Metacognition and the Autonomous Learner: Student Reflections on Cognitive Profiles and Learning Environment Development

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Abstract: *This paper considers the role of metacognitive skills in the development of autonomous learners. This is done by considering the use of student cognitive profiles for constructing interfaces for interacting with learning environments. For the purposes of this study, a cognitive profile is considered to consist of measures of an individual's cognitive style, learning style and personality. Student awareness of the learning process has become increasingly relevant with the shift of emphasis towards active learning. The need for students to become more actively involved in the management of their own learning implies an associated need for each student to be more metacognitively aware of his or her personal resources. It is suggested that each student has a cognitive profile which could help the individual develop his or her learning skills and strategies in the light of useful self knowledge. Elements of student cognitive profiles were used for reflection and to inform the design of web-based interfaces to learning resources. Computer-based and self report tests were administered to a group of 64 Human Computer Interaction students. The results of the study are considered and conclusions drawn on their relevance to individual approaches to learning and the design of interfaces for learning environments*.

Keywords: cognitive profile, learning environment, interface design

Introduction

A gap has emerged between the model of student learning in higher education being proposed (active, resource-based, student-driven learning) and the experience of many students and lecturers. A continuing problem with the current scenario in higher education is that while there may have been a much expanded student intake and a move to a mass system, many of the processes and practices in use are those developed for an instruction-based elite system. While many of the processes and practices developed are and will remain useful and relevant, we have to ensure that those in use are suitable for functioning effectively within the resources and constraints of a mass system. Some central processes and practices (forms of assessment, tutorials which functioned effectively with eight participants but struggle with sixteen to twenty, personal tutoring) are increasingly under-resourced and under strain. In addition, a perception has developed, especially amongst higher education managers, that the provision of information and communication technologies will, *by themselves*, provide useful and cost saving solutions. This approach often misses the point that the learning systems we are concerned with are social

systems of which technology is only one aspect, often acting simply as an information carrier or interaction enabler.

Several writers (Tait & Knight, 1996;Goodyear, 2000) have discussed the concept of independent learning and the emergence of the *autonomous* learner. Goodyear in particular concerns himself with the question of *"How we should approach the design of learning environments that are consistent with the needs of autonomous life long learners"* (Goodyear, 2000). It can also be argued that the autonomous learner needs to be metacognitively aware while Phelps et al (2001) make the connection between metacognition and the concept of the expert learner. Metacognition can be described as thinking about thinking. A more comprehensive definition was provided by Flavell (1976) who suggested that:

"Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g. the learner-related properties of information or data. For example, I am engaging in metacognition if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact."

In a study concerning the potential role of reflective learning and metacognitive processes in the development of capable and competent computer users, the authors came to the conclusion that *"Reflection and metacognition is central to the development of 'expert learners' and thus can be seen to provide a sound framework for the development of 'capable' computer users."* (Phelps et al, 2001). One aim of this study was to increase student awareness of their own learning resources via metacognitive processes and investigate the effects of this awareness on the design and completion of a personal learning environment.

A model (Sadler-Smith, 1996) has been adopted which itself was derived from Curry's "Onion Model" of individual differences (Curry, 1983) and which attempts to define and show the relationship between personality, cognitive styles, learning styles and learning strategies. These elements make up an individual's cognitive profile. The core of the model represents the individual's "central personality dimension" with the next layer being cognitive style. Between cognitive style and learning strategies lies learning style. The outer layer is that of learning preferences where the individual has a general preference for one specific mode of learning over others. Three well known and reliable measures, Richard Riding's Cognitive Styles Analysis, Entwistle's Approaches to Study Inventory and the Myers-Briggs Type Indicator were used to develop the cognitive profile. The results were then used by students to help develop a simple prototype Individual Learning Environment (ILE - basically a personal website) organised around the units they were studying. Elements of the cognitive profile were used to help inform the design and development of the ILE.

Measures

Cognitive Style can be defined as "an individual's preferred and habitual approach to organising and representing information." (Riding and Rayner, 1998). 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 reflected a continuing problem with the quasi-experimental and quantitative approaches used in that the results often found no significant relationship

between the material presentation/interface style and learning. 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. 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 his or her cognitive profile and the interface development process.

The following three tests were selected based on empirical evidence of their validity and reliability as measurements and constructs.

- Cognitive Styles Analysis (Riding, 1991) - a 15 minute computer-based test which measures personal preferences for representing and processing information.
- Approaches and Study Skills Inventory for Students (ASSIST) (Tait et al., 1998) - aims to measures deep, surface and strategic approaches to learning in addition to other categories of learning.
- Myers-Briggs Type Inventory (Myers et al., 1999) - a well known management and educational tool for classifying personality type and which can also be used to measure cognitive style. Although there has been and continues to be a debate on the reliability of the MBTI (Nowak, 1996), its widespread use in HE studies and close connection to measures of cognitive style (Scholl, 1999) led to it being adopted.

Computer-based and self-report tests for each of the above measures were administered to a group of 64 students participating in a Human Computer Interaction unit.

Cognitive Styles Analysis (CSA)

This measure of cognitive style is central to the study as it deals directly with the form and content of the information which each individual processes. In addition, its development (Riding & Cheema, 1991) was based on an extensive review and consolidation of many other measures. The two cognitive style dimensions 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)
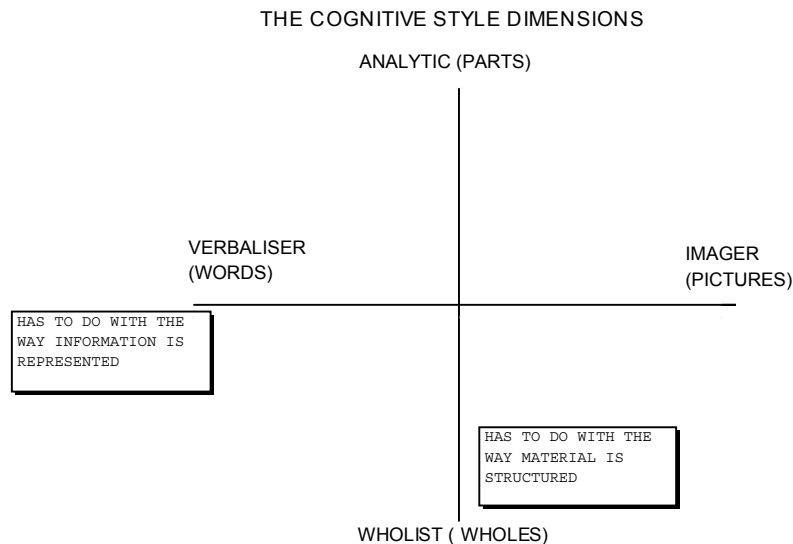
THE COGNITIVE STYLE DIMENSIONS

ANALYTIC (PARTS)

VERBALISER
(WORDS)

IMAGER
(PICTURES)

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HAS TO DO WITH THE
WAY INFORMATION IS
REPRESENTED
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HAS TO DO WITH THE
WAY MATERIAL IS
STRUCTURED
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WHOLIST (WHOLES)

Figure 1: Cognitive style dimensions (Riding, 1991)

Approaches and Study Skills Inventory for Students (ASSIST)

ASSIST is developed from the earlier versions of the Approaches to Study Inventory (Tait et al., 1998). The main section of ASSIST consists of a self-report questionnaire. It measures approaches to learning on three main scales - deep, surface and strategic. Each of the main scales is comprised of several sub-scales:

Deep: seeking meaning; relating ideas; use of evidence; interest in ideas
Strategic: organised study; time management; alertness to assessment demands; achieving; monitoring effectiveness
Surface/Apathetic: lack of purpose; unrelated memorising; syllabus boundness; fear of failure

**Myers-Briggs Type Indicator (MBTI*)*

The Myers-Briggs Type Indicator (MBTI) is developed from the work of C. G. Jung and his theory of psychological types (Jung, 1923). Myers suggested 16 basic personality types which were created by the combinations of the elements of the four main scales (Myers and Myers, 1980):
Extraversion (E) and Introversion (I)   Sensing (S) and Intuition (N)
Thinking (T) and Feeling (F)   Judging (J) and Perceiving (P)

The results of an individual's MBTI assessment give a provisional type such as ENTJ, ISFP or ESFJ - i.e. the type is composed of one element from each of these pairs of preferences. This measure is widely used in educational and managerial research (Hammer, 1996).

Method

64 students completed the study. The tests and data collection procedures were an agreed part of the course content of a human computer interaction unit. The assessment procedures were designed to allow further data collection via reflective journals and the development and

documentation of the Individual Learning Environment. The cognitive style, learning styles and personality indicator measures were considered to be part of the process of user modelling for HCI and interface design.

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 of an ILE 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 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 sources (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 functional 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. Other 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.

Results

Cognitive Style (CSA)
The figures for the CSA is a simple frequency count for each of the four main classifications. The cognitive styles were distributed in the following manner:

Style	Frequency	Percentage
Analytic-Imager	21	32.8%
Analytic-Verbaliser	16	25.0%
Wholist-Imager	10	15.6%
Wholist-Verbaliser	17	26.6%
Total	64	100.0%

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 (32.8%). Also,

while the verbaliser and imager categories are almost evenly split between the group (51.6% and 48.4%), there are more analytics than wholists (57.8% and 42.2%).

Learning Style (ASSIST)
The frequencies for ASSIST reflect the sequence of the strength of the scores for the three learning styles - deep (D), strategic (S) and surface/apathetic (A). ASSIST returns a score for each of the styles and these were converted to percentage scores to indicate a sequence from most dominant to least dominant.

Sequence	Frequency	Percentage	
ADS	7	10.9%	D = Deep
ASD	3	4.7%	S = Strategic
DAS	8	12.5%	A = Surface/Apathetic
DSA	27	34.4%	
SAD	3	4.7%	
SDA	21	32.8%	
Total	64	100.0%	

The three learning styles have been put in sequence from most dominant to least dominant style. The two categories Surface-Apathetic/Deep and Deep/Strategic comprise the largest groups in the sample with 33% and 34%. However, although the largest single Surface-Apathetic category contains only 11% of the sample, the number of students having the Surface-Apathetic category as either the dominant or second dominant style comprises almost 33% of the total.

Personality (MBTI)
The MBTI "dichotomous frequencies" indicate the distribution of the 64 participants on each of the four main dimensions outlined above.

Dimension	Frequency	Percentage
Extroversion(E)-Introversion(I)	30(E) – 34(I)	47%(E) - 53%(I)
Sensing(S)-Intuition(N)	35 – 29	55% - 45%
Thinking(T)-Feeling(F)	49 – 15	77% - 23%
Judging(J)-Perceiving(P)	29 – 35	45% - 55%

The dichotomous frequencies for the MBTI, which indicate the overall distribution of the population along each main dimension, show that for three of the categories - E/I, S/N and J/P - the distributions are almost even. The remaining category, T/F shows a strikingly different pattern with almost four out of every five student taking the unit being classified in the thinking category rather than the feeling category. This may well reflect the nature of the subject area and its perception by the student body.

Student comments

A large number of student comments and qualitative data were sought and received via various methods. Reflective journals were used to facilitate reflection on each individual's cognitive profile. Interface documentation described the design and development process of the ILE and again related it to elements of the cognitive profile. This material is organised by

cognitive profile element. Some journal reflections are first presented in each case, followed by descriptions of how each measure might have impacted on the design process for the ILE.

Cognitive Style (CSA) -Reflection
The students found the CSA to be an accurate measure of their cognitive style as described and discussed in class and the readings. The reflective journal comments below are but a small selection of those which often showed students to be at least partially aware of their different cognitive styles, but lacking a framework in which to place and discuss, related issues.

"*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.*" **(wholist-verbaliser)**

" *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.*" **(analytic-imager)**

"*(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"* **(analytic-verbaliser)**

Cognitive Style (CSA) –ILE development
Participants were especially able to use the cognitive style measure to influence the design of the ILE. This was because, as it gave measures of their supposed preferences for the format and content of information, there was a direct link to the design process that required little further reflection. There was a drawback to this in that some students took the classifications to be absolute rules rather than preferences or guidelines with which they were able to agree or disagree.

" *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 ie. by means of the top frame. This frame acted as an overview that could be referred to at all times.*" **(analytic-imager)**

"*I received an Analytic score of 2.24 and a Verbal score of 0.89. More so an analytic than a verbaliser which also illustrates that I may be more of a "bimodal" person ... (that is – either imager or verbaliser). .... Viewing information in an analytic form as described in a CSA format, I tend to separate it into parts. This is evident in the ILE as the use of LHS and RHS frames segregate the choice and display of relevant of information."* **(analytic-verbaliser)**

"*To facilitate the viewing of the web pages as a whole I have included a page summary at the top of each web page. Additionally, the first page (index.html) includes a description of what the ILE contains. This was to allow me to complement the Wholist section of my cognitive style according to the CSA tests. The Verbaliser section of my cognitive style indicates that I prefer a textual layout to a graphical one and learn best from verbal presentations. I felt that*

this was a very accurate reflection of my cognitive style and took definitive steps to incorporate this into my ILE." **(wholist-verbaliser)**

Learning Style (ASSIST) - Reflection
ASSIST was the most accessible of the measures in terms of reflection. This was because both the main scales and the sub-scales (interest in ideas, organised study, fear of failure, etc.) use terms which are perhaps more comprehensible and related to the day to day aspects of learning than those used by the other two measures. Most students tended to concentrate on reported areas of possible weaknesses and were usually able to reconcile these with their approaches to studying and learning. The two following examples contrast a strongly strategic student who also engages in deep learning with one who certainly engages in deep learning but who is not particularly strategic.

"My highest percentage in this test was in the Strategic Approach section. What got me in this section was how high my percentage was in the Monitoring Effectiveness category (95). ……. I structure the way I learn and always want things to be organised and not here nor there. (In the Deep Approach)……..What pulled my overall percentage down in this section was the Interest in Ideas category (35%). When it comes to university, and in the context of what I am learning, unless it is a theoretical unit I would much rather be given all the facts than what people may be thinking or assuming. I'd rather be able to think about the given information myself and form my own opinion." **(SDA – Strategic 72%, Deep 65%, Surface 45%)**

 "In looking at the ASI, the aspect that struck me was in the Strategic Approach. I scored particularly low in this area: 45% for organising study, 55% for alertness to assessment demands, 35% for time management. I think the reason for this may be because of my tendency to lose track of (the) objective when I am reading or doing research. I can get carried away in what I am reading and read out of interest rather than to fulfil the objectives for the assignment or exam." **(DAS – Deep 79%, Surface 59%, Strategic 51%)**

Learning Style (ASSIST) – ILE development

Although ASSIST was the most accessible of the measures in terms of reflection and interpretation, many students found it difficult to relate to or integrate into the ILE design. In contrast to the CSA, this was especially true of the format of the ILE. However, some made connections with the content. The most straightforward element was the time-management sub-scale of the strategic scale. This could be directly translated into features such as an assignment timetable. Some students did, however, attempt to integrate features at a more abstract level.

" From the ASI results, I discovered that I need to know how the new pieces of information I am exposed to are interrelated. Therefore, when designing my ILE, I will try to link the pieces of information so that they appear to be chunks of information instead of bits and pieces of information. I scrutinise information and question its existence. I do not simply accept. Therefore. Only relevant and factual information would be included in my ILE. Finally, I am quite systematic and organised. This applies not just to revising for exams but to every aspect of my life. I need order. Therefore, my ILE should be well organised." **(SDA – Strategic 99%, Deep 95%, Surface 68%)**
"My Strategic Approach is as follows *(table illustrating sub-scale scores):*

An organised study routine indicated to me a consistent time frame of ILE usage – where the primary source of unit material could be found at any time of the day or night. This factor is particularly important in designing the pages to accommodate for those times – which have to allow for when I am tired/awake/determined to study and when I am not feeling motivated. The graphics at the start page assist in this function as I begin to expect what they entail, and that right behind them is the resource to my study routine. These factors are also relevant for Time Management and the Alertness to Assessment Demands." **(DSA – Deep 86%, Strategic 72%, Surface 53%)**

Personality (MBTI) - Reflection

This is the measure the participants were most familiar with, several having taken the test previously. In those cases, there was a greater metacognitive awareness of their attitudes to learning and studying. Several had made successful attempts to overcome what they saw as shortfalls in their learning practices and studying techniques. Other students, encountering the MBTI for the first time, expressed surprise at the accuracy of the measure and it was perceived as a more accurate measure of personality than the CSA. The first student in the reflective section makes an interesting transition from the explanation of the information-seeking habits of "perceiving" students to the ILE design. It is on the basis of a marginal score (5) and thus illustrates the potential problem of literal adoption of general classifications. However, in this case, the student's comments suggest that it is a reasonable interpretation.

The initials represent the different types, the numbers their strength on scales of between 1 and 67.
E - Extroversion,   I - Introversion
S – Sensing,   N - Intuition
T – Thinking,   F - Feeling
J – Judging,   P – Perceiving

"I agree with the part about perceptive people, that 'They start many tasks, want to know everything about each task.' When learning, feedback is important to me. And yes, I tend to leave things to the last minute, to 'seek information to the very last minute', emmm…okay."
This is later linked to the ILE design as follows:
"Structuring the navigation so that the resource pages would open in separate windows was so that I could have all the information in front of me at one time……… the MBTI results confirm that in one of my dimensions I am constantly looking for information before making a decision. Therefore, I would rather have 5 windows open showing all the possible information to learn from, than just one to concentrate on." **(INFP - 5, 27, 5, 5)**

"I was not expecting to say this, but the Myers-Briggs Test has actually explained to me some of my habits that I could never fully understand. This is sort of frustrating, as I never thought that a test could understand me better than myself. But I'll look on it as more of a guideline," **(INTJ – 1, 9, 37, 27)**

Personality (MBTI) – ILE development

Several students made the point that, while they found the MBTI to be accurate, they could not see how a personality measure could affect either the form or content of the ILE design. Others could make a connection and recognised that their personalities very much affected

how they approached learning. Translating this into design aspects was still a problem but, as the following comments illustrate, this was achieved on a more abstract and conceptual level.

"The MBTI results also influenced the purpose of my ILE because it made me think about how my personality affects the way I tackle assignments and prepare for exams. I am organised with my assignments and work throughout the semester but when it comes to exams I always (used to???) leave the preparation for the last minute. The comment about relying on the ability to improvise instead of preparing in advance applies to the way I study."
(ENFP - 19, 13, 3, 19)

"In this test I was classified as an ESTP….This description of me is very accurate….All this has contributed mainly to the layout and appearance of my ILE. I have used strong and dominant colours, such as the blue theme throughout the entire web site. The brushes and blocks of white captioning around the icons contrasted this….All these factors also combined together to form a simple, clear, and manageable style. It lacks clutter, and the icons do an extremely good job of controlling the flow of information throughout the site." **(ESTP - 9, 19, 49, 27)**

Conclusions

The study and results indicate that the ability of each individual to develop a personal learning resource and reflect on the role of their metacognitive characteristics could be a useful instrument in the development of the autonomous life long learner. The student comments and qualitative data suggest that knowledge of and reflection on the characteristics of individual cognitive profiles could also affect the design and content of individual learning environments, albeit in different ways. Several respondents questioned why they had not had access to this type of metacognitive information earlier in their school or university careers. They also suggested that they would have found the knowledge particularly useful for the transition to university life and the greater demands of independent learning. Responses and comments often showed that participants were aware of their cognitive and learning styles in a relatively uninformed way. The information provided by the three measures comprising the cognitive profile, allowed them to reflect on their learning related characteristics and preferences in a much more structured and informed manner. The outcome of applying the results of this reflection was enhanced matacognitive skills and knowledge. The design of the Individual Learning Environment was affected in terms of both structure and content. Many found that the dimensions of the CSA gave them the most directly useful information. This information helped develop the format and content of the ILE with reference to their information handling and processing preferences. In contrast, the MBTI and ASSIST measures provided personal learning and information preference details which were informative and had greater relevance to the learning process. These details could then be either integrated into the 'look and feel' of the ILE or used more directly to suggest the inclusion of specific learning related features.

References

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, , 66-71.

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

Curry, L. (1983). An organization of learning styles theory and constructs. In Curry, L. (ed), *Learning style in continuing education* (115-131). Dalhousie University.

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

Flavel, J.H. (1976). Metacognitive aspects of problem solving. In Resnick, L.B. (ed*)The nature of intelligence,* 231-235. Erlbaum.

Goodyear, P. (2000). Environments for Lifelong Learning: Ergonomics, architecture and educational design, in Spector, J.M., (ed) *Integrated Perspectives on Learning, Instruction and Technology,* Kluwer Academic Publishers, Dordrecht.

Hammer, A. L. (ed.) (1996) *MBTI Applications: A decade of Research on the MBTI,* Consulting Psychological Press, Paolo Alto, CA.

HUSAT (1990). *The HUFIT Planning, Analysis and Specification Toolset.* HUSAT Research Institute, Loughborough University.

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

Jung, C. G. (1923) *Psychological Types,* Routledge and Kegan Paul, London.

Marton, F. and Saljo, R. (1976). On Qualitative Differences in Learning: I. Outcome and process. *British Journal of Educational Psychology,* 46, 4-11.

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.

Myers, I. B., McCaulley, M. H., Quenk, N. I. and Hammer, A. L. (1999) *MBTI Manual: A Guide to the Development and Use of the Myers-Briggs Type Indicator,* Consulting Psychologist Press, Paolo Alto, CA.

Myers, I. B. and Myers, P. B. (1980) *Gifts Differing,* Consulting Psychologist Press, Paolo Alto, CA.

Nowack, K. (1996). Is the Myers Briggs Type Indicator the Right Tool to Use? *Performance in Practice,* American Society of Training and Development, 6.

Pask, G. (1976). Styles and Strategies of Learning. *British Journal of Educational Psychology,* 46, 128-148.

Phelps, R., Ellis, A. and Hase, S. (2001). The Role of Metacognitive and Reflective Learning Processes in Developing Capable Computer Users. In G. Kennedy, M. Keppell, C. McNaught & T. Petrovic (Eds.), *Meeting at the Crossroads. Proceedings of the 18th Annual Conference of the Australian Society for Computers in Learning in Tertiary Education,* 481-490. University of Melbourne.

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

Riding, R. and Cheema, I. (1991). Cognitive Styles: An overview and integration. *EducationalPsychology,* 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. and Rayner, S. G. (2000) *International Perspectives on Individual Differences - Volume 1: Cognitive Styles,* Ablex Publishing Corporation, Stamford, Conneticut.

Sadler-Smith, E. (1996). 'Learning Styles' and Instructional Design. *Innovations in Educational and Training International,* 33, 185-193.

Scholl, R. W. (1999). Cognitive Style and the Myers-Briggs Type Inventory (MBTI). [Web page].http://www.cba.uri.edu/Scholl/Notes/Cognitive_Style.htm. Accessed 6/12/01.

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

Tait, H. and Knight, P. (Eds), (1996). The Management of Independent Learning. London: Kogan Page.

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, 262-271.

Vora, P. (1998). Human Factors Methodology for Designing Web Sites. *Human Factors and Web Development,* Lawrence Erlbaum Associates, London.

Witkin, H. A., Moore, C. A., Goodenough, D. R. and Cox, P. W. (1977). Field-Dependent and Field Independent Cognitive Styles and Their Educational Implications. *Review of Educational Research*, 47, 1, 1-64.

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