Web-Based Learning: The Impact of Cognitive Styles on Learning Environment Development

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ABSTRACT

This paper looks at the use of cognitive styles to help support Web-Based Learning. This is attempted in two ways. The first is by involving the students more comprehensively in the design process by discussing the results of their cognitive styles test. The second is by using those results to inform the design and construction of individual learning environments(ILE). 64 students undertaking a unit in Human Computer Interaction were involved in the study. A range of measures were used to capture the participants response to their cognitive styles. These included: reflective journals; a survey; ILE development documentation; the individual learning environment itself; interviews. The details of the task of constructing the ILE are presented followed by an initial cognitive style profile of the respondents. Student marks for a range of cognitive style and ILE related assessments are considered and expanded upon by the inclusion of related comments on the design and development process by individual students. Student comments on the approach and results are discussed and conclusions are drawn on the relevance of the various elements to the design of individual learning environments.

INTRODUCTION

This paper looks at the use of cognitive styles to help support Web-Based Learning. Elements of the cognitive style of a group of students were used to inform the design of individual learning environments (ILE) - web-based interfaces to learning resources. The participants, 64 students studying a Human Computer Interaction unit, were informed of the results of the cognitive style test and the material was integrated into the unit content. As an assessed part of the unit, students were then asked to document the process of designing and developing a web-based individual learning environment (ILE) with specific reference to their own cognitive style. Coyne has suggested that "we discover new ways of acting and thinking" and that we "reveal aspects of our practice" (Coyne, 1995) when using technology for design and it was considered that the ILE design exercise would be particularly suitable for students considering their own cognitive styles. A range of measures were introduced to capture quantitative and qualitative data on the overall process. These included reflective journals, the individual learning environment - its design and its documentation, a survey and interviews. This paper deals with preliminary results which look at the cognitive style measure, the survey results and some comments from the reflective journals and ILE documentation.

BACKGROUND

Cognitive Style can be defined as "an individual's preferred and habitual approach to organising and representing information" (Riding and Rayner, 1998). Many different measures have been developed over the past few decades (Jonassen and Grabowski, 1993, Morgan, 1997, Riding and Rayner, 2000), but this main assertion of the relationship between cognitive style and individual information processing has remained central to all definitions. Ford studied the implications of the distinction between holists and serialists in learning for supporting individual users through user interface design (Ford, 2000), Another study looked at the possible impact of cognitive styles on the user-model based design of adaptive human-computer interfaces (Averbukh et al., 1997).

Additional studies have attempted to look at the relationship between cognitive style and the format of learning materials for computer assisted instruction or web-based learning (Pillay, 1998, Boles and Pillay, 1999, McKay, 1999). Although much work has been done on the nature of cognitive and learning styles, the application of styles to interface design and learning has proved more problematic. These studies often reflect a continuing problem with the quasi-experimental approach to this type of study in that the results often find no significant relationship between the material presentation/interface style and learning. The use of single quantitative measures to capture a representation of students' cognitive style and measures of learning has often produced inconclusive results. Several authors have commented on the need for qualitative research concerning the ways in which individuals with different cognitive styles interact with web-based learning environments (Summerville, 1999, Chen, 2000).

In an attempt to provide an alternative approach to exploring this area, a different and more process and qualitatively based methodology was developed. In this approach, one of the main aims was to involve the students in the design and development of the interface while at the same time getting each student to reflect and comment on both his or her cognitive style elements and the interface design and development process. A review of literature plus discussions with a range of colleagues including those in the field of educational psychology led to the choice of the Cognitive Styles Analysis (Riding, 1991) as the measure to be used. This was on the basis of the large number of empirical studies available establishing the reliability and validity of the measure (Riding & Rayner, 1998).

COGNITIVE STYLES ANALYSIS

The Cognitive Styles Analysis (Riding, 1991) is a 15 minute computer-based test which measures personal preferences for representing and processing information.

Two principle cognitive style dimensions are identified by the CSA and have the following characteristics:

- **Verbal-Imagery** - an individual's position on this dimension determines whether that person tends to use images or verbal representation to represent information when thinking.
- **Wholist-Analytic** - an individual's position on this dimension determines whether that person processes information in parts or as a whole. (Riding and Cheema, 1991)

Measurements on the two dimensions produce four basic classifications - analytic-imager (AI), analytic-verbaliser (AV), wholist-imager (WI) and wholist-verbaliser (WV). In terms of the presentation of material and interface design, Riding and Rayner (1998) suggest that the following guidelines are applicable:

- analytic-verbaliser – the individual will prefer information presented in a textual form (VI) and as analytics tend to break down and structure material, assistance with the overview of material (WA) may be helpful.
- analytic-imager – the individual will prefer information presented in an image or pictorial form (VI) and as analytics tend to break down and structure material, assistance with the overview of material (WA) may be helpful.

- wholist-imager – the individual will prefer information presented in an image or pictorial form (VI) and as wholists tend to take a general overview of material, assistance with the structure of material (WA) may be helpful.
- wholist-verbaliser – this individual will prefer information presented in a textual form (VI) and as wholists tend to take a general overview of material, assistance with the structure of material (WA) may be helpful.

(Riding & Rayner, 1998)

METHOD

64 students took part in the study to the extent that they completed the cognitive styles analysis (CSA) and also completed the unit. The CSA and data collection procedures were an agreed part of the course content of a human computer interaction unit which had a reasonable amount of material on the cognitive aspects of HCI. The assessment procedures of the unit were designed to allow further data collection via reflective journals and the development and documentation of the Individual Learning Environment. The cognitive style measure was considered to be part of the process of user modelling for HCI and interface design.

The elements of the cognitive style outlined above can be viewed as the independent variables in the study (WA & VI dimensions). A series of measures, which can be viewed as dependent variables, was designed to measure the impact of the elements of the cognitive style on the learning process and learning outcomes. These included reflective journals; ILE (website) assessment - interface characteristics; ILE (website) assessment - documentation on development process; feedback survey; interviews with a subset of students.

The Individual Learning Environment

The process of designing and implementing an Individual Learning Environment had two purposes:
- it gave the student experience of the cognitive aspects of Human Computer Interaction via the cognitive profiles
- it allowed the students to work on a system and develop a set of interfaces in a particularly well known area for the group (education) - a functional context application.

The following definition was provided:

"An Individual Learning Environment (ILE) is a system which is designed to support the information retrieval, information handling and learning support needs of the individual student. In its entirety, the ILE is a hardware and software system which is set up to replicate as many of the Learning Resource Centre (see Tutorial 4 handout) functions as possible. These functions can include: Learning Support; Study Skills; Media Services; I.T. Support (Administrative); I.T. Support (Academic); Learning Resources and Career Services. The ILE should allow the student to store, retrieve and manipulate information from internal souces (storage, scanner etc.) and external sources (Internet, WWW etc.)."
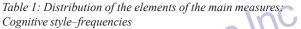
The functions of the ILE were to be organised around a series of web pages which would contain URL's and processes relevant to that function. The majority of the processes (file/open/save/delete etc.) would be provided by the operating system and browser.
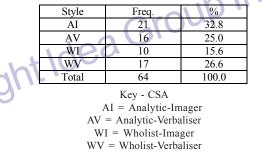
The assessment criteria requested that the system should be structured around the student's current and future units and any learning resources he or she wished to include. For example, resources for a particular unit could include URL's to articles, newsgroups or even the websites of similar units at other institutions. Learning resources could include, for example, links to information on graduate courses the student might be considering or URL's to information considered useful to studies and learning in general.

Elements to be considered in design of ILE included:
- Conceptual structure (the needs for an organiser or an overview)
- Type of content (verbal or visual)
- Layout of information (e.g. tables, tree diagrams, etc.)
- Choice of mode of presentation (words or pictures) (Riding & Rayner, 1998)

RESULTS

The first table shows the distribution of each element of the main measures of the cognitive style across the student sample.

Table 1: Distribution of the elements of the main measures: Cognitive style–frequencies

Style	Freq.	%
AI	21	32.8
AV	16	25.0
WI	10	15.6
WV	17	26.6
Total	64	100.0

Key - CSA
AI = Analytic-Imager
AV = Analytic-Verbaliser
WI = Wholist-Imager
WV = Wholist-Verbaliser

The distribution of the cognitive styles as measured by the CSA show that the largest category is the analytic-imager, comprising nearly one third of the population. Also, while the verbaliser and imager categories are almost evenly split between the group (33 and 31), there are rather more analytics than wholists (37 and 27).

Survey Comments on the CSA

The survey asked a range of questions about students' views on the use and relevance of the cognitive style measures to both the unit and the design of the ILE. Of the 60 students completing all the relevant assessments, 39 (65%) also completed the feedback survey. Both quantitative and qualitative responses were recorded. The quantitative responses were measured using five point Likert scales with 5 indicating 'strongly agree' and 1 indicating 'strongly disagree'. Due to restrictions of space, only selected results will be summarised here

When asked to consider the accuracy of the CSA as a measure of their cognitive style, 98% of the respondents either strongly agreed (44%) or agreed (54%). This was rather more than those who held these views for CSA as a measure of personality where 72% agreed with 26% strongly agreeing (sa) and 46% agreeing (a). In terms of the format and content of the ILE, 87% of the respondents considered the CSA "important in terms of helping to determine the format of the ILE design" (sa - 36%, a - 51%), while 66% considered the CSA important in helping determine the content of the same (sa - 15%, a - 41%).

Cognitive Style and Impact on a Range of Assessments

In tables 2, cognitive style as measured by the CSA is considered with reference to a range of assessment tasks. Of the 64 students who completed the unit, 60 completed all of the above and other assessments. In Table 2, it can be seen that students whose cognitive style is either analytic-imager or analytic- verbaliser consistently scored higher marks across the range of assessments than those with the wholist-imager or wholist-verbaliser cognitive style.

STUDENT COMMENTS

A large number of student comments and qualitative data were sought and received via various methods. Reflective journals were used to reflect on each individual's cognitive style. Interface documentation described the design and development process of the ILE and again related it to elements of the cognitive style. Interviews were conducted and survey comments elicited. The range of student comments and reflections included those on how aspects of their cognitive style might impact on interface design and the development of the ILE. For the CSA and cognitive style, an important factor was a preference for text or graphics. While all students recognised the need

Table 2: CSA and assessment marks (%) means and standard deviations

Ass.	AI	AV	WI	WV
RJ1	70.9	68.9	67.6	63.7
	(14.0)	(11.8)	(7.5)	(10.2)
ILE Doc	72.1	72.9	66.2	64.4
	(21.6)	(13)	(16.7)	(18)
ILE Int	79.4	78.5	74.9	75.3
	(12.4)	(9.7)	(8.8)	(9.1)
Exam	64.0	64.7	56.4	59.8
	(14.7)	(6.9)	(6.9)	(11.0)
Final	69.3	68.9	64.2	64.4
	(14.7)	(6.9)	(6.9)	(11)

Key (Assessments)
RJl - First reflective journal   ILE Int - ILE interface
ILE Doc - ILE design documentation   Exam - Final examination
Final - Total unit mark

for the added dimension of textual information, they often differed considerably on their own stated preferences for informational form and content. The two statements below, the first a wholist-verbaliser, the second an analytic imager, contrast these preferences well:

"*I have always been puzzled as to why teachers would always recommend to us to draw diagrams to help   us understand better as I have always found diagrams to be more of a bane than a boon.*"

" *In learning, I agree that I prefer to have the facts set out in a clear structured order and that diagrams and pictures help a great deal.*"

On extending the analysis to the design of the ILE, the same student commented:

" *When I study, one of the most important things is that all the information is in one place and not scattered about. This structured approach to learning is characteristic of my cognitive style, an **analytic-imager**, and is the foundational element in the design of my ILE. The structure of the ILE was set out in way that allowed me to see the different available categories at all times i.e. by means of the top frame. This frame acted as an overview that could be referred to at all times.*"
(Students comments from reflective journals)

An analytic-verbaliser was surprised by the accuracy of the results:

"*(I found the results to be) true as I tend to hold and process textual information in place of graphical information.....The test itself did not give any hint as to what the results would be like. In fact I was astounded by the results. My result – analytic-verbaliser, was like reading a book about myself when referring to the description of an Analytic-Verbaliser*"

Whereas not all respondents were similarly impressed:
"*Riding's report claims that I am 'reasonable spatially and have a sense of geographical direction.' I beg to differ on this one. From previous experience, my sense of direction has not*

been all that wonderful and I have a reputation for getting lost, whether it be in the physical sense or on the net.*"

One multimedia student had been confronted with usability problems stemming from different interface designs and had already reflected on them:
"*I have also wondered why some people seem to pick up a new piece of software really easily, while I sometimes can seem to struggle for hours. For example (with this software)....the interface seemed completely foreign to me relative to other programmes, and I had no idea where to start.......Thus any subject that focuses on how we can improve the problem of difficulty with software is of great interest to me as a Multimedia software developer.*"

Because of the relatively large number of forms of data collection, a large amount of qualitative data has still to be properly classified and analysed.

DISCUSSION AND CONCLUSIONS

When considering an approach where the participants are more fully involved in the research process, and that process involves aspects of an assessed unit, one must be aware of several potential pitfalls. Because the work was assessed, it is possible that students might over emphasise the positive aspects of the process in documents such as the reflective journal, ILE documentation and the feed-back survey. To counter this, some cross-checking of comments and opinions is available because of the multiple measures. In addition, the fact that the CSA test was a computer generated test rather than a self-administered questionnaire gave some assurance as to the objectivity of the results.

The survey results indicated a high level of agreement with the relevance of the overall process and the accuracy of the CSA. It will be necessary to cross check the range of measures in more detail to try to see if the survey responses match the comments in the reflective journals, documentation and interviews. From this study, the data suggests that those students who had an analytic-imager or analytic-verbaliser cognitive style consistently outperformed those with a wholist-imager or wholist-verbaliser style across a range of assessment types on the human computer interaction unit. This effect was least on the actual ILE/website development and greatest on the ILE documentation. These differences, while not large, were consistent.

What the qualitative data and student comments did show however was that knowledge of and reflection on the characteristics of individual cognitive style could affect the design of the individual learning environment. Participants were often initially aware of their information handling preferences in a relatively uninformed way. The information provided by the cognitive profile allowed them to reflect on these preferences in a much more structured and informed manner. Most found that the dimensions of the CSA gave them useful information which could help develop the ILE with suitable individual characteristics. The results indicate that the ability of each person to develop individualised interfaces and reflect on the role of the range of characteristics present in the user population could also help with the future development and production of more effective user interfaces.

REFERENCES

Averbukh, E., Gavrilova, T., Johannsen, G. and Voinov, A. (1997). User-model based design of adaptive human-computer interfaces, In *The 1997 IEEE International Conference on Systems, Man, and Cybernetics.*, Vol. 2 IEEE, Piscataway, NJ, pp. p1693-1697.
Boles, W. and Pillay, H. (1999). A Study on the Impact of Designing Computer-Based Instruction Considering Preferred Cognitive Styles, In *Proceedings, 11th Annual Conference and Convention Australasian Association for Engineering Education*AAEE, , pp. 66-71.

Chen, C. (2000). Individual Differences in a Spatial-Semantic Virtual Environment. *Journal of the American Society for Information Science,* **51,** 529-542.

Coyne, R. (1995) *Designing Information Technology in the Postmodern Age: From Method to Metaphor,* MIT Press, Cambridge, Massachusetts.

Ford, N. (2000). Cognitive styles and virtual environments. *Journal of the American Society for Information Science,* **51,** 543-557.

Jonassen, D. H. and Grabowski, B. L. (1993) *Handbook of Individual Differences , Learning , and Instruction,* Lawrence Erlbaum Assocs,.

McKay, E. (1999). An investigation of text-based instructional materials enhanced with graphics. *Educational Psychology,* **19,** 323-335.

Morgan, H. (1997) *Cognitive Style and Classroom Learning,* Praeger, Westport, Conneticut.

Pillay, H. (1998). An Investigation of the Effect of Individual Cognitive Preferences on Learning through Computer-based Instruction. *Educational Psychology,* **18,** 171-182.

Riding, R. and Cheema, I. (1991). Cognitive Styles: An overview and integration. *Educational Psychology,* **11,** 193-213.

Riding, R. and Rayner, S. (1998) *Cognitive Styles and Learning Strategies: Understanding Style Differences in Learning and Behaviour,* David Fulton Publishers, London.

Riding, R. J. (1991) *Cognitive Styles Analysis,* Learning and Training Technology, Birmingham.

Riding, R. J. and Rayner, S. G. (2000) *International Perspectives on Individual Differences - Volume 1: Cognitive Styles,* Ablex Publishing Corporation, Stamford, Conneticut.

Summerville, J. (1999). Role of awareness of cognitive style in hypermedia. *International Journal of Educational Technology,* **1**.

Tait, H., Entwistle, N. J. and McCune, V. (1998). ASSIST: a reconceptualisation of the *Approaches to Studying Inventory*, In *Improving Student Learning*(Ed, Rust, C.) Oxford Centre for Staff and Learning Development, Oxford, pp. 262-271.

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