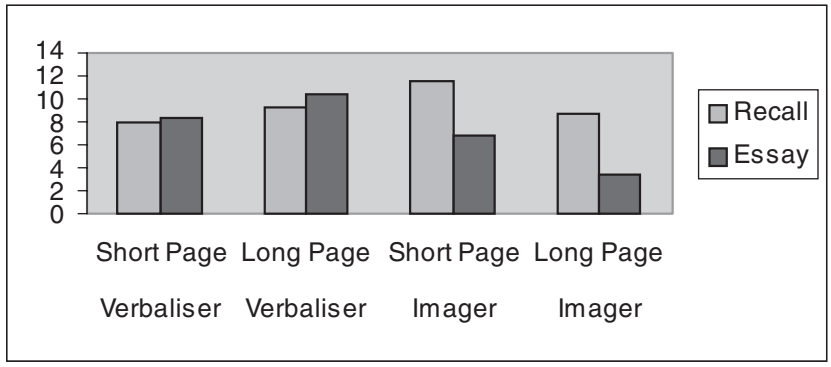

Figure 4: Verbaliser-imager style, web structure and learning performance

for recall and essay scores for verbaliser and imager cognitive styles performing in each web structure condition.

A further 2 × 2 MANOVA was calculated for verbaliser-imager cognitive style and web structure. A significant interaction effect was observed for recall scores, $F(1.46) = 3.11$, $p < 0.05$, with imagers superior to verbalisers in the short page condition. Also a significant main effect was apparent for the verbaliser-imager cognitive style for the essay scores $F(1,46) = 3.59$, $p < 0.05$. Verbalisers outperformed imagers here.

Learning—effects of provision of an overview

Figure 5 displays the mean scores for recall and essay scores for wholist-analytic cognitive style and provision of an overview of the system. The calculation of a 2 × 2 MANOVA for wholist-analytic cognitive style and provision of an overview, revealed no significant main effects or interaction effects. Figure 6 displays the mean scores for recall and essay scores for verbaliser-imager cognitive style for provision of an overview. A 2 × 2 MANOVA was calculated for verbaliser-imager cognitive style and provision of

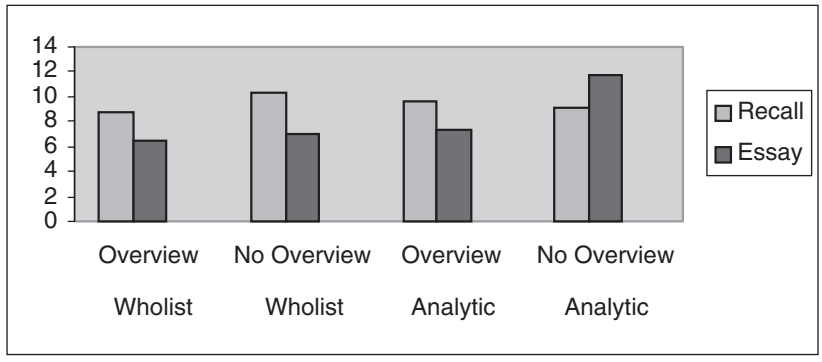

Figure 5: Wholist-analytic style, provision of overview and learning performance

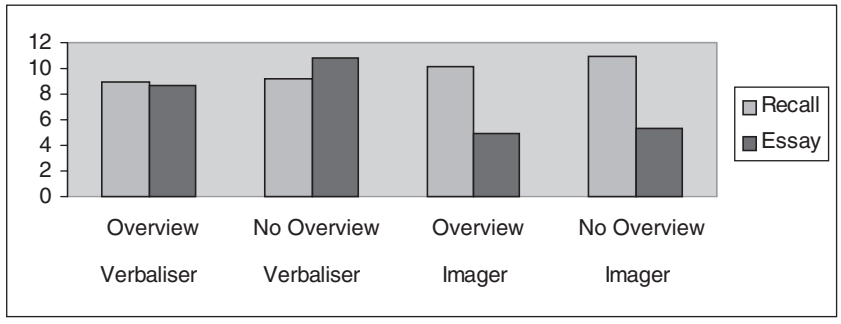

Figure 6: Verbaliser-imager style, provision of overview and learning performance

overview. A significant main effect was observed here for cognitive style with verbalisers again outperforming imagers in essay performance. $F(1,46) = 3.61$ $p < 0.05$. No interaction effects were observed between verbaliser-imager cognitive style and provision of the overview.

Discussion

This study aimed to investigate whether segmentation of information and the provision of an overview of the web system differentially facilitated learning performance for individuals with different cognitive styles. Learning performance was measured with recall questions and a short essay question.

Effects of web structure

For wholist-analytic cognitive style and web structure a significant effect was observed for the essay scores, with analytics having inferior scores to wholists in the short page, more segmented web condition. This finding is consistent with that of Riding and Grimley (1999), who suggested that analytics did not learn as effectively from information which was segmented, because this increased the tendency of analytics to view the information content in discrete parts therefore debilitating their learning. Wholists on the other hand learned best from the short page, segmented condition where the information was more explicitly structured.

For the verbaliser-imager cognitive style, imagers were superior to verbalisers on recall performance in the short-page condition, although there was little difference between these two styles in the long page condition. This finding is consistent with the notion that imagers are superior at keeping track of their spatial locations within the web system, which would be more critical in the short page more segmented condition, where users would have to click back and forth between pages more often. In terms of the essay scores, verbalisers outperformed imagers in both short and long page conditions. This highlights the difference between the two measures of learning assessed here. Verbalisers are typically superior at working with verbal information, although focus less on keeping track of their location within the system. The present result may be interpreted by the suggestion that keeping track of their location within the web might have been less crucial to users in order to perform well on the essay question. To achieve a high score on this, users would not need to effectively process the verbal content of the information, an ability more suited to verbalisers.

Effects of provision of an overview

In terms of the effects of the provision of an overview of the system, no significant effects on either measure of learning performance were evident for wholist-analytic cognitive style, and this finding is consistent with that of Ford and Chen (2000). However, analytics achieved slightly superior essay scores without the provision of an overview, suggesting that this may have had a debilitating effect on their performance. A possible interpretation of this may be explained in terms of cognitive load theory

(Sweller, 1988), whereby learners have difficulty attending to several tasks at the same time when attempting to learn. In this case using the overview map and attempting to read information from the web concurrently had a negative effect on essay performance because the user was performing both tasks simultaneously.

For the verbaliser-imager cognitive style, no differences in performance between verbalisers and imagers were observed for recall performance, although verbalisers outperformed imagers on essay performance. The superior performance of verbalisers on essay scores is explained above. No interaction effect was observed for cognitive style and provision of the overview, suggesting that the overview did not facilitate learning for verbalisers, contrary to what was predicted. The lack of any significant effect for overview provision alone is not consistent with the finding of Dee-Lucas and Larkin, (1995) and McDonald and Stevenson (1999). Although an overview of the web was provided in this study, what is not certain is the extent to which participants engaged with this as an aid to using the system, and this is an issue, which needs further investigation in subsequent research.

The immediate implications of the findings from this study for instructional designers, suggest that it may be profitable to design web-based learning environments to match the cognitive style of the user. More specifically, this implies designing systems that are less segmented for analytic individuals and constructing pages that are more segmented for individuals who are imagers. The presence or absence of the provision of an overview of the web appears to be of little consequence for effective learning, and as such, this would at first appear not be an important consideration for instructional design. However, further investigation is required into the extent to which users engaged with the system overview.

The instructional system employed in the present study focused on the subject of psychological ethics. However, it is possible that individuals may engage differently with other subject domains and this may also depend on cognitive style. For example, Tinajero and Paramo (1997) noted that cognitive style influences academic preferences. Therefore it is possible that an instructional system with information on a different subject and also possibly a system incorporating a multimedia component may yield a different finding. Furthermore, in terms of methodology it may also be prudent in further research to augment the data on learning with user responses regarding their perceptions of using the web-based instructional system employed in this study.

Conclusion

The aim of this study was to investigate whether segmentation of information and the provision of an overview of a web-based instructional system differentially facilitated learning performance for individuals with different cognitive styles. The general finding was that individuals possessing different cognitive styles learned more effectively when

the appropriate level of segmentation of information was provided by the web system. However, the effect of an overview map had no effect on learning performance although individuals possessing an analytic cognitive style learned slightly less effectively when provided with such an overview. The immediate implications of the findings from this study suggest that it may be appropriate to design web-based learning environments, which match the cognitive style of the learner. Analytics require information to be provided in a less segmented format, whereas imagers perform best in a more segmented web-based environment. The effectiveness of an overview of the web for facilitating learning requires further investigation in terms of the extent to which users engage with such a provision.

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