Computer Assisted Instruction & Individual Cognitive Style Preferences in Learning: Does it Matter?

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This paper reports the findings of a pilot study aimed at improving learning outcomes from Computer Assisted Instruction (CAI). The study involved second year nursing students at the Queensland University of Technology. Students were assessed for their preferred cognitive style and presented with either matched or mismatched instructional material. The instructional material was developed in accordance with four cognitive styles (Riding & Cheema, 1991). The findings indicate groups that received instructional material which matched their preferred cognitive style, possibly, performed better than groups that received mismatched instructional material. The matched group was particularly better in the explanation and problem solving tasks.

Introduction

Computer Assisted Instruction (CAI) first began in the 1950s (Yazdani, 1987). Over the last two decades CAI progressed from the use of mainframe computers to microcomputers which can be afforded by many schools and educational institutions (Yong, 1989). Innovations in multimedia technology and powerful programming software in conjunction with statements such as, ". . by the year 2010 we can expect that the computer will be one of the dominant educational delivery systems in many parts of the world" (Bork, 1991, p. 34) ensure that CAI will become an integral part of the teaching and learning process. Most available CAI has advantages such as providing increased accessibility, immediate feedback, interactive learning, and learner-based learning as well as providing a more flexible learning environment. Most of these considerations deal with physical aspects of CAI design. For example flexibility is seen as the ability to navigate through the content and select aspects one wishes to study while having limited dialogue with the computer. This type of navigational advantage can be achieved in print material as well. The major impetus for accommodating many of the above mentioned aspects in CAI was the emergence of innovative technologies for presenting instructional material. This unintentionally relegated learning theories to the back seat and with them the concern for individual's preferred cognitive style. Current research in learning suggests there is a striking range of individual differences in ways students go about their learning. Individuals have their own habitual ways of representing and structuring information for learning. Claxton and Murrell (1987, p.1) state,

> *". . . studies show that identifying a student's style and then providing instruction consistent with that style contributes to more effective learning". Even though there is a general belief that students differ, this is not necessarily reflected in the design of many CAI programmes.*

Cognitive Styles

Cognitive style is an individual's characteristic and consistent approach to organising and processing information. Keefe (1979, p.4) defined cognitive style as "characteristic cognitive, affective, and physiological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment". Cognitive style needs to be distinguished from cognitive strategies; a style is considered to be a fairly fixed characteristic of an individual while strategies are methods of coping with information which are incongruent with the indiviual's preferred style (Riding & Cheema, 1991). Cognitive styles have been investigated by many researchers resulting in a myriad of theories and cognitive style types. Researchers such as Fowler (1980), Brumby (1982), and Riding and Buckle (1990) have argued that a number of different classifications of cognitive style are actually different conceptualisations of the same dimensions. A comprehensive analysis of the various labels, descriptors, classifications, and methods of assessment by Riding and Cheema (1991) led to the formation of two principal cognitive style

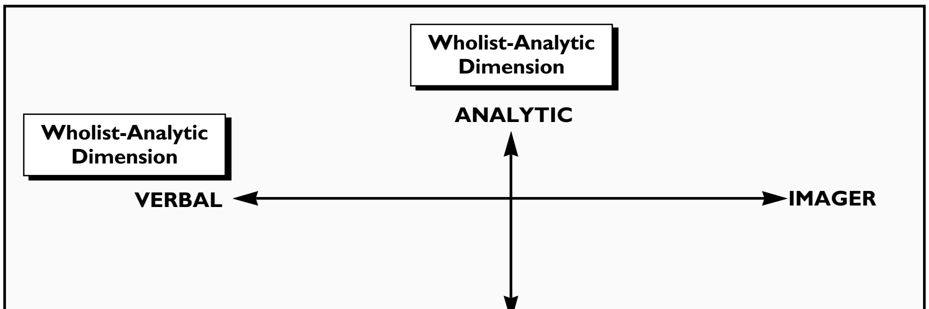

Figure 1 - The continuum of Riding's cognitive style dimensions

groups: the Wholist-Analytic and the Verbal-Imagery dimensions. These form a continuum of diametrically opposed styles for each dimension as depicted in Figure 1.

The Wholist-Analytic continuum represents individuals who tend to process information in wholes or parts. The Verbal-Imagery dimension represents individuals who are inclined to represent information during thinking verbally or in mental images. Individuals can have a single cognitive style or be bi-modal such as Wholist/Verbaliser or Wholist/Imager. The two dimensions are independent of each other in that the position of an individual on the Wholist/Analytic dimension does not affect their position on the Verbal/Imager dimension.

Cognitive Styles and Learning

Cognitive styles influence the way individuals deal with and learn information, solve problems, make decisions and respond to other people in social situations. For example, considering the Wholist-Analytic dimension, Wholists tend to organise information into loosely clustered wholes so as to construct an overall perspective of the given information. By contrast, Analytics tend to perceive information in clear-cut conceptual groupings and often focus on one of these groupings at a time (Witkin, Moore, Goodenough, & Cox, 1977).

Strengths for Wholists include their ability to see the "big picture" of a situation and therefore have a balanced view of the given information. The down side for Wholists is that they often find it difficult to separate situations into parts and become analytical. Analysts can decompose problems into separate parts and may quickly find the source of problems but they may not be able to develop a big picture of the problem, that is synthesise information. In the context of performance in learning tasks, position on the Wholist-Analytic dimension has been found to affect reading performance (Riding & Mathis, 1991), learning from structured material (Riding & Sadler-Smith, 1992), and occupational stress (Borg & Riding, 1993).

The Verbal-Imagery dimension affects the modes in which individuals represent information during thinking. They may use mental images to represent given information or use verbal representations as thoughts can be articulated in words or pictures. Verbalisers prefer information presented as words or verbal associations whereas Imagers represent information better with mental pictures of given information (see Figure 2). In terms of content to be learned, Verbalisers cope better with understanding and recall from prose passages which may contain unfamiliar information whereas Imagers learn best from passages with few unfamiliar terms and which are descriptive and illustrated (Riding & Mathis, 1991).

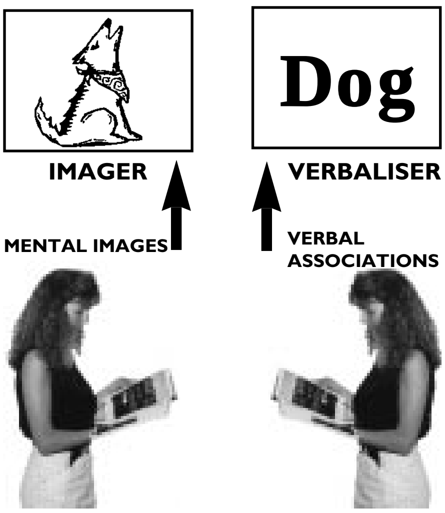

Figure 2 - Verbal and Imagery styles of processing information

All four groups can make use of either mode of representation if they make a conscious choice. Verbalisers can form mental images if they try, but it is not their habitual way of representing information. Often imagery mode is used by Analytics to acquire a Wholist view because an image can be encompassing and a whole. However, if circumstances force learners to choose modes other then their habitual ones, this would require additional processing effort. For example, in the absence of strategies to convert mismatched information to habitual modes for processing, Verbalisers will translate pictorial information into words or semantic representations and Imagers will represent semantic information in mental pictures. The effort required for such translating may not be essential for learning (Sweller, 1989) but necessary for understanding the given information prior to learning.

Sweller argues that the design of instructional material often imposes extraneous cognitive load and consequently hinders learning. The need for learners to reorient instructional material so that it is congruent with their existing cognitive styles (schema) draws on the same pool of cognitive resources used for learning. Since we have limited cognitive capacity (Halford, 1993), if cognitive resources are directed to reorganising the given information then reduced resources will be available for learning. However structuring instructional material in a manner suited to an individual's preferred cognitive style will reduce extraneous cognitive load and enhance learning.

Cognitive Styles and CAI

Most CAI programmes are knowledge-based expert systems which mimic the associated network of knowledge displayed by experts' memory systems (Jonassen, 1989). Because CAI mimics expert behaviour it limits individuals from processing information in a manner familiar to them. In view of the recent focus on individual learner's needs, the design of CAI may be lacking in some ways. Individuals deal with and respond to information in different ways and this difference affects their understanding of given information (Kolb, 1977; Dunn, Dunn & Price, 1985). Recent CAI material has endeavoured to consider individual differences in its design of instructional material by varying the sequencing of material; spacing the instruction, response, and feedback times; changing the feed-back density; and catering for access flexibility (Farrow, 1993; Jacobson & Spiro, 1994). The need to change the CAI learning environment to cater for an individual's cognitive needs as a learner was recognised in a limited way by McDaniel, McInerney and Armstrong (1993). Although there is growing interest and increasing research in adapting CAI to individuals' needs, investigation into the effect of accommodating preferred cognitive styles in instruction on learning in CAI systems comprises only a small proportion of such research. As mentioned above we know that most CAI materials model instruction based on experts' preferred cognitive styles which may be in contradiction with an individual learner's preferred style. This can significantly affect learning outcomes. Riding and Sadler-Smith (1992), Riding and Douglas (1993), Riding and Caine (1993), and Rush and Moore (1991) have found an association between cognitive style and performance using conventional instruction. They argue that optimum learning outcomes are possible when the instructional material can be transferred readily to learners' personal modes of representation. Although cognitive styles are considered an essential cognitive learning attribute in conventional instructional design they have not made an impact with CAI designers.

Since we know from research that a preferred cognitive style exists, then matching the style with the instructional format may enhance learning (Entwistle 1981; Riding & Sadler-Smith, 1992). If students can access information in a format that matches their cognitive style, then the need to reorganise information in accordance with their preferred style prior to learning is not necessary. The elimination of this step in information processing presumably reduces the cognitive load imposed by the task. We know from the work of Sweller (1989) and Halford (1993) that to enhance performance, extraneous cognitive load should be reduced. For example, Satterly and Telfer (1979) provided evidence that the use of advanced organisers helped Wholists to develop a big picture of given information rather than having to engage in search and construction processes from unfamiliarly structured information. Such a procedure may not benefit the Analytic style person who seeks detailed and highly structured information to conceptualise (Riding & Calvey, 1981). Individuals confronted with instruction which is incongruent with their cognitive style experience great difficulty in comprehending the information. In the absence of strategies to deal with mismatched information, the processing of information presumably requires search processes and means-end analysis (Sweller, 1989) which impose extraneous cognitive load and thus make the learning process difficult. This process of reorganising mismatched instructional material is extraneous to learning the information and consequently hinders learning. The findings of this study will provide evidence of learning enhancement when cognitive styles are considered in CAI design and presentation.

Research Design

The study adopted an experimental design involving eight groups and four sets of instructional material which were developed in accordance with the four cognitive styles. The groups were based on an instructional format that either matched or mismatched the individual's cognitive style. Mismatched lessons were presented according to the opposing cognitive style of Riding's (Riding & Cheema, 1991) cognitive style dimensions. For example the mismatched lesson for an Analytic cognitive style would be the Wholist lesson. Instructional format is shown in Table 1.

Computer assisted instructional material was developed for a topic from the second year nursing course - "Compartment Syndrome". All students were assessed for their preferred cognitive style using the Cognitive Style Analysis software (CSA) (Riding, 1991). Cognitive style analysis works on the basis of response times to a battery of statements which are categorised into subsets and a ratio for each subset is calculated. The first subset measures the Verbal/Imager dimension by asking conceptual and appearance recognition questions. The other two subsets in the CSA assess the Wholist/Analytic dimension. The first of these two subsets involves judging overall similarity of complex geometrical shapes. The second subset requires a degree of disembedding of simple shapes within complex geometrical figures.

Preferred cognitive style was calculated on the basis of the individual's highest measurement from the ratios of cognitive style. This was determined by finding the central point for the Wholist/Analytic ratio, which is 1.19, and the Verbal/Imagery ratio which is 1.04, as depicted in Figure 3. Following this breakdown for the Wholist/Analytic dimension, greater than 1.19 would be Analyst and less than 1.19 would be Wholist. Similarly for the VI ratio, greater than 1.04 would be Imager and less than 1.04 would be Verbal. Using these subdivisions, a student with a Wholist/Analytic ratio of 0.91 and a Verbal/Imagery ratio of 1.29 would have a preferred cognitive style of Wholist Imager. The stronger ratio for this student is 1.29 which is in the Verbal/Imagery dimension. As this is greater than the central point, the preferred cognitive style would be Imagery.

Table 1 Instructional format for each cognitive style

Cognitive Style	Matched Instructional Format	Mismatched Instructional Format
Wholist	Wholist	Analytic
Analytic	Analytic	Wholist
Verbaliser	Verbaliser	Imager
Imager	Imager	Verbaliser

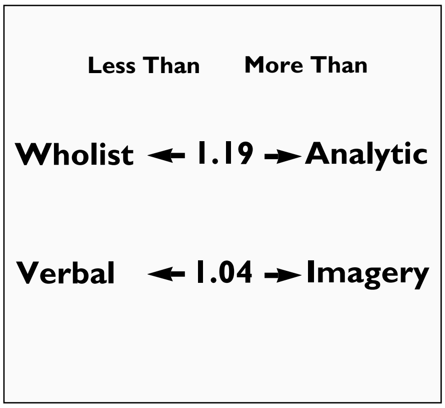

Figure 3 - Subdivision of each cognitive style according to the central points of each cognitive style dimension

A detailed discussion of the rationale for CSA design can be found in Riding and Cheema, (1991) and Riding and Douglas (1993).

Students were randomly assigned to instructional material that either matched or mismatched their preferred cognitive style. The matched and mismatched groups for each cognitive style were compared on the following performance measures: percentage correct on recall questions, sophistication of explanations, and successful problem solving skills. A final comparison of the overall difference between matched and mismatched cognitive styles was also analysed.

Sample and Procedure

Twenty-six students participated in the pilot study. The small sample size and the uneven distribution over the cognitive styles prevented the computation of any significant statistical analyses, however the results are still worth considering. The main method of data analysis was quantitative and constituted calculation of frequencies and percentages of correct responses according to instructional format and task type and comparisons of these data.

Students were tested during their normal tutorial times. They were informed about the process of working through the CSA and lesson and were then asked to log on. At the log on screen they entered their identification number, age, and gender. Having completed this they then worked through the CSA, which takes approximately 15 minutes, and depending on the result were defaulted to instructional material. They had no control on choice of instructional material. Students studied the lesson, taking as long as they needed, then proceeded to the test phase. Once in the test phase they could not return to the instructional material. The whole process took approximately 45 minutes per student. Responses to test items were recorded on a data file and analysed later.

Material

The topic "Compartment Syndrome", from the second year nursing programme, was used for the study. The content material was structured for the four cognitive styles using Toolbook 1.53 programming software. All instructional formats had the same subject content. The experiment material was put on the network in an undergraduate computer lab.

Differences in presentation of the four instructional formats is apparent. The advance organiser for the Wholist lesson contained information about the entire lesson, while the advance organiser for the Analytic lesson was fragmented and contained information relating to specific parts of the lesson. This exemplifies the difference for the Wholist style of learning in that people of this type learn best when presented with an overall conceptual structure while Analytic learners require smaller groups of information which they subsequently piece together as a whole.

The Imager advance organiser is the only one that includes a graphical depiction of the information while Verbalisers are the only ones presented with sentence structure in their advance organiser. Analytics viewed bullet points of this information and Imagers saw diagrammatic representations. The Wholist screen contained more than just this section of information as it also moved onto neurovascular assessment, thus allowing students of this preferred cognitive style to develop a "big picture" of the given information.

As each lesson, except the Verbal, contained diagrams throughout, it was necessary to make a distinction between the groups regarding the inclusion of diagrams. For example, Wholists received a complete presentation of the components of a compartment, a diagram showing the compartments, what compartment syndrome is, as well as information regarding the location of compartments. Analytics were presented with three separate screens containing this information. This also included graphical depictions but they were of the separate components of a compartment, rather than the overall view of a compartment that the Wholist lesson contained. Thus they viewed step-by-step, rather than complete, information. Verbalisers, because they represent information during thinking in words (Riding, Glass, & Douglas, 1993), were presented with sentences containing the same information while Imagers had a single diagram that featured prominently in this section. Thus consideration of the requirements of each cognitive style is clearly evident in each lesson.

Results

Each cognitive style group, whether matched or mismatched, was presented with identical test items. Recall items were based on statements requiring a true or false response, listing specific terminology, and multiple choice questions. The explanation item required synthesis of details relating to the components of a 'compartment'. For the problem solving task, students were presented with a description of a situation involving 'compartment syndrome' and were to determine what manifestations of 'compartment syndrome' might be evident and outline procedures for further assessment of the situation.

Students' responses to the test items were recorded and compared. Performance between matched and mismatched instructional groups on all sub-tasks and for each of the four cognitive styles indicated that when Wholists and Analytics received matched instruction they did better than when these groups were mismatched. The mismatched Verbaliser cognitive style group performed better in two of the three sub-tasks. The Imager group did not have any students presented with the mismatched instructional material thus making it impossible to compare. A summary of these results are shown in Table 2.

Task	Wholist		Analytic		Verbal		Imager	
	Matched (n=2)	Mismatch (n=9)	Matched (n=7)	Mismatch (n=2)	Matched (n=1)	Mismatch (n=1)	Matched (n=4)	Mismatch (n=0)
Recall	71%	66%	74%	68%	57%	935	68%	-
Expanation	100%	66%	71%	0%	100%	0%	25%	-
Problem Solving	33%	30%	43%	17%	)%	100%	58%	-
Total Correct	66%	60%	69%	55%	50%	88%	64%	-

Table 2 - Percentage correct for each task type according to matched and mismatched instructional format for each cognitive style

In light of the small sample size for each cognitive style, the above table was collapsed to show total effect between the matched and mismatched groups. A comparison of the total sample revealed the matched group achieved a higher percentage of correct responses for each task type than the mismatched group (see Table 3). An analysis of the task types showed the largest difference between matched and mismatched groups was for the sub-task explanation problems (14%) followed by problem solving (10%) and finally recall problems (2%).

Discussion and Conclusions

CAI design is gradually becoming more sophisticated and increasingly popular as an instructional medium. The acceptance and implementation of CAI must however proceed with caution as often it is nothing more than an electronic page. Issues such as increased accessibility in CAI design is often limited to providing greater opportunities for learners to get physical access to this medium. However recent literature in cognitive science suggests that there may be another dimension to accessibility, that is cognitive accessibility, which helps learners in processing information and acquiring understanding. One way of addressing cognitive accessibility is by designing instruction in a manner that matches the learner's preferred way of processing information. The results of this study suggest that by structuring instructional material in accordance with preferred cognitive style, learners may be able to comprehend instruction better. Thus the design of CAI needs to consider learning variables such as preferred cognitive style as identified by recent research in cognition and learning.

Although this study must be regarded as tentative, due to small sample size and its unequal distribution over the cognitive style groups, the results did reveal some interesting findings when CAI is designed to match the learner's preferred cognitive style. A comparison of performance when the cognitive styles were collapsed into matched and mismatched groups indicated that if CAI material was matched to individuals' preferred cognitive style, students tended to perform better (66%) than those who received mismatched instruction (62%). Although this was not statistically significant, the results are in accord with the argument presented by Claxton and Murrell (1987) (using conventional instruction) that learning can be enhanced by matching the instruction to individuals' preferred cognitive style. This pilot study provides preliminary information to suggest that there may be an interaction between CAI and individuals' preferred cognitive style. Further research needs to be undertaken to confirm this finding.

The better performance by the mismatched Vebalisers (who received an Imager lesson) may be due to variance caused by the type of information. Riding

Task	Percentage Correct for Matched Instruction (n=14)	Percentage Correct for Mismatched Instruction (n=12)
Recall	71%	69%
Expanation	64%	50%
Problem Solving	43%	33%
Total Correct	66%	62%

Table 3 Percentage correct for each task type according to matched or mismatched instruction

and Douglas (1993) argue that verbal descriptive information which is easier to visualise can be recalled easily by Imagers. For example, in architecture it is difficult to imagine a house design in terms of verbal statements. Thus the nature of subject matter may also influence the manner in which individuals process information. In the case of the verbaliser group in this study, it is plausible to suggest that the nature of the information favoured Imager style and hence the mismatched group performed better. Support for the above contention has also been raised by Riding and Caine (1993).

The other interesting finding was the response to each sub-task. The Wholists may be better at explanation type problems which generally require a big picture of the situation. Students had to synthesise information from a number of screens in order to construct a suitable explanation. The use of advance organisers seemed to assist Wholists to make links between the various pieces of within and across screen information and develop an understanding. The Analytics appeared to perform better in the problem solving task. This may be attributed to their ability to decompose and analyse the details of problems. This aspect of the analysis needs further investigation to find the effect of task type on preferred cognitive styles.

In conclusion, the results of this research are interesting. They concur with findings from similar studies conducted with conventional instruction. However, when considering CAI design, further work with a larger sample needs to be undertaken. The study is now being extended to include a larger sample in order to obtain stronger evidence to support the findings and make firmer conclusions regarding CAI design. As we near the 21st Century and technology is becoming increasingly apparent in our daily lives, it would seem that methods of teaching of the current century have become outdated. To educate students in the same way that occurred prior to the technological innovations of today is to ignore the vast opportunities available that enhance instructional methods and learning.

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