Cognitive Styles and Computer Aided Learning (CAL): Exploring Designer and User Perspectives.

Stephanie Atkinson
University of Sunderland
UK

Introduction

The information revolution of the past twenty years has transformed society, business and culture, placing preeminence on the ability to access and use information (Rice, 1995). Across the globe in an educational context, government and private sector initiatives have led to an unprecedented rapid injection of computer based technologies into school systems. For example, in America, Clinton's Technological Literacy Plan provided two billion dollars over a five year period for the development of Information Technology in schools (Whitehouse, 1996). In the UK, the Government's manifesto pledged to set up a National Grid for Learning (Government Consultation paper 1997, 1998). It has since supported this commitment with substantial funding programmes, in the Stevenson report (Blair, 1996) and in various Department for Education and Employment (DfEE) documentation (e.g.. DfEE, 2000). The latter stated that the UK Government was fully committed to ensuring that all schools and teachers were in a position to deploy new information and communication technologies (ICT) to raise standards, enhance learning and prepare young people with the ICT skills they would need in society and at work in the 21st Century [1]. This paper is particularly concerned with exploring the area of enhanced learning in the context of ICT. Within this framework Computer Aided Learning (CAL), cognitive style and effective learning will all be discussed from the perspective of the designer and the user of such learning materials. The review of existing literature will be carried out to investigate the author's belief that there is a need to research the relationship between the cognitive styles of the designers of CAL materials and the cognitive style of those who wish to learn using CAL materials.

Background

The design of educational software that would support pupils in developing ICT skills has been prolific. However, the variety of educational settings in which the software has been found has been disappointingly limited. NCET (2000) in their report evaluating Integrated Learning Systems in the UK provided evidence to suggest that too often CAL has been used only for remedial work, whilst an analysis conducted by Boucher, Davis, Dillon, Hobbs & Tearle (1997) suggested that the majority of subjects using CAL tended to be ones where: routine or mechanical skills played an important role; the knowledge component could be precisely defined; there was a well-defined professional base.

The pedagogical advantages of CAL have all been well researched (e.g. Alexander, 1995; Ford, 1999; Lee, 1999). Benefits have been reported in terms of individualised learning that can be self paced, self accessed, asynchronised, synchronised or in real time

[1] In this context ICT skills refer to a pupil's ability to use word-processing, data base and spreadsheet software through to the use of sophisticated computer presented information retrieval mechanisms and learning systems.

modes, provide non-sequential based delivery, include positive motivational interactive features, whilst affording access to more accurate appraisal and documentation of learners' progress. The hope that ICT will deliver more cost effective teaching and learning has also played a significant role in its development (Somekh, 1998). However, there have been expectations without due regard to the difficulties that are an inevitable part of any technological innovation in education. Disadvantages have been cited (e.g. Mak, 1995; Ferris, 1999) particularly in terms of the technical support needed, and the lack of training for teachers to exploit the potential of this technology (Oliver, 1997). In the context of the CAL materials themselves, the non-linear nature of the information provided, the absence of personal contact and clarity of message due to the nonexistence of physical presence, voice intonation, gesture and other tacit cues (Harasim, 1998; Moore, 1992), together with the difficulty in conveying humour, irony and subtle nuances of meaning (Feenburg, 1998) have all been shown to be disadvantageous for certain types of learner.

Computer Aided Learning

The term's hypertext, hypermedia, and interactive multimedia have each been used interchangeably to describe CAL delivery. Text, graphics, audio, video, and animation all make up the form and functional elements of CAL materials. Regardless of the term, the concept has best been understood as the merging of formally separate media in a manner that has allowed associations or links between the various elements (Ebersole, 1997).

The flexible nature of CAL materials has been highlighted as one of its prime advantages over traditional learning materials. Steuer (1992) explained that two principal features of such materials were the non-linear organisation of information and the ability of the user to interact with and under certain circumstances modify the form of the materials to be learned. Additionally, research has indicated that the hierarchical linking arrangements that facilitate browsing could also act as an aid to learning. However, the advantage of the non-linear organisation of information has also proved to be a distinct disadvantage for some learners. Edwards and Hardman (1989) suggested that the complex structuring arrangement could create a greater potential for users to become disorientated with an inevitable adverse effect on learning. Such structures suffer from a lack of what Gygi (1990) called 'discourse cues': these being a set of commonly understood indications about how information is organised (e.g. 'chapters' and 'sections'). As these do not exist in CAL materials users have to make more Meta level decisions regarding how to proceed than when using more traditional means of learning. For many, the interface employed at present is confusing and opaque. Shum (1990) stated that there was a need to reduce cognitive overload for the user by designing a better system of cues or cognitive maps that would aid the user's navigation through the CAL materials and thereby help to refute claims that CAL materials are only suitable for certain types of learning.

Media cognition, the study of the mental processes engaged by interaction with various forms of media, has been a topic of great interest to psychologists, sociologists, educators, communication theorists, and media practitioners during recent times (Ebersole, 1997). Much research into traditional media has been conducted in the areas of perception, sensory stimulation, memory and recall, and media effects. The media covered have been newspapers, magazines, film and television (e.g. Garcia & Stark, 1991; Utt & Pasternack, 1989; Bandura, 1994; Graber, 1990; Grimes, 1990; Reeves and Anderson, 1991). However, because of the relatively short history of computer based

interactive, non-linear, multi-sensory, digital multimedia, research into the cognitive processes used by individuals when using such materials has been limited.

Ebersole (1997) has described designing effective interactive media as a daunting proposition. He explained that in addition to the collection and organisation of useful content the interactive multimedia designer must create a user interface that facilitated access to the content. He, Recker (1995) and Lord (1998) all believed that learning materials needed to be crafted with careful attention to the mental processes and learning style that the user was likely to employ.

Cognitive Style

The terms learning style or cognitive style have been widely used by educational theorists for the past sixty years. Terminology has varied from writer to writer (Curry, 1983; Riding & Cheema, 1991) although, many (e.g. Witkin et al, 1971; Goldstein and Blackman, 1978; Tennant, 1988; Biggs & Moore, 1993; Riding & Pearson, 1994) have agreed that cognitive style is a distinct and consistent way for an individual to encode, store and perform, and one that is mainly independent of intelligence.

Armstrong writing in 1999 expressed the commonly shared view that cognitive style differences between human beings were possibly due to differences in left/right hemispheric specialisation of the brain. Eminent research studies (e.g. Sperry, 1964; Luria, 1966; Bogen, 1969) during the 1960s demonstrated that the left cerebral hemisphere specialised in primarily analytic, rational and sequential information processing and the right cerebral hemisphere specialised in primarily intuitive, holistic, and simultaneous information processing (Armstrong, 1999). Whilst some researchers (e.g. Rao et al, 1992) now regard this split brain formulation to be an oversimplification of the facts, others (e.g. Languis & Miller, 1992) continue to report evidence consistent with this theory.

As the relevant research base into cognitive style has developed so have the number of terms used to describe cognitive style groupings. In 1984 Messick identified nineteen different labels referred to as cognitive or learning style. In research published by Riding and Cheema in 1991 they presented over thirty such classifications. By 1999 Armstrong, in a search of the relevant literature, identified fifty-four dimensions on which cognitive style had been differentiated.

Riding and Douglas' (1993) analysis of the multiplicity of constructs concluded that the terms could all be grouped into two principal cognitive styles and a number of learning strategies. They referred to these cognitive style dimensions as a Wholist-Analytic Cognitive Style Family, and a Verbalizer-Imager Cognitive Style Family. The Wholist-Analytic style was defined as the tendency for individuals to process information in wholes or in parts, while the Verbaliser-Imager style was defined as the tendency for individuals to represent information during thinking verbally or pictorially.

Many notable investigations have been carried out concerning the relationship between cognitive style and ability. Researchers have agreed that cognitive styles are different from intellectual ability (e.g. Witkin, Moore, Oltman, Goodenough, Friedman, Owen & Raskin, 1977; Sharma, 1986; Riding and Cheema, 1993). Messick (1984) reported in Armstrong (1999) explained that intellectual ability referred to what kind of information was being processed, by what operation, in what form and how well, whereas cognitive style referred to the manner or mode of cognition - to the question of how. Witkin et al (1977) differentiated between the two by emphasising the bi-polar nature of cognitive styles, unlike intelligence and other abilities. They suggested that each pole of cognitive style had adaptive value under specified circumstances, whereas to have more of an attribute such as intelligence was better than to have less of it. This difference was

well defined by Riding (1996). He explained that the basic distinction between cognitive style and ability was that performance on all tasks would improve as ability increased, whereas the effect of style on performance for an individual would either be positive or negative depending upon the nature of the task. This would indicate that for an individual at one end of a style dimension, a task of a type they found difficult would be found easier by someone at the other end of the dimension, and visa versa.

Another important relationship to be researched has been the connection between cognitive or learning styles and teaching styles (e.g. Entwistle and Ramsden, 1983). Dunn and Griggs (1989) claimed that learning styles were the biologically and developmentally imposed set of characteristics that made the same teaching method wonderful for some and ineffective for others.

Effective Learning

When considering effective learning, one cannot ignore the importance of such factors as a learner's: intelligence; prior knowledge of the subject domain; level of motivation; anxiety; self-confidence; and the amount of learner control offered (Valley, 1997). However recent research would suggest that of paramount importance with regard to this issue is an individual's preferred learning or cognitive style (e.g. de Corte, 1990; Riding & Rayner, 1998). Riding and Read (1996) pointed out that the nature of school subjects and a pupil's ability interacted with the relationship between style and learning format preference. They also explained that more able pupils were better able to mediate the effects of style attributes than were less able pupils, particularly when teaching strategies were restricted[2]. Bahar & Hansell (1999) believed that when individuals were confronted with new information, they had different ways of selecting, perceiving and processing that information. They suggested that this was related to what learners already knew, and their style of learning.

In addition to the style of learning, individuals have been shown to adopt different approaches to their studying. Influenced by the work of Marton and Saljo (1976), Entwistle and Ramsden (1983), referring to students in higher education, identified them as deep or surface learners. They explained that students who engaged in a task with the intention of understanding or seeking meaning adopted a deep approach whilst those whose intention was to memorise the information adopted a surface approach. Alexander (1995) believed that if it was important for learners to understand rather than memorise then it was important to think of the kind of learning strategies that could be adopted to encourage this approach. She believed that CAL had the potential to provide such approaches although she questioned to what extent learners would have the ability to acquire the original author's structure and map it on to their own learning style.

In a traditional teaching situation the teacher can monitor an individual's learning. The way in which teaching materials have been presented can be adjusted by the teacher if it becomes evident to them that understanding of the content has not been achieved. The form of those changes will generally arise out of the teacher's ability to 'read' the situation, their knowledge of the learner and their portfolio of teaching strategies. Combinations of these factors have enabled teachers to provide appropriate action for the individual learner in any given situation. In present computer environments it is mainly the learner who must take on this responsibility for themselves (Steuer, 1992). They must decide how best to work they're way through the materials provided. For many learners this has been shown to be problematic (Recker, 1995; Ebersole, 1997). Learners

[2] The inference one could make from this would be that more able learners are better able to cope with poorly designed courseware.

have been seen to waste valuable time navigating an erratic course through the complex structure of the materials provided for them (Shum, 1990).

The Learning Environment

This leads us comfortably into an exploration of the importance of the design of a learning environment. Reiber (1992) specified that when designing new learning materials consideration should be given to: providing a meaningful learning context that supported, intrinsically motivated and self-regulated learning; establishing a pattern whereby the learner went comfortably from the known to the unknown; providing a balance between inductive and deductive learning; emphasising the usefulness of errors; anticipating and nurturing incidental learning.

With specific reference to CAL, Handy, Gordon & Gow (1988) stated that CAL material that failed to appreciate the needs of the learner hampered improvement in learning. Whilst other research into learning in a CAL environment was more specific, suggesting that the way in which information was structured (Clark and Craig, 1992; Alexander, 1995; Bahar & Hansell, 1999) and presented to learners' (Molich & Nielson, 1990; Ford, 1999) affected the quality (Armstrong, 1999) and durability of what was learnt. Carswell (1998) believed that all too often technical expediency rather than pedagogical considerations drove the design of CAL materials. Paterson and Rosbottom (1995) suggested that there was a need for a change of emphasis from instructionalist programmed learning to constructivist 'intelligent tutoring' CAL approaches. Ford (1999) referred specifically to the importance of cognitively well designed learning environments. He believed that a key feature of this was the notion of cognitive ergonomics.

> *"...just as an ergonomically designed chair is well adapted to the physical requirements of its user, so a cognitively ergonomic learning resource is well adapted to the learning requirements of its user" (Ford, 1999, p188)*

Nielson (1990) referred to the *'look and feel' (p.4)* of CAL materials using such terms as 'overhead' and 'cognitive load' to describe the users experience within a CAL environment. Conklin (1986) spoke of the negative effect of cognitive overhead which he described as *'the additional mental overhead required to create, name and keep track of links' (p 40)* within interactive multimedia. Wright (1993) used the term cognitive 'bottlenecks' to explain the overload that he proposed could be the result of the multi-modal processing inherent in multimedia presentation systems.

Salmon (1979) suggested that the translation from external symbol to internal mode required different mental skills from those used when learning from traditional teaching materials. He believed that the increase in mental resources required for re-coding palatable multimedia materials could result in a decrease in comprehension of those materials.

In a traditional, teacher led, paper-based environment, learning in matched conditions (in which the instructional style is matched to the students' preferred learning styles) has been demonstrated to be significantly more effective than learning in mismatched conditions in many instances (Pask & Scott, 1972; Ford, 1999). Research findings have indicated that this was especially the case for young pupils and those of low ability, particularly when the task was complicated and the material was difficult. On the other hand for more able pupils mismatching learning materials to cognitive style has been shown to be advantageous as it has encouraged pupils to develop learning strategies that could cope with a wider range of materials and experiences in the future (Riding and Rayner, 1999).

In the context of CAL environments, Ford (1999) suggested that it would be tempting to think that the potential navigational freedom inherent in such systems meant that mismatched education was a thing of the past. However, his research findings indicated that this was not the case. He explained that the potential for navigational freedom was frequently not recognised by the learner nor were they always able or willing to use such freedom optimally, or even effectively, in relation to their preferred style of information processing.

Academic work in schools has traditionally become increasingly verbal, both in the manner in which it has been presented and in its content, as pupils have progressed up through their secondary school career. Guidance produced for teachers to support the introduction of the National Curriculum reflected this emphasis both across subject boundaries and key stages (NCC, 1989; NEAB, 1993). This was shown to have unfortunate consequences for those pupils whose cognitive style preference was towards processing information using images rather than verbal means (Atkinson, 1998). Research would suggest that CAL has the potential to ameliorate this to some extent as materials can be presented in a variety of forms thus being more sensitive to style differences.

An analysis of various learning style inventories has indicated an assumption that an identified learning style would hold good whatever the learning context. Researchers (e.g. Riding and Cheema, 1991; Cousin & Davidson, 1999) speculated that using Honey and Mumford's (1992) model of learning preference (Activist; Reflector; Theorist; Pragmatist[3]) active experimenters would be the group most comfortable with CAL. However, McKenzie, Rose and Head's (1999) findings concerning computer supported co-operative learning indicated that Theorists showed the strongest preference for computer aided learning. Activists they found were initially enthusiastic users, but they became bored by the novelty value and reduced their usage over time, whilst the lack of the immediate dynamic of the real classroom caused frustrations for strong Pragmatists.

Using Kolb's Learning Style Inventory that classifies learners as Accomodators, Divergers, Assimulators and Convergers[4] Lord (1998) found that there was a preponderance of Accomodator and Diverger styles among low achievers in CAL environments when testing students in Higher Education.

Using Riding's model of a Wholist-Analytic cognitive style dimension Graff (1999) found that Wholists benefited from computer-based instruction if the mode of delivery provided an organisational aid to learning. By contrast, when the material was less structured, and the learner must provide organisation, then such an environment favoured Analytics.

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[3] 'activists' - enjoy new experiences, engaging in activity, intuitive decision-making & group-work, but dislike administration or the implementation of procedure
'theorists' - focus on ideas, logic, generalisations and systematic planning, but mistrust intuitive insight or social/emotional involvement
pragmatists - enjoy group-work, discussion, debate, risk-taking and practical applications which get results, but avoid reflection, observation and levels of deeper understanding
'reflectors' - focus on understanding meaning, observe and describe process or predict outcome, and are concerned with the 'what is' rather than the 'how' in any directed activity
(taken from Riding and Rayner, 1998)

[4] 'accomodators' - dominant learning modes of concrete experience and active experimentation
'divergers' - dominant modes of concrete experience and reflective observation
'assimulators' - dominant modes of reflective observation and abstract conceptualisation
'convergers' dominant modes of abstract conceptualisation and active experimentation
(taken from Lord, 1998).

Although terminology used to describe groups of learners has differed between the various cognitive style models, each author has identified comparable, crucial character differences between each category of learner. In the context of CAL, for maximum benefit to learners, it would seem that individualised presentation and order of delivery based on learning style should be at the forefront of criteria used by the designers of such learning materials.

It is also the case that there is strong evidence to suggest that cognitive style is a distinct and consistent way for individuals to encode, store and perform. Therefore it would seem to be appropriate to assume that the learning style of the designer of CAL materials may influence the way in which they design their CAL environments.

Conclusion

The information revolution of the past twenty years has transformed society, business, culture and education across the globe. The potential benefits of utilising CAL for teaching a wide range of knowledge, skills and understanding have been recognised. Although evidence would suggest that in practice its use has tended to be limited to remedial activities or to subjects where routine or mechanical skills played an important role; the knowledge component was precisely defined; or where there was a well-defined professional base.

Despite advances in the understanding of both the pedagogical advantages and disadvantages of CAL and the development of sophisticated teaching and learning paradigms there is still concern at the way in which CAL materials are presented to the learner (Dillon, 1998). Whatever the context or content of the CAL materials, one of the fundamental issues that the literature has identified is that such materials enhance learning for some rather than for all users.

Navigation through CAL materials and the form in which they are presented to the learner have been identified as important stumbling blocks for many users. Disorientation, frustration and even disaffection when using CAL materials have all been evidenced. The advantage of matching the presentation of learning materials to the user's cognitive style, particularly for the young and the less able of all ages, has been highlighted in several studies.

As the literature has established that one's cognitive style is consistent and influences how one codes, stores and performs it is possible that the cognitive style of the designers of CAL materials could influence the form of the learning materials that they present. That being so it follows that, whether one is a learner using CAL materials or the person designing those materials there could be an interaction between the cognitive styles of the two people involved. The study of the literature would indicate that this relationship has not been researched.

It is therefore now the aim of this researcher to design and carry out a project that will establish the relationship between the cognitive style of the designer of CAL materials and the learner; see if matched or mismatched learning styles affect task engagement and achievement in the context of CAL materials; find out if any one learning style is more adaptable to learning using mismatched CAL materials. It is intended that an analysis of the results of this research will provide a list of factors that need to be taken into account by the designers of CAL learning materials. Factors that will enable them to design materials that will enhance the learning environment for all users rather than just some users, which has been found to be the case at present.

Correspondence: Dr Stephanie Atkinson, School of Education, University of Sunderland, Hammerton Hall, Gray Road, Sunderland SR2 8JB. e-mail: stephanie.atkinson@sunderland.ac.uk

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