ON BEING DEPENDENT OR INDEPENDENT IN COMPUTER BASED LEARNING ENVIRONMENTS

Dr Boris Handal
University of Technology Sydney
Boris.Handal@uts.edu.au

Dr Anthony Herrington
University of Wollongong
tony_herrington@uow.edu.au

Abstract

This paper critically examines the concepts of field dependent and field independent cognitive styles within the context of computer-based instruction. The literature suggests that hypermedia instructional environments are more likely to engage cognitively field independent learners. This active engagement may be the result of the non-structured and explorative nature of hypermedia environments, whereas field dependent learners prefer a more prescriptive and linear style of instruction. Following a review of both these learning style constructs and research studies associated with hypermedia environments, the paper provides a summary of implications together with potential avenues for future research.

Field Dependence and Field Independence

Each student learns in a different way and individual differences in learning have been corroborated in many studies (cf., Yu-ping Hsiao, 1997). It has been argued that, given students learn in different ways, instruction should be designed in such a way that it can accommodate different learning styles (Raven, Cano, Garton, & Shelhamer, 1993). Several classifications of learning and/or cognitive styles have been proposed by authors such as Dunn and Dunn (1978), Felder (2000), Gardner (1993) and Kolb (1984). For the sake of brevity, the terms learning and cognitive styles will be used interchangeably to denote aptitudes, regular mental behaviours, traits, habits or mental tasks that an individual displays under problem-solving situations (Jonassen & Grabowski, 1993). The research literature in education offers an array of terms to distinguish the different ways in which individuals display these aptitudes (cf. McLoughlin, 1999) with the dimensions of field dependence (FD) and field independence (FI) being prominent.

Witkin and his associates (Witkin & Goodenough, 1979; Witkin, Moore, Goodenough, & Cox, 1977; Witkin, Oltman, Raskin, & Karp, 1971) developed the concept of field dependence and field independence to differentiate two distinct cognitive learning styles. According to these authors, the FI/FD dimensions are defined as ‘the extent to which a person perceives part of a field as discrete from the surrounding field as a whole, rather than embedded in the field; the extent to which a person perceives analytically’ (Witkin et al., 1977, p. 7). Over the years, other attributes have been described to characterise FI/FD learning styles. Summerville (1999) referred to field independence and field dependence dimensions as a global versus an articulated style that reflected the ‘degree to which an individual’s processing of information is affected by the contextual field’ (p. 3). FI learners have been referred to as ‘analytical, competitive, individualistic, task oriented, internally

referent, intrinsically motivated, hypothesis testing, self-structuring, linear, detail oriented, and visually perceptive' (Hall, 2000, p. 5) whereas FD learners have been referred to as 'group-oriented, global sensitive to social interactions and criticism, extrinsically motivated, externally referential, not visually perceptive, non-verbal, and passive learners who prefer external information structures' (Hall, 2000, p. 6). Governor (1998) added that FD learners are in more need of social input and external help in interpreting clues embedded in a particular learning task. Hu (1998) observed that FI learners are more analytic and rely less on external clues than their FD counterparts. FI learners, it appears, are more able to generate and structure their own knowledge rather than accepting knowledge reprocessed by others. Hall (2000) pointed out that the differences between FI and FD learners are more likely the result of 'varying information processing skills such as selective attention, short-term memory encoding, and long-term recall at which field independent individuals are more accurate and efficient' (p. 72).

Further development by Witkin's team has led to the creation of the Group Embedded Figures Test (GEFT) to measure the FD/FI constructs and identify those learners that lean towards each category in their learning style. This test measures visual perceptiveness and requires the respondent to locate and differentiate simple geometrical figures that are embedded within a more complex visual field. Respondents scoring within one standard deviation above the mean are considered to be FI learners compared to their FD counterparts, whose scores are located one standard deviation below the mean. Students around the mean are considered to be field-mixed (FM). FI and FD scores measured by the GEFT are supposedly not correlated with intelligence or ability (Witkin & Goodenough, 1979; Witkin, Moore, Goodenough, & Cox, 1977; Witkin, Oltman, Raskin, & Karp, 1971). However, that claim is disputed by Sternberg (1997) and Tamaoka (1985) who argue that GEFT scores are related to intellectual ability since the test consists of correct and incorrect questions, and because those classified as FI learners are recognised as 'better' learners than their FD counterparts.

Several studies have indicated that FI learners perform better in traditional academic tasks than their FD counterparts. According to Simonson (1985), FD learners are more influenced by the social environments rather than by their own motivation. FD learners also appear to be more influenced by praise and criticism than FI learners. FI learners, in turn, are more proactive and usually have a strong self-concept. Yea-Ru Chuang (1999), contended that FI learners tend to solve problems through intuition and use of trial-and-error strategies, as opposed to FD learners, who perceive objects as a whole and look more for more uni-dimensional relationships. According to Miller (1997, p. 210) FD learners 'prefer externally defined goals and organization' while FI learners 'can provide their own structure for learning activities'. The question then arises: How do FI/FD learners interact with computer based learning environments, in particular, hypermedia based environments?

Hypermedia-Based Instruction

In the past two decades computers have been increasingly used in education as a tool to foster learning. The introduction of computers in education has reformulated the role of the teacher and the learner, and the relationship between them and teaching. One of the major challenges in computer education is to refocus the view of computers as tools for learning rather than devices to learn about, that is, learning with computers rather than from or about them (Handal & Herrington, 2003; Jonassen & Reeves, 1996). Gibbons and Fairweather (1998) proposed that by using computers, teachers can expect students to interact with more complex materials. They also argued that computers allow teachers to act more as coaches and facilitators using a learner-centred style of teaching. There is no clear indication, however, as to whether computer-based environments can support diverse individual differences and learning styles. While a number of authors argue that educational software can accommodate those differences (Chinien & Boutin, 1992/1993; Chou & Lin, 1998; Liu & Reed, 1994; Whyte, Karolick, & Taylor, 1996), others claim the contrary (Burger, 1985; Post 1987; Rowland & Stuessy, 1988).

Ayersman and Von Minden (1995) propose two main and broad classifications of the use of computers in instruction: Computer-Assisted Instruction (CAI) and Hypermedia-Based Instruction (HBI). Tutorials, simulations, drill and practice, and games are examples of CAI. CAI is the most common form of educational software and it is characterised by programs that require students' responses to stimuli by a program. Most of these interfaces induce repetitive responses in a linear sequence. It has been argued that CAI software does not build on student' problem solving capabilities, as the software is predominantly based on routine exercises (Beynon & Mackay, 1993; Liu & Reed, 1994).

Hypermedia is a much more complex type of computer-based instruction which can manifest in a range of different forms. For example, many CD-ROM based programs are examples of hypermedia systems, as are many instructional materials delivered on the World Wide Web. In contrast to the linear approach of CAI, hypermedia materials are comprised of multiple nodes containing various media forms such as text, sound, graphics and movies either individually or combined. The structure of a hypermedia system enables users to move from one node to another at will, accessing information from nodes that are more associative and are delivered in a non-linear sequence, allowing the learner greater control and interactivity (Handal & Herrington, 2003). Because of the more sophisticated types of learning that the technology supports, and the technical advantages over CAI, it has been argued that HBI allows the learner to build more meaningful links and relationships among texts and information (Ayersman & von Minden, 1995). Moreover, it has been claimed that HBI encourages the learner to obtain a more coherent understanding, construct his or her own knowledge, and promote higher involvement in the acquisition of knowledge (Liu & Reed, 1994; Melara, 1996). There is some research suggesting that HBI is more effective than CAI in accommodating individual differences and improving academic achievement (Melara, 1996; Summerville, 1999; Weller, Repman, & Rooze, 1994). The next section explores in more detail the relationship between HBI and the FI/FD constructs.

Hypermedia Based Instruction and Field Dependence/Independence

The last decade or more has seen a great deal of research conducted in the area of field independent and field dependent learning and the interaction with hypermedia based instruction. Much of this research has sought to create guidelines for teachers and instructional designers on how to design effective and efficient learning environments for different types of learning styles. The following table provides a summary of this research and resultant implications.

Author	Study	Findings	Implication
Yea-Ru Chuang (1999)	Examined the combined effect of three media factors (text, voice and computer animation) on 175 Taiwan seventh grade children's mathematics achievement	The effect of a combination of animation, text and voice on mathematics achievement for FI students than FD students	FI learners benefit from greater media complexity
Liu and Reed (1994)	Sixty three college students from a non-English speaking background engaged in hypermedia-assisted language learning	FI students tended to create their own structure while working with the hypermedia setting whereas FD students were more prone to follow the structure imposed by the software. In	FI learners are more analytical in their approach to processing information whereas FD learners are more likely to employ a more global

Author	Study	Findings	Implication
		addition, FD students developed a more spectator and social approach to learning	visual approach to learning
Leader and Klein (1996)	Tested four different database search tools with undergraduate students undertaking hypermedia database searches	FI learners did better with those tools that encouraged exploration while FD did better with more directed tasks	Search strategies interact with learning styles
Lin and Davidson-Shivers (1996)	Examined the effect of a hypertext linking structure on comprehension and attitudes of 139 undergraduate students	FI students performed better and showed more positive attitudes towards the hypermedia materials than their FD counterparts	Motivation to learn interacts with learning styles
Weller, Repman, and Rooze (1994),	Studied the effect of hypermedia software on 33 eighth-grade students enrolled in computer literacy courses	It was found that FI learners learned more effectively than FD students. The authors reported that the two groups appeared to differ in the way they accessed information. FI learners displayed stronger information-seeking behaviour than FD learners	Learning style interacts with outcomes and approaches to learning
Summervill e (1999)	Examined the effect of a hypermedia environment on 177 students enrolled in undergraduate technology courses	Although the quantitative did not yield significant differences in achievement and satisfaction scores, interviews revealed that FD learners preferred more step-by-step instructions with more human direction	FD learners need more social interaction and assistance in a hypermedia environment
Wang and Jonassen (1993)	Conducted a study of students using a hypertext program to learn transfusion medicine	The findings showed that FI students were more actively engaged than FD students. FI students also covered most of the course, spent more time in evaluation, and appeared to read more quickly through the screens	FI adopt more productive learning strategies while working in HBI
Wey and Waughn	Investigated 61 undergraduate	Results showed that in the text-only group, FI	FD learners benefit more from

Author	Study	Findings	Implication
(1993)	students who were allocated to either a text-only based instruction or a text-with-graphics	learners performed better than FD learners, although no differences were observed with the text with graphics treatment	materials containing both text and graphics
Ching-Chun Shih and Gamon (1999)	Investigated 99 university students who chose to take two courses zoology and biology. Most of the materials and resources for this course were accessed and delivered through the Internet	More FI learners chose to take the courses than FD learners, however, there was no difference between FI and FD students in their motivation, learning strategies and achievement in web-based courses	Web-based instruction appears to be more appealing to FI learners
Fitzgerald and Semrau (1998)	Studied the effect of FI/FD learning styles on usage patterns and learning outcomes of twenty-three preservice teachers engaging with hypermedia case studies	Although there were some differences in the usage pattern of the hypermedia instructional components, these differences did not have an effect on learning outcomes	Hypermedia environments do not favour any particular learning style

Conclusion and Recommendations

In general, the findings outlined above appear to suggest that hypermedia learning environments, such as multimedia CD-ROMs and websites, provide an environment where FI learners have more opportunities to succeed. As Witkin et al. (1977) proposed, FD learners are less likely to establish a meaningful organization of ideas when the field lacks structure and where few clues are obtainable. The findings also suggest that FD learners benefit from graphic-based instruction in accordance with Hall's (2000) suggestion than FD are less verbal and may require alternative and more visual forms of instruction. Differences across studies can be attributed to different researchers' conceptualisations of operational variables, variety and use of hypermedia programs and the diversity of methodologies and research designs. On the basis of these studies it would be tempting to recommend that HBI environments should be used with FI learners and avoided with FD learners. Such a recommendation would fail to recognise that learning environments, learning styles and technology are not constant variables.

Traditional learning environments based on a linear sequencing of 'bite-sized' content arrived at through task analysis are being replaced, in both face to face and virtual classrooms, by tasks that are complex, authentic and ill defined (Herrington, Oliver, Herrington & Sparrow, 2000). It has been argued that such tasks can accommodate the diversity of learners' backgrounds, abilities and learning styles (Kerka, 1995). Current learning theories also emphasise the importance of social interaction in the learning process (Bransford, Brown & Cocking 2000). As learning environments adopt these more recent theories of learning and instructional design, and as the technology continues to migrate from CD-ROM based multimedia to a greater online presence, then the increased opportunity for communication, collaboration and cooperation between learners and teachers on complex problem solving and investigations becomes apparent.

The possibility of learners' styles changing over time has not been well researched, however, there appears to be some evidence that cognitive style may be a 'flexible construct and malleable over the long term' (Brown, 2003, p. 2). A potentially beneficial area for future research would be to investigate if and how both FI and FD learning styles change over time when they engage with HBI software that reflects current technology, learning theory and instructional design. Future studies would also benefit from research designs that did not seek to compare learning outcomes for different groups of learners, but instead investigated the qualitative interactions between cognitive styles, contexts, outcomes and learning environments that are facilitated by the affordances offered by computer-based technologies.

References

Ayersman, D., & von Minden, A. (1995) Individual differences, computers, and instruction. Computers in Human Behavior, 11(3-4), 371-390.

Beynon, J., & Mackay, H. (1993) Computer based instruction: Methods and development. New Jersey: Prentice Hall.

Bransford, J.D., Brown, A.L., & Cocking, R.R. (2000) How people learn: Brain, mind, experience, and school. Washington, DC.: National Academy Press.

Brown, B.L. (2003) Teaching style vs. learning style. ERIC Clearinghouse on Adult, Career, and Vocational Education. Myths and Realities No. 26. Available online from the ACVE Website: http://www.cete.org/acve/docgen.asp?tbl=mr&ID=117. Last accessed date: April 5, 2004

Burger, K. (1985) Computer assisted instruction: learning style and academic achievement. Journal of Computer Based Instruction, 12(1), 21-22.

Ching-Chun Shih & Gamon, J. (1999) Student learning styles, motivation, learning strategies, and achievement in web-based courses. Proceedings of the 1st Annual Congress on the Impact of Technology Upon Learning, Winston-Salem, NC, March 1999.

Chinien, C., & Boutin, F. (1992/1993) Cognitive Style FD/I: An important learner characteristic for educational technologists. Journal of Educational Technology Systems, 21(4), 303-311.

Chou, C., & Lin, H. (1998) The effect of navigation map types and cognitive styles on learners' performance in a computer-networked hypertext learning system. Journal of Educational Multimedia and Hypermedia, 7(2/3), 151-176.

Dunn, R., & Dunn, K. (1978) Teaching students through their individual learning styles: A practical approach. Virginia: Reston Publishing.

Felder, R.M. (2000) Index of learning styles. Available online from the North Carolina State University Web site, College of Engineering: www2.ncsu.edu/unity/lockers/users/f/felder/public/ILSpage.html. Last date accessed: April 5, 2004

Fitzgerald, G. E., & Semrau, L. P. (1998) The effects of learner differences on usage patterns and learning outcomes with hypermedia case studies. Journal of Educational Multimedia and Hypermedia, 7(4), 309-331.

Gardner, H. (1993) Frames of mind: The theory of multiple intelligences. New York: Basic Books.

Gibbons, A.S., & Fairweather, P.G. (1998) Computer-based instruction: design and development. Englewood Cliffs, N.J.: Educational Technology Publications.

Governor, D. (1998) Cognitive styles and metacognition in web based instruction. Available online: http://www.members.cox.net/vogannod/THESIS.html. Last date accessed: April 5, 2004.

Hall, J.K. (2000) Field dependence-independence and computer-based instruction in geography. Doctoral Dissertation, Virginia Polytechnic Institute and State University.

Handal, B., & Herrington (2003). Re-Examining categories of computer-based learning in mathematics
education. [Online serial], Contemporary Issues in Technology and Teacher Education. Available online: http://www.citejournal.org/vol3/iss3/mathematics/article1.cfm. Last date accessed: April 5, 2004.

Herrington, J., Oliver, R., Herrington, A., & Sparrow, H. (2000) Towards a new tradition of online instruction: Using situated learning to design web-based units. In R. Sims, M. O'Reilly, & S. Sawkins (Eds.), Learning to choose: Choosing to Learn: Proceedings of the 17th Annual ASCILITE Conference (pp. 305-315). Lismore, NSW: Southern Cross University Press.

Hu, J. (1998) The relationship between hypermedia features and the learning style/cognitive control of hypermedia developers. Doctoral Dissertation, West Virginia University. Available online from the West Virginia University Web site: http://etd.wvu.edu/templates/showETD.cfm?recnum=691. Last date accessed: April 5, 2004.

Jonassen, D.H. & Grabowski, B.L. (1993) Handbook of individual differences, learning and instruction. Hillsdale, NJ: Lawrence Erlbaum Associates.

Jonassen, D. H., & Reeves, T. C. (1996) Learning with technology: Using computers as cognitive tools. In D. H. Jonassen (Ed.), Handbook of research on educational communications and technology (pp. 693-719). New York: Macmillan

Kerka, S. (1995) Techniques for authentic assessment. ERIC Clearinghouse on Adult, Career, and Vocational Education. Practice Application Brief. Available online from the ACVA Website: http://www.cete.org/acve/docgen.asp?tbl=archive&ID=A032. Last date accessed: April 5, 2004.

Kolb, D.A. (1984) Experiential learning. Englewood Cliffs, NJ: Prentice Hall.

Leader, L. F., & Klein, J.D. (1996) The effects of search tool type and cognitive style on performance during hypermedia database searches. Educational Technology Research and Development, 44(2), 5-15.

Lin, C.-H., & Davidson-Shivers, G. V. (1996) Effects of Linking structure and cognitive style on students'
performance and attitude in a computer based hypertext environment. Journal of Educational Computing Research, 15(4), 317-329.

Liu, M., & Reed, M.R. (1994) The relationship between the learning strategies and learning styles in a hypermedia environment. Computers in Human Behavior, 1(4), 419-434.

McLoughlin, C. (1999) The implications of the research literature on learning styles for the design of instructional material. Australian Journal of Educational Technology, 15(3), 222-241.

Melara, G.E. (1996) Investigating learning styles on different hypertexts environments: hierarchical-like and network-like structures. Journal of Educational Computing Research, 14(4), 313-328.

Miller, G. (1997) Are distance education programs more acceptable to field-independent learners? (ERIC Document Reproduction Service No. ED 409854.)

Post, P. E. (1987) The effect of field independence/field dependence on computer-assisted instruction
achievement. Journal of Industrial Teacher Education, 25(1), 60-67.

Raven, M.R., Cano, J., Garton, B.L., & Shelhamer, V. (1993) A comparison of learning styles, teaching styles, and personality styles of preservice Montana and Ohio agriculture teachers. Journal of Agricultural Education, 31(1), 40-50.

Rowland, P., & Stuessy, C. L. (1988) Matching mode of CAI to cognitive style: An exploratory study. Computers in Mathematics and Science Teaching, 7(4), 36-40.

Simonson, M.R. (1985) Persuasion: Five studies dealing with the relationships between media, attitudes, and learning style . (ERIC Document Reproduction Service No. ED 256 337.)

Sternberg, R.J. (1997) Thinking styles. Cambridge University Press.

Summerville, J. (1999, July) Role of awareness of cognitive style in hypermedia [Electronic version] International Journal of Educational Technology. Available online: http://www.outreach.uiuc.edu/ijet/v1n1/summerville/. Last date accessed: April 5, 2004.

Tamaoka, K. (1985) Historical development of learning style inventories from dichotomous cognitive concepts of field dependence and field independence to multi-dimensional assessment (Report). Matsuyama University, Matsuyama, Japan: Author. (ERIC Document Reproduction Service No. ED 339 729.) Texas Education Agency.

Wang, S.R., & Jonassen, D.H. (1993, April) Investigating the effects of individual differences on performance in cognitive flexibility hypertexts. Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.

Weller, H.G., Repman, J., & Rooze, G.E. (1994) The relationship of learning, behavior, and cognitive style in hypermedia-based instruction. In H. Liu, W.M. Reed, & J.K. Burton (Eds.), Multimedia and megachange: New roles for educational computing (pp. 401-420). The Haworth Press.

Wey, P. & Waughn, M.L. (1993) The effects of different interface presentation modes and users' individual differences on users' hypertext information access performance. Paper presented at the annual Meeting of the American Educational Research Association, Atlanta, Georgia.

Whyte, M., Karolick, D., & Taylor, M. D. (1996) Cognitive learning styles and their impact on curriculum
development and instruction. Proceedings of the National Convention of the Association for Educational Communications and Technology, 1996, pp. 783-799.

Witkin, H. A., & Goodenough, D. R. (1979) Cognitive styles: essence and origins. Psychological Issues, Monograph 51.

Witkin, H. A., Moore, C. A., Goodenough, D. R., & Cox, P. W. (1977) Field dependent and field independent cognitive styles and their educational implications. Review of Educational Research, 47, 1-64.

Witkin, H.A., Oltman, P.K. Raskin, E. & Karp, S.A. (1971) A Manual for the embedded figures test. Palo Alto: Consulting Psychologists Press, Inc.

Yea-Ru Chuang. (1999) Teaching in a multimedia computer environment: A study of the effects of learning style, gender, and math achievement [Electronic version]. Interactive Multimedia

Electronic Journal of Computer-Enhanced Learning. Available online: http://imej.wfu.edu/articles/1999/1/10/index.asp. Last date accessed: April 5, 2004.

Yu-ping Hsiao (1997) The effects of cognitive styles and learning strategies in a hypermedia environment: A review of literature. Available online: http://www.edb.utexas.edu/mmresearch/Students97/Hsiao. Last date accessed: April 5, 2004.