Field Dependence-Independence and Computer-based Instruction in Geography

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(ABSTRACT)

Research on the cognitive style field dependence-independence establishes its influence on learning and students' outcomes across academic disciplines and at all levels of schooling. Field dependent learners generally perform less well than field independent individuals in most instructional environments. The consequences of cognitive style differences have not been thoroughly pursued by geography educators, and field dependent learners are generally disadvantaged. Review of literature suggests that field dependent learners may perform well in hypermedia-based environments configured to support their learning needs. This study presented geography students with a computer program that contained jigsaw puzzles made from maps and randomly varied the type of interactivity available to learners when solving the puzzles. Field dependent learners were expected to solve the puzzles more quickly and accurately when they were able to interact with the jigsaw puzzle. The interactive treatments provided by the program did not improve the performance of field dependent individuals as expected.

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Chapter One

LITERATURE REVIEW

Introduction to Literature Review

Field dependence/independence is an established cognitive style that correlates with particular abilities and often predicts success in traditional and computer-based instructional environments. This literature review describes the construct of field dependence/independence (field articulation or field style), its consequences for learners in computer-based environments, and its potential to assist geography educators to better understand learner performance. These three themes are woven together by a common thread: the prevalence of complex, visual information in geography and hypermedia and the critical visual perceptiveness differences between field dependent and field independent individuals.

The cognitive style itself is described along with an overview of hypermedia. The relationship between field articulation and hypermedia is examined with an emphasis on whether cognitive style can inform learner-centered instructional environments. Interactivity, a problematic concept often confounded with ideas about hypermedia, is examined to uncover information about the effects of cognitive style and particular elements or features within hypermedia. The current state of computer use in geography education is explored, as is the need for educational research grounded in cognitive style and an operational definition of interactivity.

Such research is critical to geography educators who suffer from a lack of data and conceptual models about hypermedia-based instruction in their discipline. This review supports the need to uncover how the interactive elements of hypermedia and cognitive style intertwine when geography students use computer-based instruction to learn geographic concepts and practices.

Field Dependence-Independence and Computer-based Instruction

Numerous studies explore the importance of learners' cognitive styles and the role of field dependence/independence in instruction and learning (Burton, Moore,

& Holmes, 1995). With the rapid development of computer technologies as educational tools, the role of cognitive style in the computerized classroom is becoming part of the literature. Examining cognitive style vis-à-vis computerized contexts rests on ideas about both styles and computers. Computers are perceived as ideal tools for providing individualized instruction, and cognitive style describes the manners in which various learners receive and process information (Kini, 1994; Messick, 1993). Appropriate environmental conditions and cues can be presented when information about learners is accommodated by the flexibility of computerized environments (Kini, 1994).

Because attention and pattern recognition determine the environmental stimuli that are processed (Burton et al, p. 351), examining cognitive style is paramount as it describes how this process occurs. Supporting this position, Sadler-Smith (1996) overviews design that specifically addresses individual preferences and needs of learners and argues for an approach that provides learners with stylistically appropriate cues and organization of content. In examining the intensely visual realm of computer-based instruction, the role of the field independent / dependent cognitive style may be a key to the effective design of instructional environments (Ayersman, 1993; Chinien & Boutin, 1992 / 1993; Kini, 1994; Packard, Holmes, Viveiros, & Fortune, 1997; Sadler-Smith, 1996; Stemler, 1997; Tergan, 1997a; Weller, Repman, & Rooze, 1994; Whyte, Karolick, Nielsen, & Elder, 1995).

Asserting that cognitive style is relevant to the success of “independent or self-directed learning” (Jones, 1993, p.195), Jones implicates an appreciation of learners’ differences in the delivery of effective computer-based instruction. This review is grounded in a perceived need to continue to explore the consequences of field dependence and field independence in computerized learning environments (Ayersman, 1993; Chinien & Boutin, 1992 / 1993; Chou & Lin, 1998; Jonassen & Wang, 1993; Leader & Klein, 1996; Tergan, 1997b; Whyte et al., 1995).

Hypermedia

Elements of computer-based instruction researched with regards to field independence are often described as hypermedia. (See Ayersman, 1993; Lin & Davidson-Shivers, 1996; Stanton & Baber, 1992; Weller et al., 1994). The current concept of hypermedia brings together navigational properties such as hypertext and the various presentation styles of multimedia (Burton et al., 1995). While the theoretical background and development of hypertext is rooted in cognitive psychology and its assumptions about the human thought process, multimedia descends from an amalgamation of classroom practices in which available technologies are continually pressed into use (Burton et al., 1995). Multimedia presupposes that the concurrent use of different presentations of information (auditory, visual, etc.) will result in each presentation reinforcing the others.

Hypermedia can be defined as an associative, possibly nonlinear information presentation and representation system built around a network of multimedia materials (Liu & Reed, 1994 p. 421). Other descriptions include the concept of computer-driven interactivity and a learner's ability to determine and control selection and non-linear sequence of content, (Burton et al, p. 349); it is composed of user-determined (associative) links which add up to an individual navigational trail (p. 350). This review will consider hypermedia systems to include a navigation mechanism by which learners control the order and flow of information, and / or the availability to the learner of more than one presentation format, and / or some type of interactivity with the material presented.

The following sections provide a general description of field dependence and independence and the cognitive styles' associated learner characteristics. The instruments used to measure field independence or dependence in a population of learners are examined. The consequences of field dependence or independence for learners in computerized environments are presented, and the use of color to help learners apprehend visual cues is discussed briefly.

History of the Cognitive Style Field Independence / Dependence

Messick's (1993) defines cognitive styles as "characteristics modes of perceiving, remembering, thinking, problem solving, decision making" that are "reflective of information processing regularities that develop in congenial ways" (p.3). A cognitive style is a "fixed characteristic" of an individual that is developmental, static, and stable (Riding & Cheema, 1991, p. 195).

The exploration of the field independent / dependent construct, also known as the global-articulated continuum, began in the 1940s with Herman Witkin's research on human perception of the upright (Witkin & Goodenough, 1979; Witkin, Moore, Goodenough, & Cox, 1977). Individuals who were able to orient themselves along the true vertical in a room despite confusing physical and visual cues generated by a tilted floor and moveable chair were described as articulated or field independent. Their sense of the vertical originated from internal body awareness of gravity and was not effected by misleading visual clues created by the environment (field). Individuals who aligned themselves along a vertical axis relative to the misleading environment were labeled global or field dependent. They relied on visual cues from the external environment to determine body placement and did not rely on an internal, bodily awareness of gravity. Thus, the construct describes the manner in which people perceive, acquire and act on knowledge about their surroundings (Witkin et al., 1977).

Witkin's research uncovered that associated cognitive characteristics are correlated with perception of the upright and can be measured using instruments that determine field articulation. The construct broadened from perception of the upright to include perceptual and intellectual problem solving (Witkin et al., 1977). Field independent individuals, characterized by reliance on an internal frame of reference, were discovered to be more capable at cognitive restructuring and disembedding skills than field dependent individuals who are characterized by reliance on an external frame of reference. These skills can be described as: "1) providing structure for an ambiguous stimulus complex, 2) breaking up an organized field into its basic elements, and 3) providing a different organization to a field than that which is suggested by the inherent structure of the stimulus complex" (Riding & Cheema, 1991, p. 198).

Witkin, Moore, Goodenough, and Cox (1977) identified field dependence/ independence as widely applicable to educational research and claim it "may be applied with profit to a variety of educational issues" (p. 1). Establishing that individual differences first recognized as varying perceptual abilities manifest themselves across problem-solving domains in which both immediately present stimuli or symbolic representations require restructuring or decontextualizing, Witkin, et al. also established differences in social behavior patterns and schooling outcomes. The effects of cognitive style are persistent and wide ranging (Davis, 1991; Messick, 1993; Riding & Cheema, 1991; Whyte, Karolick, & Taylor, 1996; Witkin et al., 1977). Correspondingly, all aspects of learning experiences will be guided to some degree by each learner's field articulation.

Learner Characteristics and Performance

Field dependence/independence is generally considered to describe learners along a testable, value neutral, bipolar continuum such that individuals at one end are measured as field independent. Individuals at the opposite end are considered field dependent, and subjects in the middle of the range are characterized as field mixed or field neutral (Liu & Reed, 1994). A number of learner characteristics and tendencies have been established in the literature as part of the cognitive style construct that effect learning and academic performance (Chinien & Boutin, 1992; Davis, 1991; Jones, 1993; Sadler-Smith, 1996).

Adjectives used to describe field independent learners include analytical, competitive, individualistic, task oriented, internally referent, intrinsically motivated, hypothesis testing, self-structuring, linear, detail oriented, and visually perceptive (Fritz, 1994; Lyons-Lawrence, 1994; Reiff, 1996). Field dependent individuals are described as group-oriented, global, sensitive to social interactions and criticisms, extrinsically motivated, externally referential, not visually perceptive, non-verbal, and passive learners who prefer external information structures (Chinien & Boutin, 1992/1993; Liu & Reed, 1994; Lyons-Lawrence, 1994; Riding & Cheema, 1991). Field independents are more likely to have an internal locus of control than field dependents, but field dependents are more likely to be successful self-monitors in a social group (Leventhal & Sisco, 1996). In educational situations, field dependent learners' tendency to be influenced by their peers is critical as they prefer feedback and social sources of information (Jones, 1993). Field independent learners are more individualistic and rule-oriented and less likely to seek peer input (Jones, 1993). Field independent learners are also more efficient information processors with better short term memory encoding, better long term recall, and more accurate performance on visual search tasks than field dependent individuals (Davis, 1991).

The key differentiation between field independent and dependent learners is visual perceptiveness: the ability to distinguish the parts of an image or visual environment from the whole (also referred to as the "field") (Riding & Cheema, 1991). Field independent individuals are not distracted by irrelevant details but are able to discover pertinent visual information easily. Field dependent individuals are more prone to visual miscues and may be distracted from the intended message of the image or field by visually striking (salient) but irrelevant information (Whyte et al., 1996; Witkin et al., 1977).

Related differences that are important in instructional situations are sampling and speed. Field dependent learners tend to sample less often than field independent learners (Burton et al., 1995). They also prefer a slower pace of stimulus presentation than field independent learners and move more slowly through materials (Davis, 1991). This relationship between sampling and speed remains true in hypermedia based instruction (Burton et al., 1995).

Perhaps the most important difference between field independent and field dependent individuals that may contribute to performance differences is visual discrimination. Field dependent learners “accept a stimulus field as given” (Reardon & Moore, 1988 p. 355) and have more difficulty processing complex images than field independent students (Dwyer & Moore, 1997/98; Moore, 1985/86; Reardon & Moore, 1988). Field independent individuals can successfully identify, analyze and manipulate (disembed) the singular components that comprise an image; field dependent learners have difficulty with that task and fuse the elements of an image into one visual field (Berry, 1984; Dwyer & Moore, 1997/98).

Witkin, et al. (1977) found cue salience versus cue relevance to be particularly important for field dependent learners especially with regards to hypothesis formation or problem solving tasks. Field independent learners sample more cues regardless of saliency and form hypotheses more quickly. Field dependent learners attend to salient cues first regardless of relevancy; and this behavior may be linked to field dependents’ more spectator-like approach to learning. Witkin, et al. theorize that field dependents may learn most efficiently when cues are equally salient and relevant. As an instructional design consequence, they suggest that field dependent learners perform optimally when given guidance that emphasizes key information and draws attention to necessary cues.

The second key difference between the cognitive styles is correlated to visual perceptiveness and is commonly referred to as cognitive restructuring. Field independent individuals are capable of distilling or extracting pertinent information from an image or environment (disembedding) and ordering or applying structure to that information (Davis, 1991; Riding & Cheema, 1991; Witkin et al., 1977, Messick, 1993). Field independent learners apply internally generated structural rules often arising from prior instructional experiences or developed from cues available in the material (Davis, 1991; Riding & Cheema, 1991; Witkin et al., 1977). Field dependent individuals lack this inherent ability to impose order and defer to the organizational structure represented by the visual field as a whole (Witkin et al., 1977, Reardon & Moore, 1988). Because field dependent students have greater difficulty imposing organization in an unstructured environment, Witkin, et al.

theorize that field dependent and field independent learners may perform equally well when learning materials are highly organized.

Cognitive style represents a potential impact on the expectations of learners in all instructional settings (Reiff, 1996). Most instruction favors the field independent learner (Reiff, 1996, Davis, 1991). Field independent students typically outperform their field dependent counterparts in all academic subjects (Tinajero & Paramo, 1997). Griffin and Franklin (1995/96) report that field independence predicts success at the undergraduate level across majors. Typical instructional environments reward field independent students, and the abilities and behaviors of those students closely match desired schooling outcomes (Reiff, 1996, Davis, 1991). Field independent learners outperform their field dependent counterparts with current forms of instruction and assessment across all levels of schooling and often despite strategies implemented to assist field dependent learners (Davis, 1991). In none of the reported research have field dependent learners outperformed field independent learners on outcome measures (Davis, 1991).

Measurement

Witkin originally used the body adjustment test (BAT) and later developed the rod and frame test (RFT) to uncover field type. The RFT requires subjects to orient a luminescent rod until it is perpendicular within a frame. The most widely used instruments are the Embedded Figures Test and Group Embedded Figures Test (EFT and GEFT, respectively). These instruments measure an individual's ability to disembed a simple shape from a complex visual field and thus to restructure information as a correlated skill (Witkin et al., 1977). Questions have arisen as to whether the EFT and GEFT measure perceptual acuity or if results tending toward field dependence might be due to other factors such as low motivation or visual deficiencies (Riding & Cheema, 1991). An important and long-held criticism of the field articulation construct centers on conclusively identifying what is actually being measured and the validity of measurement instruments: how is cognitive style not a measure of general ability / intelligence given that style correlates with ability outcomes and that factor analyses often place field articulation and intelligence on the same factor (Rosenberg, Mintz, & Clark, 1977)?

Messick (1992) argues that all instruments do not measure precisely equivalent characteristics. Moreover, the actual cognitive construct is in danger of not being measured at all. Messick asserts that the tendency to rely on one test, the EFT or GEFT, to establish field articulation places subjects under "maximal performance" conditions so that researchers "confound [analytical] ability with style" (p. 14) by testing for field independence as a desired outcome. The cognitive style test runs the risk of becoming an intelligence test under those conditions.

In order to differentiate between analytical skill as captured by the EFT or GEFT under potentially value-directional conditions, Messick (1993) pushes for the use of two instruments to establish contrasting tendencies. This methodology would pit "indicators of field independence against indicators of field dependence" (p.15). Messick selects the EFT and RFT as appropriately contrasting instruments. Citing research that these two tests may capture different phenomena, he offers up the RFT as a measure of "responsiveness to field effects" (p. 18) while the EFT or GEFT remains a measure of restructuring skill. The RFT measures field dependent tendencies that balance against the field independent biases of the EFT or GEFT. Overall, Messick argues against sole reliance on either the EFT or GEFT on the grounds that analytical ability will always be conflated with test scores, and the cognitive construct itself will remain unmeasured.

Tinajero and Paramo (1997) confirm Messick's (1993) argument and add to the measurement debate. They used both the RFT and the EFT to measure field articulation but found that only the EFT covaried with school achievement in six areas. They conclude that the RFT measures perception of the upright while embedded figures performance is a measure of cognitive analytical ability. Field independent students' better performance may be related to internal bias native to traditional schooling, and more research and design interventions are needed for learners who are identified as field dependent by the EFT (Tinajero & Paramo, 1997).

However, the EFT or GEFT is easier to administer, requiring only everyday office supplies and a testing room, while the RFT requires the construction of the apparatus itself and a testing environment free of overt perceptual distractions. The group form of the EFT, the GEFT, can be administered to an entire sample population at once while the RFT requires an individualized approach to data collection. Despite the cogency of Messick's (1993) argument and Tinajero and Paramo's (1997) evidence, the application of the EFT or GEFT will likely remain the most common measure of field articulation due to the procedural requirements for administering the contrasting instrument. Data about possible interactions between field type and performance in a hypermedia environment are likely to include levels of field dependence determined by either the EFT or GEFT alone. No other test is as well represented in the literature discussed here.

Implications for Computer-based Instruction

Investigating the possible ramifications of field type on the interpretation of computer based, hypermedia driven environments leads to an inevitable reiteration of Burton, Moore, and Holmes' (1995) point that little research has been done and scant evidence is available about any effects at all. Tergan (1997a) would add that most of the available research is problematic due to serious conceptual shortcomings. However, the premise continues to be maintained that computerized instructional systems can be effective, can accommodate different learning needs, and are interpreted by learners through the lens of cognitive style (Chinien & Boutin, 1992/1993; Chou & Lin, 1998; Liu & Reed, 1994; Whyte et al., 1996; Whyte et al., 1995). Some research questioned whether particular types of computer tools were better fitted to either style and sought to match style with technological functions as well as to uncover general relationships between cognitive style and the medium. For examples of these studies, see Burger, (1985); Post, (1987); and Rowland and Stuessy, (1988). More recent inquiries follow conceptual constructs about hypermedia itself or explore the relationships between hypermedia attributes and learner characteristics in the tradition of aptitude-treatment-interaction research (Davis, 1991).

Implementing Witkin et al's (1977) suggestion that field dependent learners can be supported by highly structured materials that make relevant cues prominent and eliminate distractions has resulted in mixed findings (Davis, 1991). In a comprehensive overview of educational research focused on the effects of field independence/dependence in the learning environment, Davis found that "cognitive style effects override the effect of instructional manipulations" (p.160) in most instances. Treatments intended to compensate for field dependent students' lack of disembedding and restructuring abilities have not consistently met with success. This mix of significant and nonsignificant results parallels the reported results of studies examining the effects of field style in hypermedia environments.

Grabinger (1993) analyzed visual organization: does screen layout elicit different behaviors from different learners? Hoping to uncover visual design guidelines, Grabinger directed subjects to compare a number of sample screens to each other and rate each for readability. No significant differences were found between the two field styles and screen design preferences.

Chinien and Boutin (1992-1993) review field dependence/independence and argue that the construct should be central to the instructional design process. Focusing on results of aptitude-treatment interaction research, Chinien and Boutin place cognitive style at the center of learner analysis for educational technologists. Ignoring cognitive style biases instructional materials and contexts (Chinien & Boutin 1992-1993). If hypermedia is to maximize its assumed ability to accommodate all learners, then the design process must be informed by learners' needs. Chinien and Boutin (1992) and Boutin and Chinien (1992) research the utility of cognitive style for single-subject formative evaluations and report that responses from field dependent subjects significantly improved instruction. Field dependent learners performed as well as field independent subjects when given revised materials (Boutin & Chinien, 1992). Cognitive style emerges not only as a key learner difference under performance conditions but also as a “missing ingredient” in the hypermedia design cycle.

Whyte, Knirk, Casey, and Willard (1990/91) made use of field dependent students’ preference for social interactions and paired learners during a computer-based learning exercise. Field dependent students paired with field independent students performed as well as the groups of field independent learners. Field dependent learners paired together fared worse despite more social interaction. This research provides an example of an instructional design option that may aid field dependent learners in computer-based learning contexts that does not rely on the hypermedia material itself. Field dependent learners can be accommodated by the organization of the larger instructional environment.

Packard, Holmes, Viveiros and Fortune (1997) examined performance between three presentation modes and field articulation style. Providing learners with text, text plus graphics, and text plus animated graphics, they report significant performance differences between the text only treatment and the other two. Unfortunately, more detailed analysis is not provided. However, these findings introduce the notion that cognitive style has a role in how learners engage with and learn from computer based instruction.

Lyons-Lawrence (1994) examination of field type and computer based instruction supports the idea that field independence or dependence may affect learning in a non-traditional environment. Field independent learners tested significantly higher than field dependent learners upon assessment over the content area presented by the computerized instruction Concluding that visually perceptive students are well-matched with computerized instruction and that field dependent learners may be fundamentally mismatched with computers as learning tools, her results are less an indication of learner characteristics predicting outcomes than they are reflections of design biases that substantiate the positions taken by Reiff (1996) and Griffin and Franklin (1995-96).

Zehavi (1995) explored the relationship between field type and math ability while simultaneously evaluating the effectiveness of software to teach junior high level math. (Interestingly, Zehavi used the rod and frame test to establish field type, so his results should not be skewed toward a measurement of analytical ability.) Math ability was correlated to field type with field independent students displaying better math skills and performing better with the initial version of the software (Zehavi, 1995). However, parts of the software were identified as more helpful to field dependent learners (Zehavi, 1995). Thus, Zehavi's research focused on revising software so that it would "capitalize on students' strengths...compensate for individual weaknesses, and...supplement the preferred style with a different approach to the problem" (p. 16).

Zehavi (1995) focused on cognitive style and incorporated performance by field type into the formative evaluation of the math program. His results showed that not only did student scores improve after revision, but the second group of subjects also displayed a deeper understanding of more complex concepts than the previous subjects (Zehavi, 1995). These results contradict Lyons-Lawrence's (1994) blanket pronouncement that field dependent learners are not suited to computerized instruction; and confirm Boutin and Chiniens' (1992) claim that conducting formative evaluation of computer based instruction with field dependent learners improves both instruction and performance. Although Zehavi does not describe the software revisions, his results confirm Witkin, et al's (1977) supposition that no significant difference would emerge from properly structured materials.

Liu and Reed (1994) tested students' achievement in learning English as a second language using a hypermedia instructional system. The courseware was designed to accommodate the expected preferences of both field independent and dependent learners: information could be accessed "holistically" or "componentially" (Liu & Reed, 1994, p.423). Indicating that field type is already established as a predictor of foreign language ability, they investigated the relationships between field type, learning patterns, and choice of learning aids provided by the courseware.

Significant differences were found with respect to some aspects of courseware use (Liu & Reed, 1994). Field independent subjects used a larger total number of the learner controlled tools available. Field dependent students chose to view more video segments than either field mixed or field independent students. Field independent students used navigational options more frequently to change the sequence of instruction. Both field mixed and field dependent learners experienced the instruction in the predetermined sequence they encountered. Field dependent learners also spent more time using the courseware than field independent students.

Since no significant differences were found in English vocabulary use when all students were assessed, Liu and Reed (1994) conclude that the hypermedia courseware accommodated different field types equally. While students chose different media (video or text) and used different tools, all learned English. Liu and Reed and Zehavi (1995) begin to answer the problem posed by Burton, Moore, and Holmes (1995).

Weller, Repman, and Rooze, (1994) offer evidence that the effectiveness of hypermedia is correlated with cognitive style. Arguing that hypermedia may "model the structure of human memory" (p. 403), they assert that "it is likely that field dependence/field independence has an important relationship with student achievement" in hypermedia systems (p.405). Interestingly, Weller, et al. consider interactivity in the nature of their treatment groups but limit the definition to navigational opportunities. They constructed four treatments that varied according to the presence of advance or structural organizers and navigational cues. Field independent students outperformed field dependent students across all treatments. No other significant findings were reported (Weller et al., 1994). However, they do report that information seeking behavior tended to follow opposite pathways according to cognitive style and conclude that field type does have bearing on learning from hypermedia (Weller et al., 1994).

Leader and Klein (1996), like other researchers, posit that hypermedia may reflect semantic networks and assist learners with knowledge structure acquisition. Recognizing the role of cognitive style in hypermedia performance, Leader and Klein tested four different database search tools presented in a browser-like environment. When cognitive style was matched with an appropriately designed search tool, no significant differences emerged. Field independent subjects did significantly better with tools that suited active exploration outside the content area, and field dependent subjects were successful with a more contextualized, intuitive browser tool. Cognitive style also predicted the number of content screens visited during a search (field independents saw more) and attitude (field independents were more positive about the database search). These results reiterate the need to consider cognitive style during hypermedia design (Leader & Klein, 1996).

Chou and Lin (1998) examine field style and information search patterns, attitudes, and cognitive map creation. The refine upon one of Leader & Klein's (1996) search tools, a map, assumed to best fit field dependent subjects and present different versions to each treatment group. Cognitive style did not interact with the type of search tool used. Cognitive style was also unrelated to search efficiency, task completion, search accuracy, or attitude. Chou and Lin conclude that varying search tools overcame expected biases that favor field independent learners and supported field dependent ones. They call for more research to verify results.

Lin and Davidson-Shivers (1996) found that field articulation predicted post-test performance as expected with field independent students scoring significantly higher than others after participation in a hypertext learning environment. They also examined the effects of cognitive style on attitudes about different hypertext treatments. Field independent students preferred a content structure that was hierarchical and enjoyed using hypertext overall more than field dependent learners. Field dependent subjects preferred less structure and more random hypertext linkages (Lin & Davidson-Shivers, 1996) although other research points to field dependents' need for pre-imposed structure for successful learning (Davis & Cochran, 1982; Witkin et al., 1977). This research points to considerations other than performance when examining how computer-based environments may be matched to cognitive style.

Small and Grabowski (1992) and Jonassen and Wang (1993) investigate hypermedia and learning from the premise that the structure of hypermedia mimics the structure of human thought and memory. Small and Grabowski examined courseware about American electoral politics and student learning. Jonassen & Wang sought to uncover how subjects acquire knowledge from hypertext systems. Neither group reported significant relationships between field type and the amount of learning that occurred.

Small and Grabowski (1992) found that field type did not predict either the amount or kind of learning that took place. The GEFT was used to determine field independence or dependence, and those scores did not correlate with detailed, qualitative measures of learning (Small & Grabowksi, 1992). Motivation and the kind of information seeking behavior employed by students were reported to correlate with learning (Small & Grabowski, 1992). Using the analogy of library research to argue that learners navigate through hypermedia in the same way, Small and Grabowski describe information seeking strategies as “highly personal, independent, individualized, and self-directed” (p. 447). The possibility that cognitive style -- a stable, inherent characteristic that influences the way in which students process information -- also influences information seeking behavior is ignored. Superficially, information seeking strategies as described would seem to be directed by choices determined by cognitive style. Small and Grabowski’s research would be greatly strengthened by either isolating information seeking strategies from or correlating them with field independence or dependence.

Other results directly highlight relationships between field articulation style and interaction with courseware. Field dependent learners consistently chose to view information presented by videos and supporting graphics while field independent learners chose to use videos with supporting text (Small & Grabowski, 1992). In examining Small & Grabowski’s overall findings, features that accommodate both sets of learning preferences again appear to indicate that the effect of field type on learning may become negligible when hypermedia systems are configured with a wide array of learner controlled options and presentation styles.

Fitzgerald and Semrau (1998) found no significant performance differences between field dependent and independent learners examining hypermedia-based case studies. Similarly, both groups spent equivalent amounts of time with the program. Other characteristics such as prior knowledge and rank in school also failed to predict significant differences in performance. Fitzgerald and Semrau use their results to support the assumption that hypermedia intrinsically supports all learners. This argument is problematic because such positions often fail to recognize either the possibility of confounding variables or poor methodology (as suggested by Tergan's 1997a and 1997b critiques) or any elements present in the hypermedia that might boost field dependent learners' outcomes.

Myers (1998) examined field dependent, field mixed, and field independent students randomly assigned to instructional treatments using variously complex visuals. No significant interaction was found between field type and performance by treatment. However, field independent subjects scored better than field dependent subjects across all treatments. Myers rejects the idea that less complex visuals are required to increase the effectiveness of field dependent subjects' ability to learn from a computer based instructional system.

Kini (1994) also examined the use of visuals and performance by more and less field independent subjects. Originally arguing that instructional strategies should accommodate individual differences, Kini found no significant differences in achievement according to field type. The treatment groups, students who received only text screens and students who saw text plus animated graphics, were randomly assigned from an undergraduate population (Kini, 1994). He attributes the rather surprising lack of difference to the possibility that the design of the lesson for this audience may have confounded the research and does not claim that field articulation style does not predict performance as a general expectation.

Stanton and Baber (1992) explore computer based instruction as modeling cognitive expectations about how learners succeed with hypermedia systems. Stating that both “the structure of the interaction” and “the style of the interaction” are important to understand (Stanton & Baber, 1992, p.148), they examined transfer and retention of skills presented in a computerized training module. Learners were able to choose the order in which topics were presented. While finding that individual choices could be grouped into three broader categories of information seeking strategies, membership in these groups did not correspond to cognitive style. No performance measures differed significantly by group (Stanton & Baber, 1992).

Jonassen and Wang (1993) focused on the acquisition of structural knowledge -- schema transfer -- from a hypermedia program believed to represent the semantic network (schema collection) of a hypermedia expert (Jonassen & Wang, 1993). In a series of experiments, Jonassen and Wang determined that field type as a characteristic of individual learners did effect the type (but not amount) of knowledge acquisition in the hypertext environment. Only field independent students gained structural knowledge (Jonassen & Wang, 1993), but this finding parallels the general expectation that field independent subjects will outperform field dependent subjects despite the medium of instruction.

Tergan (1997a) and Tergan (1997b) offer two critiques of hypermedia research and implicates the examination of individual differences in the inconsistencies and problems he finds. Tergan (1997a) argues that hypermedia systems in and of themselves are not supportive of learning, while Tergan (1997b) reports on findings that computer-based learning as an enhancement to a larger educational context is effective.

Tergan (1997a) deconstructs the assumption that the format of hypermedia can correspond to the structure and thought processes of the human mind. Research that begins with this assumption is fundamentally flawed because no empirical study has shown hypermedia to be “superior in supporting the construction of knowledge structures" (Tergan, 1997a, p. 259). Hypermedia is not a manifestation of the human semantic network presupposed by cognitive psychology – hypermedia structure is not the electronic presentation of semantic structure (Tergan, 1997a). Examining the issue from a design perspective, Yang and Moore (1995-96) arrive at the same conclusion: hypermedia is not intrinsically or naturally a vehicle for instruction.

Secondly, assumptions about the efficacy of learner-controlled and learner-regulated environments lack supporting research evidence. Tergan (1997a) rejects the idea that any learner is capable of "learning from non-linear documents" simply because hypermedia "challenges the students' ability to organize their own study activities" (p. 262) and thus students' respond positively. Tergan argues that learning outcomes with hypermedia are determined by "individual learning prerequisites" that overcome (or are rendered useless by) the organization of materials. He cites results of field dependence/independence research and other learner differences to defeat the idea of an essentialist match between learner-driven experiences and learning.

Tergan's (1997a, 1997b) critiques may be somewhat harsh in his assumption that little useful research exists due a wide range of theoretical and methodological flaws. Both analyses are useful at placing individual differences at the center of hypermedia design concerns. What data are available point to field articulation as a fruitful line of inquiry into learners' experiences. Arguing against the tendency for research to be "dominated by a technological notion of medium," he espouses a research atmosphere that uses "a psychological point of view putting the cognitive processes of the learner in the center" (Tergan, 1997b, p. 281).

Use of Color as a Cueing Strategy

Reardon and Moore (1988) argue that the field articulation construct is "especially applicable to the design and utilization of *visual* instructional material" (p. 355, emphasis original) because it accounts for how learners process the stimulus field. They also call for research that addresses the use of organizational strategies and presentation controls available to the learner that may function to support differences in learners' styles. The presence of color is an option that can now be managed by instructional designers as a cueing strategy to focus visual attention on the most pertinent information for the learner. The appropriate use of color is essential for meeting the needs of different learners (Berry, 1984; Berry, 1991). Color cues may help the encoding process if color is not merely an aesthetic enhancement but rather provides meaning or organization (Berry, 1991).

Field independent and field dependent learners may respond to the presence of color differently (Berry, 1991), and color may help field dependent individuals recognize pertinent cues embedded within a complex visual (Moore & Dwyer, 1991). Color-coded materials helped field dependent students learn more effectively and reduce the performance differences between field independent and field dependent learners (Dwyer & Moore, 1997-98; Dwyer & Moore, 1991-92; and Moore & Dwyer, 1991).

Color may help field dependent learners overcome difficulty with the disembedding task (Dwyer & Moore, 1991/92; Dwyer & Moore, 1997/98; Moore & Dwyer, 1991). Berry (1991) calls for further research on how the use of color that provides meaningful or elaborative cues intersects with cognitive style. Dwyer & Moore (1997-98) place learner characteristics at the center of the rationale for the use of colored visuals: "field dependent individuals…fuse all segments within the visual field and do not view or interact with the visual components discretely" (p. 244). These conclusions support the argument that color can be used to support individuals with different cognitive styles in a hypermedia environment.

Summary of Literature on Hypermedia and Cognitive Style

The cognitive style of field independence/dependence does appear to have a role to play in whether or not learners succeed in a computer-based setting. As this review has shown, the use of hypermedia in instruction and how learners interact with its elements are important mediators of the learning experience. Packard, et al. (1997) and Weller, et al. (1994) establish that cognitive style has a measurable effect on performance by learners in computerized environments. Zehavi (1995), Liu and Reed (1994), and Small and Grabowski's (1992) results reveal that hypermedia can be constructed to accommodate the preferences and strengths of both field types. Lyons-Lawrence (1994) serves as a warning, however, that hypermedia is just as susceptible to undiscovered bias as other forms of instruction. The possibility that cognitive style research can be confounded by courseware bias is also brought forth by Stanton and Baber (1992). Tergan (1997a and 1997b) critically deconstructs accepted research strategies and repositions learner characteristics in the center of a reconstructed conceptualization of hypermedia research.

Lin and Davidson-Shivers (1996) point to attitudinal effects of cognitive style. Myers (1998) and Kini (1994) fail to find significant effects between field type and performance given different visual presentations of instructional material, but Packard, et al (1997) succeed. And, Jonassen and Wang (1993) provide a useful caveat to expectations that learning will necessarily follow the introduction of hypermedia driven instruction as their results underscore the need to prepare learners before implementing unfamiliar learning tools.

If cognitive style is of imminent relevance to all of those involved in instructional design and development (Sadler-Smith, 1996, p.191), and predicts or correlates with how learners behave within computer based instructional systems, then research should continue to elucidate those behaviors especially as reported results are mixed (Davis, 1991), and research assumptions have been criticized (Burton, et al., 1995, Tergan, 1997a, Tergan, 1997b). Some studies uncovered significant differences in performance or behavior between students' levels of field dependence and various visual or structural aspects of computer based instruction. Other studies have not uncovered such differences.

Research that explicitly considers cognitive style when designing instruction has eliminated performance differences by incorporating visual or structural elements thought to be appropriate for field dependent learners (Zehavi, 1991, Davis, 1991). Hypermedia can fulfill the claim that divergent learner populations will be able to match style with hypermedia's capabilities, but this situation occurs only when differences are recognized and accommodated. This research in tandem with research finding significant performance differences supports the argument that cognitive style is an important factor for individuals in computer-based learning environments. Moreover, the variety of possible hypermedia elements that may be present have not been fully explored.

The Concept of Interactivity in Hypermedia

The hypermedia literature reviewed in the previous section did not explicitly examine interactivity. Actual screen elements with which users may interact that are key to the instructional goal of a program have not been addressed. Interactivity may be listed as a characteristic of a hypermedia system (Stanton & Baber, 1992; Weller et al., 1994), but it is difficult to operationalize. Jonassen (1985) claims interactivity is a means to create flexible instruction that suits all cognitive styles. Like the broader category hypermedia, interactivity is regarded as a means to impart complex schemata into the minds of learners (Jonassen, 1985; Lawless & Brown, 1997). It deserves scrutiny on both grounds.

Reeves (1997), in announcing the *Journal of Interactive Learning Research*, describes research on computer-driven, interactive learning environments as “an applied field” with a “responsibility to assure that…work is both scientifically sound and socially responsible” (p. 6). First, the concept of interactivity in computer-mediated learning environments deserves scrutiny. Second, interactivity as a research problem requires attention: what is being measured, how, and why?

Reeves (webpage) further charges that the “research community must face the reality that our efforts have failed to provide adequate guidance for developers and practitioners” and cites popular, political criticisms of the use of computers to improve educational environments -- most notably Oppenheimer, (1997). Weller et al. (1994) argue that "electronic technology has outdistanced instructional design processes to the extent that instructional designs and techniques have been mere reactions to the developing technology" (p. 401).

Definitions and Concepts from the Literature

Definitions of interactivity are available in the literature although not all are either clear or useful. While some researchers explicitly state a meaning of "interactivity", other publications leave the reader to make a best guess of what the term is meant to designate. Writers may offer examples of "interactive" programs but not clear explication of the concept itself. (See, for example, Dockterman, 1995; and Emmanouilides-Linn, 1997). Too often, the reader is left to rely on impressions of "interactivity" as a buzzword that may not correspond to either the reader's prior experiences or the literature's intent. Published definitions also range in scope and vary in the characteristics attributed to interactivity.

Descriptions of multimedia and hypermedia systems similarly incorporate some notion of "interactivity" as a system characteristic; but, the word "interactivity" itself may be inadequately or problematically defined. Burton, Moore, & Holmes discuss the history of multimedia / hypermedia and the idea of interactivity as part of its development. Romjiszowski (1993) equates hypermedia with interactive learning experiences. Jonassen (1985) lists different types of "interactive" programs: simulations, tutorial, drill and practice, and problem-solving.

Reeves (1997) provides a broad description of interactive learning environments:

> A learning environment is 'interactive' in the sense that a person can navigate through it, select relevant information, respond to questions using computer input devices such as a keyboard, mouse, touch screen, or voice command system, solve problems, complete challenging tasks, create knowledge representations, collaborate with others near or at a distance, or otherwise

engage in meaningful learning activities. (p. 5)

Weller (1988) offers that "interactivity enables learners to adjust the instruction to conform to their needs and capabilities" so that learners receive feedback as a consequence of their actions (p. 23). Borsook and Higginbothan-Wheat (1991) define interactivity as an effective feedback loop in which the computer and learner "are interdependent"(p. 11). Milheim (1995/96) defines interactivity as "the two-way communication that can occur between the instructional medium…and the learner"(p. 225) as does Jonassen (1985).

Wagner (1997) notes that "philosophical speculations" are easier to generate than operational definitions, but offers her definition as "real time exchanges of audio, video, text, and graphical information" (p. 19). Exchanges may be between learners or between learners and the instructional system providing the content. Further, interactivity must serve the purpose of moving "learners toward an action state of goal attainment" (Wagner, 1997, p. 21). Interactivity is about performance outcomes – not technology.

Less satisfying definitions include those by Bills (1997) who offers only that interactivity "provides the student with the means of being actively involved in the learning activity" (abstract) and Bork's (1992) notion of active learners participating with content via control mechanisms without any sense of agency or reciprocity between the learner and the instructional system. Latchem, Williamson, and Henderson-Lancett (1993) fail to separate the idea of interactivity from the technology that drives it.

Other uses of the word "interactivity" emphasize the navigational properties of a program such as hyperlinks, sequence controls, and menu options. (See Emmanouilides-Linn, 1997; Lawless & Brown, 1997; Lewis & Jansen, 1997; Preece, 1993; Stemler, 1997; Weller et al., 1994). For example, Foote (1994) proposes using computer-based systems to teach geography but limits the idea of interactivity to following hyperlinks and making other navigational choices. Weller, Repman, and

Rooze (1994) state “the interactivity provided by modern electronic teaching tools appears to be a *generic* interactivity, providing a great deal of control and branching possibilities to all users” (p. 402, emphasis original). Baxter (1996) adds the component of question/answer feedback to navigation in order to provide “meaningful” interaction for learners. Weller (1988) likewise marries feedback and navigation to define interactivity.

The importance of clearly establishing the meaning of interactivity and developing a robust, testable concept has been argued by Borsook and Higginbothan-Wheat, 1991; Dockterman, 1995; Gilbert and Moore, 1998; Jaspers, 1991; Kirsh, 1997; Milheim, 1995/96; and Reeves, 1993. Given the larger educational context described by Reeves (webpage), successful research requires an operationalized understanding of interactivity as a measurable, articulated variable. In order to achieve this goal, how should the idea of interactivity evolve? Dockterman’s admonition to “get our expectations right” (p. 4) about interactivity as both a term and an instructional goal is a reminder that interactive technology is neither the impetus for nor the desired end of instructional design: interactive experiences “needn’t have anything to do with technology”(p. 58). Its description, however, may spring from different philosophical outlooks.

Gilbert and Moore (1998) scrutinize interactivity as a <u>relationship</u>. Interactivity can be approached as either a social or instructional exchange. In both instances, interactivity is the relationship between the learner and some component of the learning environment. Social interactions are the exchanges between learners and between learners and instructors that often enhance the learner’s experience without involving instructional content. Instructional interactions that rely on technology are the exchanges between learners and presented content such as feedback, pacing, navigation, and information exchange (Gilbert & Moore, Table 1, p. 30).

Milheim (1995/96) approaches interactivity as an <u>instructional strategy</u> employed to maintain communication between the learners and the material. By examining interactivity through the attributes of the instructional system that make it possible, Milheim analyzes the purpose of interactivity for learning. Moreover, interactivity as an instructional variable can be captured and measured. It is no longer simply an inherent characteristic of a computer mediated learning system or a de facto property of a computer. Jonassen (1985) also envisions interactivity as a strategy – but one linked to the "how-to" of transmitting knowledge and structure to learners.

Borsook and Higginbotham-Wheat (1991) also argue against uncritically approaching interactivity as something that is merely "intuitively appealing" (p. 11) without more definitive exploration. Yet, despite the passage of almost a decade since Jaspers' (1991) and Borsook and Higginbotham-Wheat's initial arguments, the idea of interactivity has not received an overwhelming amount of attention as a research problem in instructional technology. Taken together, all of the authors cited help to position the notion of interactivity as something other than the presence of gadgetry. Interactivity can be understood as a principle or abstraction that can be examined separately from the tools or media that employ it. Interactivity becomes that which requires agency and reciprocity. To speak of "interactive software" in a technological sense but absent a learner has incomplete meaning.

Research and Measurement

Merrill, Li, and Jones (1990) argue that "there is a critical need for significantly improved methodology and tools to guide the design and development of high quality interactive technology-based instructional material" (p. 7). On what principles and data should a methodology and tools be based? How should the effectiveness and consequences of interactivity be measured and evaluated? What should be measured as the value(s) that represent the interactivity of a system? Most importantly, in what ways can the "implied assumption" that interactive software "will improve the *quality* of instruction through increases in the *quantity* of communication" (Gilbert & Moore, 1998, p.32, emphases original) be tested?

Kirsch's (1997) rethinking of the "basic idea of interactivity" (p. 82) provides an example of how research may explore interactive instruction. Kirsch seeks to move interactivity beyond the limits of a "sophisticated feedback loop" (p. 83) by rethinking the decision-cycle model prevalent in design. Jaspers (1991) argues for developing a theory of interaction that encapsulates the qualities and outcomes of encounters between learners and instructional systems.

Najjar (1996) claims to examine why learners perform better in multimedia environments than in "traditional" classrooms and cites "interactivity" as one of the reasons. Interactivity is described only as "mutual action between the learner and learning system" (p. 131), and yet Najjar finds this definition unique enough to assert that multimedia-based instruction is interactive where traditional instruction is not! Emmanouilides-Linn (1997) focuses on student creation of interactive maps in geography education yet does not adequately distinguish between navigation, multiple modes of presentation (text, sound, or graphics), and what is meant by "interactivity." Bills, despite poorly defining interactivity, conducted an experiment exploring student achievement and interactive courseware. Milheim (1995/96) describes earlier research linking achievement and time on task with interactive features of content presentation systems.

Borsook and Higginbotham-Wheat (1991) argue that seven variables can be used to determine the presence of interactivity and account for it -- the presence of any of which render a system "interactive" to varying degrees. The seven are: immediacy of response, non-sequential access of information, adaptability, feedback, options, bi-directional communication, and the length of time a learner must attend to the presentation before the next opportunity for interaction (p. 12-13). Jaspers (1991) offers a classification of media types that support increasing amounts of interactivity: linear media, feedback media, adaptive media, and communicative instruments (p. 22). Both the amount of interactivity and the various expressions of it could be explored from these rubrics, but both are oriented towards examinations of instructional systems and not learners' experiences.

Measuring interactivity often suggests the idea of a continuum or graduated scale of interactivity levels that will impose some discrete value to be captured and analyzed. Gilbert and Moore (1998) and Stanton and Baber (1992) both describe examining interactivity as a continuum or set of continua that range from very limited relationships between learner and the instructional system to more complex ones. Romjiszowski (1993) describes interactivity as levels from “surface” to “deep” as learners’ depth of processing and critical thinking increases. The difference between “low” and “high” levels of interactivity can be analyzed as the number and types of relationships that may establish agency (on the learner’s part) and reciprocity (from the instructional system). Gilbert and Moore match different instructional activities that create interactivity with examples of technologies that support them.

But what, exactly, can be measured? What are the units of interactivity? Merrill, Li, and Jones (1990) discuss instructional transactions as “a particular instructional interaction with a student” that is a “mutual, dynamic, real-time give-and-take” (p. 9) between both the learner and the technology. (This position parallels Wagner’s (1997) notion of exchange.) A transaction seems to be an instance of interactivity – one instance of feedback, or information exchange, or learner control over presentation or pace, or the instructional system adjusting to the learner’s abilities and preferences. The notion of counting the number of transactions available, or the number of opportunities for interaction that a learner chooses to engage, begins to appear as a measure of the amount of interactivity present. While the idea of counting transactions seems rather simple, it rests on the prior challenge of adequately defining and identifying the interactive characteristics of an instructional environment. (See Bork (1992) for an example of frequency determining degree and quality of “interactivity”).

Operational Definition of Interactivity

Definitions of interactivity from the literature include a number of common elements: learner control over content sequences or pace through navigational components, information exchange, and feedback (often restricted to knowledge-of-response models). Instructionally, interactivity serves a goal: the acquisition of information. In order to pursue the effects of interactivity, the idea of interactivity must be operationalized into an observable phenomenon. Interactivity is defined here from a perspective that privileges learner behavior because behaviors are observable in the relationship between learner and environment. Examining interactivity as a behavior, the key question becomes: what do learners do?

> ***Interactivity*** is a behavior loop that begins when a learner apprehends an on-screen cue that prompts an action that changes the instructional environment.
>
> ***Feedback*** is the responsive change by the hypermedia system that generates a new environmental configuration – the presentation of new visual information – to the learner.

This model of interactivity captures the idea of navigation but isn't only a notion of "going somewhere" within the instructional system, nor is feedback restricted to traditional expectations. It grounds the concept of learner control within any given hypermedia system's characteristics. Learner control only exists if learners correctly apprehend the cues / signals presented by the instructional material to mean that interactivity is possible and acts in response to them. Actions by both the learner and the system are observable and can be captured by measurement criteria.

The following section examines the use of interactive hypermedia in the discipline of geography. It emphasizes the use of visual learning materials in the discipline and describes the adoption of computers and hypermedia programs as teaching tools.

Computer-based Learning in Geography

A critical perspective on hypermedia and interactivity along with an emphasis on the importance of visual information ground the review of computer use in geography education. Geography is a broad discipline that utilizes computer technology in a number of ways. Geography educators, especially since the mid-1980s, have clamored for multimedia and hypermedia based instruction as potentially effective ways in which to present spatial relationships through visual representations. A number of educational uses for computers in geography have been identified including data analysis, presentation of facts and concepts, modeling, simulations, games, materials production, and exploratory problem solving environments (Fitzpatrick, 1990; Flowerdew & Lovett, 1992; Gold et al., 1991; Unwin, 1991). Despite the popularity of hypermedia environments, geography educators produce very little data about their instructional effects (Downs, 1994).

The history of computer use in geography can be traced to the beginnings of the “quantitative revolution” in the discipline at the beginning of the 1960s (Maguire, 1989; Shepherd, Cooper, & Walker, 1980). Profound developments in the field such as computerized mapping, geographic information systems (GIS), and remote sensing would not have been possible without computer technology that could generate powerful visual and spatial models of geographic processes (Shepherd et al., 1980). By the late 1960s and 1970s, geography educators were exploring the specific use of computers as teaching and learning tools. These two (sometimes complementary) trends demarcate the role of computers in the discipline. Geography is both a field that creates, implements, and teaches computer technology as integral to its practices (Reeve, 1985) and is simultaneously a field well suited to teaching and learning with computers (Fielding, 1968; Fitzpatrick, 1990; Foote, 1994; Gold et al., 1991; Kent, 1992; Maguire, 1989; Shepherd, 1985; Shepherd et al., 1980).

Flowerdew and Lovett (1992) published a humorous review of computer use in teaching that includes a key caveat: “we want to use computers in teaching if, and only if, they are a real help for our geography students" (p. 37). The cautionary note they strike as two ordinary professors adrift in a sea of cables and central processing units resonates throughout geography education, computer use should be effective and meaningful. (See Fielding, 1968; Foote, 1994; Nellis, 1994; Shepherd, 1985; Shepherd et al., 1980). An examination of the geography education literature highlights both why Flowerdew and Lovett's wish is critical to implementing instructional technologies successfully and how geography has failed to measure its own progress toward that end.

Visuals in Geography Education

Instructional technology in geography is rooted in the use of visuals to present information and concepts. Photographs and slides have been important teaching and learning aids for over fifty years and remain common in the classroom (Fredrich & Fuller, 1997). More recently, computers have been able to offer sophisticated graphics, and geographers hope they will prove more effective than other visual media (Fredrich & Fuller, 1997). Regardless of the mode of presentation, visual information is historically central to geography instruction.

Parker (1944) argued that the value of photographs as "basic laboratory material" (p. 434) could not be underemphasized and developed specific guidelines for photograph collections and viewing environments for learners. Vegter (1949) reinforced Parker's arguments and also reported on student preferences for visuals in instruction. Logan (1950) began with early research findings on the power of visual memory to make her case for images as key instructional tools. Logan emphasized the classroom environment necessary for successfully teaching from visuals and examined best practices. Taken together, these early publications underscore the longstanding centrality of visual information for the geography learner and the concurrent need to present that information effectively.

Maps are perhaps the most iconic representations of geography as a discipline. Defined as "an important visual or *graphic communication* medium whereby encoded spatial messages are transmitted…to the reader" (de Blij & Muller, 1997, p. A-6, emphasis original), maps are, in a sense, the image of the discipline. As learning tools, maps represent one of the most common and most useful visual resources for learners (Downs, Liben, & Daggs, 1988). As complex images, maps demonstrate the prime importance of visual information in geography education (Underwood, 1981). Maps are the visual "representation(s) of the world" (Downs, et al. 1988, p.683) that form the foundation of geographic skill and inquiry (Downs et al., 1988).

Reliance on such a key visual form, however, also implicates the innate abilities of the learner to understand and manipulate visual data (Downs et al., 1988; Underwood, 1981). While geography texts tend to present maps as transparent modes of visual communication that require little or no effort to comprehend (see, for example, Getis, Getis, & Fellman, 1988; Marshall, 1991; Renwick & Rubenstein, 1995; Stansfield, 1998), the visual-spatial abilities brought by the learner to the map reading exercise have direct bearing on success (Underwood, 1981). Underwood found a strong, predictive relationship between visual-spatial ability and performance on a map-reading exercise. She concludes that geography instruction needs to "develop spatial skills in the context of the cognitive abilities of the map user" (p.55) because "map reading requires recognition of geometrical configurations variously oriented in space, and of differences and similarities between patterns" (p.58). Research into cognitive style supports Underwood's conclusion: field independent learners are more skilled at map interpretation (Reardon & Moore, 1988).

The advent of the computer into the curriculum and classroom continues to underscore the power of images and graphics in geography education through new modes of presentation. Multimedia computers allow instruction to include complex images and animations in a highly visual discipline that may not be available through other technologies (Peterson, 1994). Nellis (1994) further argues that learners <u>require</u> computer-based environments to best apprehend geographic processes and spatial patterns through visual display and on-screen manipulation. The development of sophisticated displays for desktop computers was central to their acceptance as learning tools (Maguire, 1989). Indeed, the inability of first generation microcomputers to produce complex, realistic images represented a serious educational obstacle in the geography classroom (Archer & Lavin, 1981).

The next section provides an overview of computer use in geography. The history of implementing computers as teaching and learning tools reveals that the rate of technology adoption increases with the ability to produce and display visuals, especially those that can illustrate complex processes and concepts. Visual display capabilities can be seen as a determining force in the history of instructional technology in geography.

History of Computer Based Instruction in Geography

The first generations of computers put to instructional purposes were used to create rigid "programmed instruction" modules without visuals (Shepherd et al., 1980; Unwin, 1991). Fielding (1968) offers a glimpse into the early conditions of computer-based learning. The computer was perceived to be a tutor or replacement for lecture sessions instilling information into rather passive learners, and the lack of visual information was problematic.

By 1980, falling computer costs and the availability of microcomputers enabled more geographers to develop software and learning experiences for students (Gold et al., 1991; Maguire, 1989; Shepherd et al., 1980). Shepherd et al., (1980) note that as geography educators focused on specific content and concepts, developers shifted from teacher to learner centered software. Students could engage with computer-based materials through simulations, games, and exploratory exercises that separated the experience from the passive acquisition of knowledge by interacting with visual presentations (Shepherd et al., 1980). Overall computer use in the 1980s continued to rise (Maguire, 1989). Simultaneously, desktop computer power increased, and graphic display improved.

By the end of the 1980s, educational uses for computers were more common, and multimedia promised exciting possibilities (Peterson, 1994). Expanding computer power with graphics capabilities, lower prices, and software improvement coupled with better understanding of the organizational consequences of computer integration in the classroom supported a range of computer activities (Gold et al., 1991). Kent (1992) reports an overall positive attitude about computer use in geography education by mid-decade. More examples of simulations, games, analytical exercises, and tutorials for human geography are described by Gold, et al, Archer & Lavin (1981), Shepherd (1985), Maguire (1989), and Kent (1992).

The advent of multimedia ushered in the 1990s with an increasing interest in the development of computer-based materials. (See, for example Adams, 1995; Carstensen, Shaffer, Morrill, & Fox, 1993; Fitzpatrick, 1993; Foote, 1994; Gold, et al.; Keller, Davis, & Canessa, 1996; and Tilton, 1994). Lueckenhoff (1993) and Adams (1995) discuss the use of authoring software to create multimedia – a significant improvement over the programming environments of the 1970s and 1980s. Krygier (1994) pitches the merits of a specific authoring program. Carstensen, et al combined authoring software and programming to develop tutorials and simulations for human geography instruction. Foote proposes an entire curriculum produced in hypermedia for undergraduate study because multimedia / hypermedia is "fundamental" to geography education. Fitzpatrick notes that student projects may be revolutionized by multimedia authoring tools just as instructor designed material are.

Olson (1997) notes the increasing presence of web-based multimedia (hypermedia) employed by geographers during the 1990s in her overview of recent technological advances' impact on instructional environments. With multimedia / hypermedia taking center stage by the early 1990s, the role of computers continued to receive attention as an instructional tool that could incorporate the new bells and whistles. In the 1990s, learning software took advantage of sophisticated graphics, animations, sounds, and learner controls (Gold et al., 1991), and the idea of "interactivity" as a necessary characteristic began to appear in the literature. (See Bishop et al., 1995; Carstensen, Shaffer, Morrill, & Fox, 1993; DiBiase & Krygier, 1994; Foote, 1994; Krygier, Reeves, DiBiase, & Cupp, 1997; Proctor, Sutton, & Michaels, 1995). Olson (1997) goes so far as to claim that multimedia itself signals the presence of an "interactive" environment. The onslaught of multimedia / hypermedia and the idea of "interactivity" add to the uncritical nature of computer-based instruction in geography even as it positions geography within larger trends in instructional technology.

While a number of arguments about the efficacy and / or usefulness of computers have been made over the past thirty-odd years by geographers, little research is available from inside geography to measure the effects of changing technologies. Even the comprehensive works by Maguire (1992, 1989); Shepherd, et al., (1980); and Gold, et al., (1991) have no product evaluation or research results to offer. Flowerdew and Lovett (1992) provide first-hand observations of technology's effect in their classrooms but no systematic evidence of changes in the learning environment. Foote (1994) goes so far as to propose an entire curriculum without substantive theoretical or practical foundation.

Educational Research in Geography

Despite Fielding's (1968) decree that robust research must accompany technology diffusion, complete with a warning that computer-based learning "should not be obstructed by invidious comparison with traditional lecture procedures" (p. 481), little data is to be found twenty-five years later (Downs, 1994). Shepherd (1985) and Unwin (1991) call for research without success. Lamenting a wider problem than scant data about computer-based methodologies, Downs demands renewed research efforts from all geography educators:

> "the field of geography education is sadly lacking in empirical data that might inform and underpin decisions about standard setting, curriculum design, materials development, teaching strategies, and

assessment procedures'" (p.127).

The integration of computer-based learning is implicated within all these areas of research and points to a fundamental irony arising from the split between those who teach about and those who teach with computers. Geography, the discipline that eagerly embraced computers for data gathering and analysis during the quantitative revolution, has yet to turn any of that analytical potential fully onto itself.

Maguire (1992) typifies the broad claims made by geography educators about computers: "computers can make significant improvement in the quality of teaching earth and social science" (p. 317) but fails to explain how or why. As Downs (1994) notes, this type of posturing can no longer substitute for adequate research. Even Foote's (1994) lengthy description of the "Geographer's Craft" curriculum project fails to acknowledge the dearth of support for claims about hypermedia. Foote expects that "by its very nature" (p. 19) hypermedia will encourage independent learning, problem solving, focus on key concepts, and the correct associations between different ideas and data sets; and make corollary lectures more efficient.

Apart from overly optimistic expectations about the nature of the hypermedia beast, a handful of published research and evaluation articles can be examined. Proctor and Richardson (1997) and Proctor et al. (1995) studied the effects of multimedia in human geography instruction. Proctor et al. used time logs, essay analysis, and student surveys to gather information on performance outcomes and attitudes. While noting that the study lacked some controls due to software revision, they report conceptual learning gains, overall student satisfaction, student belief that the software promoted appreciation of human geography, and a relationship between prior computer familiarity and satisfaction.

Proctor and Richardson (1997) utilize both quantitative and qualitative methodologies to explore the same multimedia modules examined by Proctor et al (1995). Students completed a survey and one of two modules with a post-test. Student performance did not differ across the two content areas of the modules, and all students reported general satisfaction with their experiences regardless of score.

All students also reported a belief that the modules were a valuable learning experience. They argue for combining qualitative methods with quantitative analyses for a more complete description of the learners' experiences.

Krygier, Reeves, DiBiase, and Cupp (1997) published comprehensive design and evaluation guidelines for geography educators stemming from their own software development cycle. Acknowledging the current data drought, Krygier et al. closely link evaluation methods with overall product goals and the design process. They support their choices of two qualitative methods (focus groups and surveys) by focusing on information about general student experiences and not performance outcomes. However, student responses did lead to the development of future research questions requiring quantitative approaches – supporting Proctor & Richardson's position that both methods are necessary in tandem. Krygier, et al. found that student exposure to multimedia-based learning materials as part of a course improves student attitude toward computer-based learning and students' abilities to set learning goals vis-à-vis multimedia resources. Students also noted that graphic displays of concepts were important learning aids. These findings begin to support the long-argued claim that complex visuals assist geography instruction by illustrating processes and ideas through computer technology.

Chrisman and Harvey (1998) offer an evaluation of a hypermedia enhanced course although it derives from a small number of participants. They reiterate the finding of positive student attitudes despite some difficulties (access, network problems, software bugs). Overall, geography students appear to enjoy learning from hypermedia and to find that environment supportive of their learning goals.

While the potential for individualizing instruction has been a touchstone for the proponents of computer-based learning (Fielding, 1968; Gold et al., 1991; Maguire, 1989), research into learner differences is scarce. Moreover, the idea of individual differences between learners is not examined critically. Differences among geography learners are mostly conceptualized along the ability spectrum –

high / low achievers, year in school, amount of prior knowledge, or standardized test scores.

Fielding (1968) emphasized student ability as the only learner difference accommodated by computer-based learning and "ability" remains an undefined, a priori characteristic without relationship to the potential biases of the instructional design of materials. Proctor, et al's (1995) subjects were characterized by year in school, major, computer familiarity, SAT score, and expected grade. Students' "abilities" can be immediately implicated in all of these items except computer familiarity, and the researchers did not look for correlations between these items. (Nor is the expectation that high ability learners unfamiliar with computers would have an easier learning experience than low ability learners unfamiliar with computers unreasonable. The authors did not explore this question.) The findings do not offer very robust evidence about learner characteristics effecting student experiences. Proctor and Richardson include gender as a learner characteristic (that did not predict differences in performance), but other characteristics are potentially correlated measures of ability: math skill, map reading skill, SAT score, and year in school.

Krygier, et al. (1997) do not address individual differences directly, but they do discuss both positive and negative evaluations of their software. The researchers note that different reactions most likely stem from divergent learner populations but did not explore the sources of difference. Chrisman and Harvey (1998) mention the possibility of hypermedia accommodating individual learning styles but did not pursue style difference in their evaluation. Like Krygier, et al., Chrisman and Harvey report some learners became confused by the material and requested more structure and clearer contexts – highlighting the need for more research and evaluation of geography programs.

Grieve and Davis (1971) and Satterly (1979) directly address a measurable difference between learners, field dependence / independence, and its general effects on learning geography. Satterly reports the expected performance differences:

levels of field independence / dependence correlate with grades. Grieve and Davis offer an early exploration of the idea that different learners may respond more or less favorably in varying learning environments and identify a group at-risk for suppressed performance outcomes (field dependent males). This pursuit has not been continued by geography educators, and Grieve and Davis's results are not reflected in current literature about hypermedia-based learning contexts even though computer-based learning may be increasingly prevalent. Only Underwood (1981), with her examination of visual-spatial ability and map reading, calls for research that specifically addresses the cognitive processes and needs of learners and success with common geographic tasks. Despite demonstrating a strong link between visual competency and map analysis, Underwood's potential contribution to geography education remains untapped.

The history of computer-based learning in geography education is characterized by the challenges of hardware acquisition and programming in the 1970s, the identification of obstacles to diffusion and creative developments in the 1980s, and the promise of multimedia / hypermedia in the 1990s to offer learners more sophisticated computerized materials. An historical lack of research data problematizes the claims and arguments made by proponents of hypermedia about its efficacy in general and its specific ability to accommodate individual learner preferences. Downs (1994) argues the situation arises from having "confused activity with movement" (p. 127): geography educators have done much, accomplished little, and devalued research. "Existing research in geography education fails to meet generally accepted research standards…" [and is] "handicapped by a lack of coherent theory" (Downs, 1994, p. 129). Improved instruction can only arise from improved research, and improved research requires borrowing "theoretical structures" from "the nexus of developmental psychology, cognitive psychology, and education" (Downs, 1994, p. 129).

Summary

The cognitive style of field independence-dependence has been researched as an influence on how learners perform in computer-based learning environments because it describes the visual perceptiveness and analytical abilities of learners. Computer-based environments are generally referred to as hypermedia systems if they include multiple presentation formats, learner control, and interactivity. Overall, field independent learners perform better than field dependent learners unless the hypermedia materials includes features that assist field dependent learners. Conflicting research results suggest that how field articulation influences learners' experiences is not a clear-cut problem.

Interactivity, an oft-cited feature of hypermedia, is a problematic concept. Definitions of interactivity include the presence of information exchange, feedback and learner control. Instructionally, interactivity is assumed to help learners acquire knowledge from the content presented. While a number of different descriptions are available in the literature, definitions vary with the philosophical outlooks of researchers. Defined here, interactivity is a sequence of related behaviors that begins when a learner acts upon a visual cue and the hypermedia system responds by changing the instructional environment (presenting new visual information).

Little research has examined how field articulation may influence learners' use of interactivity as a function of hypermedia. Evidence from studies of other attributes suggest that field dependent learners may prefer to spend more time using the features of hypermedia while field independent learners may prefer to employ a wider range of features.

As a discipline, geography relies on the ability of practitioners to interpret and create sophisticated visual presentations of data and processes. The ability to disembed relevant visual features and restructure visual information as measured by field style is implicated within geography instruction twice. First, research shows field style is related to performance in geography. Second, field style shapes individual experiences with computer-based learning. The discipline has not examined the relationship between field independence / dependence and computer-based, interactive environments as predictive of learning outcomes even though learners encounter complex visual information.

Conclusions and Need for Research

This literature review explores the connection between cognitive style and performance with instructional hypermedia. That connection is key to furthering research in geography education as geography educators continue to embrace computer-based learning. Implications for successful implementation of hypermedia can be uncovered by inquiring into cognitive style differences and their consequences for learners (Ayersman, 1993; Chinien & Boutin, 1992 / 1993; Kini, 1994; Packard et al., 1997; Sadler-Smith, 1996; Stemler, 1997; Tergan, 1997a; Weller et al., 1994; Whyte et al., 1995). Ironically, while geography educators have not examined the intersection of cognitive style and hypermedia, other researchers have used maps as instruments when examining field articulation and learning (see Reardon & Moore, 1988). Educational research in geography does not adequately address either the consequences of current instructional technologies or the needs of different learners (Downs, 1994).

What are the likely effects of a learner's cognitive style on the use of interactivity in a computer-based environment? Geography educators lack this kind of data, and examinations of hypermedia and cognitive style have not critically analyzed interactivity even as it has been touted as a feature of computer-based learning. Cognitive style is expected to influence learners' behavior given that hypermedia materials are predominately visual and the effect of interactive learner controls is to change the presentation of information on the computer screen.

Chapter Two

METHODOLOGY

Introduction to Study

Geography education relies on the presentation of visual information to transfer key concepts to learners (Fredrich & Fuller, 1997; Nellis, 1994). Map interpretation is a common strategy to help students learn geographic ideas and models (Emmanouilides-Linn, 1997). Like interpreting other kinds of visuals, map reading is a task influenced by field dependence (Reardon & Moore, 1988) and general visual-spatial ability (Underwood, 1981). If a learning task requires recognizing and manipulating the internal elements that comprise a map in a computer-based environment, then the field style of the learner will have direct bearing on the student's achievement. Field style and visual-spatial ability correlate with map skills such that field dependent individuals are less successful at tasks requiring map recognition (Reardon & Moore, 1988; Underwood, 1981).

In hypermedia settings, field independent participants may be more successful in a less structured environment while the lack of an organizational structure available for reference is a condition that adversely effects field dependent learners (Witkin & Goodenough, 1979; Witkin et al., 1977). Providing interactivity as part of computer-based learning has been shown to assist both field dependent and field independent learners (Jonassen, 1985; Liu & Reed, 1994; Weller et al., 1994)

Review of literature identified the following variables of interest: the field independence / dependence cognitive style, interactivity in computer-based environments, and the speed and accuracy of field independent and field dependent learners when asked to complete visually complex tasks. This section presents key points from the literature supporting the selection of each variable, the purpose of the study, research questions, and the experimental hypotheses. Following sections describe the experimental design, the development and selection of instruments, procedures and participants, and appropriate statistical analyses.

Cognitive Style

Review of literature establishes that the cognitive style field dependence/independence can determine learners' success in hypermedia learning environments. The key differentiation between the two types of field articulation is the ability to distinguish and manipulate a figure within a larger visual field (Witkin, Oltman, Raskin, & Karp, 1971). Witkin et al., (1977) established that field dependents' difficulty with a disembedding task rests in part in a tendency to attend to those cues that are more salient than relevant. Relevant visual information that is not prominent against the visual field may not be encoded, and an environment that focuses the field dependent learners on critical cues may ameliorate this deficit (Davis, 1991; Witkin et al., 1977). Field dependent learners also require more organizational structure to succeed at problem solving tasks than field independent learners (Witkin & Goodenough, 1979; Witkin et al., 1977).

Interactivity

As presented in the literature review, interactivity is defined as the availability of a learner control that alters the appearance of the visual information on the computer screen. Because field dependent individuals are less able to recognize pertinent cues and disembed key information from complex visuals than are field independent individuals (Riding & Cheema, 1991; Witkin, et al., 1977), the effects of learner control over the appearance of visual information are of interest. Color change was chosen as the response to learner interactions with the computer based material because it is an appropriate method for revealing the organization of an image (Berry, 1991), and the use of contrasting colors may lessen common performance differences between field dependent and field independent students (Dwyer & Moore, 1997-98; Dwyer & Moore, 1991-92; Moore & Dwyer, 1991).

Field independent learners may perform equally well with or without interactive assistance because of their greater disembedding skill and active approach to problem solving. Field dependent learners may opt not to utilize features designed specifically to assist them if their problem solving strategy is a passive, less exploratory approach . Field dependent learners also may not recognize their greater need for organizational and cueing assistance when given a highly visual problem to solve (Riding & Cheema, 1991).

Field dependent learners accept the organizational structure of an image as it is initially presented (Moore, 1985/86; Reardon & Moore, 1988) and sample less often than field independent individuals (Burton, et al., 1995). Learner controls may assist field dependent learners to focus on the components of an image that comprise its organization and encourage sampling. Differences in learner preferences for interactive controls include the tendency of field independent learners to use interactive controls more often (Liu & Reed, 1994; Weller et al., 1994) and to generally behave as more active learners in computer based environments (Leader & Klein, 1996).

Learner Performance

Because field independent learners exhibit greater visual perceptiveness than field dependent learners (Riding & Cheema, 1991; Reiff, 1996) and sample more frequently with less error (Burton et al., 1995), accuracy in solving visual problems is of interest. Field independent individuals are more successful recognizing and organizing important cues available within an image (Davis, 1991; Riding & Cheema, 1991). However, field dependent learners may solve problems with greater accuracy if materials are designed with supporting organizational structures and include a method by which important cues are emphasized (Witkin, et al., 1977).

Time is a key performance variable because field dependent learners generally require a longer period to process information and solve problems than field independent learners (Burton et al., 1995; Davis, 1991; Liu & Reed, 1994). Specifically within computer-based settings, field dependent learners may choose to spend markedly more time with materials than others (Liu & Reed, 1994). The availability of interactive features also implicates the measurement of time since these features give learners the opportunity to manipulate the environment. Students have control over the duration of their participation with the program by deciding whether or not to use interactive tools.

Further, categorizing participants' scores into field independent and field dependent poles depends on a time-oriented test. The administration of the GEFT controls time in order to maximize the variability in scores (Di Nuovo, 1984). Given unlimited time to complete the GEFT, the variability in outcomes is greatly reduced (Di Nuovo, 1984). If solving a problem requires visual discrimination skills, field dependent learners generally require more time to complete the task successfully.

Purpose of Study

The purpose of this study is to determine the effects of interactivity in a hypermedia environment on the performance of students with different cognitive styles. A computer program was created to reveal performance differences (time and accuracy) between cognitive styles (field independent/field dependent) by providing three different levels of interactivity (mandatory, optional, and no interactivity) for students completing a series of map-like jigsaw puzzles.

The program randomly assigned each participant to one of three treatments and measured time necessary to complete the given tasks (time) and the number of attempts made to complete tasks (accuracy). The design of each treatment was grounded in the description of field independent and field dependent learner characteristics and behavior discussed in the literature. The treatments were constructed in order to test the assumption initially put forth by Witkin, et al. (1971) that field dependent learners would perform optimally if their learning environment provided an organizational structure for tasks and visual cues that helped them to focus on relevant information.

Two experimental treatments were designed specifically to assist field dependent individuals with the puzzle solving task. The experimental and control treatments differed by providing or not providing an interactive, organizational solution for the jigsaw puzzle in the form of a disembedding aid (color change) that learners controlled. The control treatment did not provider learners with assistance before presenting them with puzzles to solve. Participants assigned to one of the two experimental treatments received an interactive puzzle solution as an organizational aid prior to attempting the puzzle itself. These two treatments varied according to the conditions under which participants interacted with the organizational aid. By offering an interactive, organizational aid, experimental treatments were designed to support the performance of field dependent learners with adversely effecting field independent learners.

Research Questions

This study sought to explore the following research questions based on examination of current literature about cognitive style, hypermedia, and geography.

One: Will field independent learners recognize and manipulate the parts of a complex image presented by a computer program more quickly and with greater accuracy (fewer errors) than field dependent learners?

Two: Will field independent learners use more interactive controls in a computer-based environment than field dependent learners?

Three: Will field dependent and field independent learners perform equally quickly and accurately on a task that requires recognizing and manipulating the parts of a complex image if given an interactive, organizational aid that emphasizes relevant cues?

Experimental Hypotheses

H_o *One*: Field independent learners will complete puzzles faster than field dependent learners across all treatments.

H_o *Two*: Field independent learners will complete puzzles more accurately than field dependent learners across all treatments.

H_o *Three*: Field independent learners will choose to activate more interactive controls than field dependent learners when assigned to treatments with interactive help available.

H_o *Four*: Field dependent learners assigned to a treatment with mandatory interaction will complete puzzles faster and more accurately than field dependent learners assigned to other treatments.

H_o *Five*: Field dependent learners assigned to a treatment with optional interactivity will complete puzzles faster and more accurately than field dependent learners assigned to the control treatment.

Experimental Design

The computer program presented a series of three jigsaw puzzles of maps in identical order to learners. Participants were identified as field dependent, field neutral, or field independent by the Group Embedded Figures Test and randomly assigned to one of three treatment groups. The treatments varied according to the conditions of interactivity presented by the computer program: 1) mandatory; 2) optional; and 3) no interactivity.

The computer program recorded performance outcomes of each participant using the following criteria: 1) the total time required to complete all puzzles (time); and 2) the total number of attempts required to solve all puzzles (accuracy). Table 1 shows the possibilities for random group assignment by cognitive style and treatment for both time and accuracy measurements. A minimum of 135 student volunteers were needed in order to assign fifteen participants randomly to each cell in the 3 X 3 design for sufficient power.

Table 1: Experimental Group Assignment

	VARIABLES					
	Time			Accuracy		
	Treatment			*Treatment*		
Cognitive Style	ONE	TWO	THREE	ONE	TWO	THREE
Field Independent	G1	G2	G3	G1	G2	G3
Field Neutral	G4	G5	G6	G4	G5	G6
Field Depedent	G7	G8	G9	G7	G8	G9

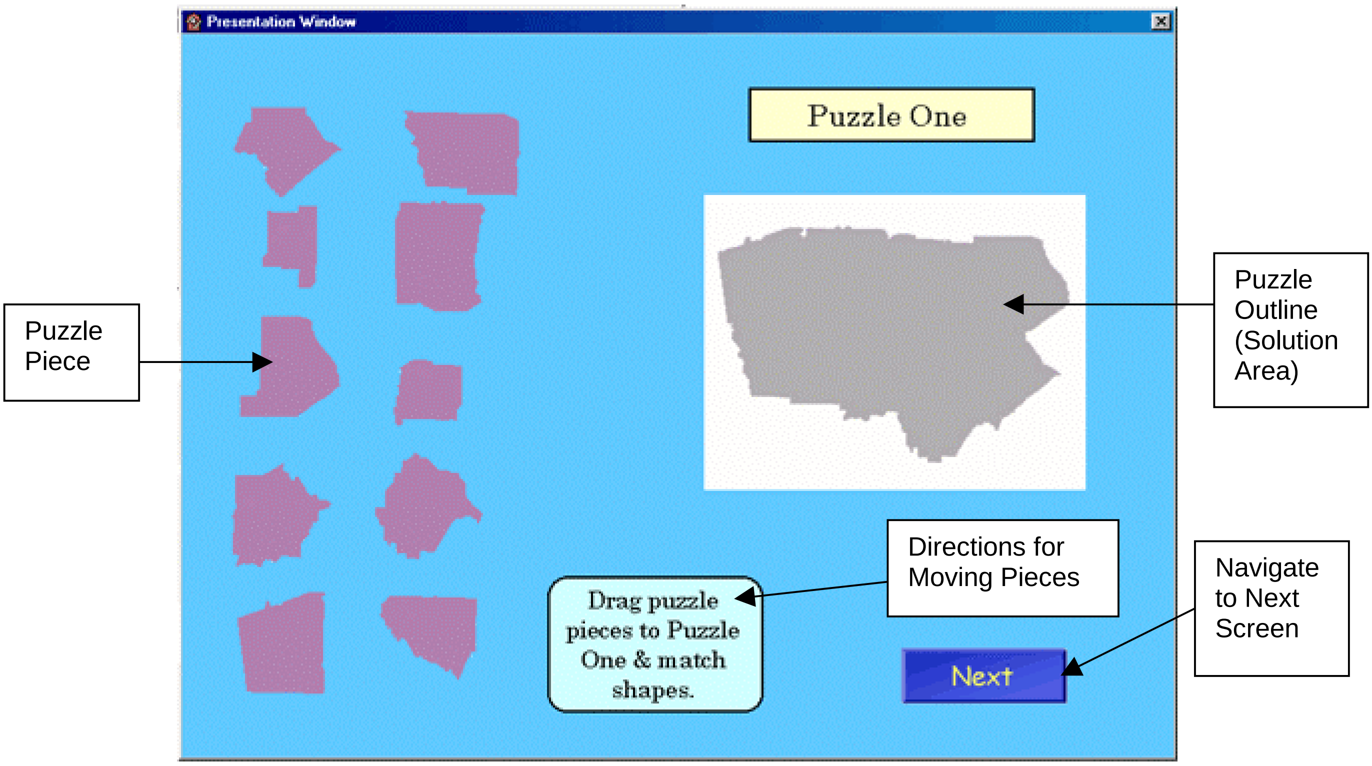
Development of Computer Program

A computer program was developed using Macromedia's Authorware® in order to examine the effects of providing interactivity to field dependent, field neutral, and field independent learners when manipulating maps. The program presented users with three map-like jigsaw puzzles to be solved. Each puzzle was composed of a ten-county region of the United States; each of the ten pieces represents one county. Participants were not expected to have sufficient prior knowledge of county maps of the United States to recognize these shapes since most geopolitical maps do not emphasize the county unit. The State of Georgia was identified as the best area from which to draw three irregularly shaped regions of ten counties each without duplication.

Selected counties were chosen for uniqueness of shape to avoid regular geometric patterns, and pieces did not exhibit large differences in size. Each piece only featured the shape and area of the county. Other information such as land forms, roads, cities, etc. was absent. Each puzzle was judged to be solved when the participant placed each of the ten pieces in a correct location on the computer screen so that all pieces were joined along the appropriate boundaries.

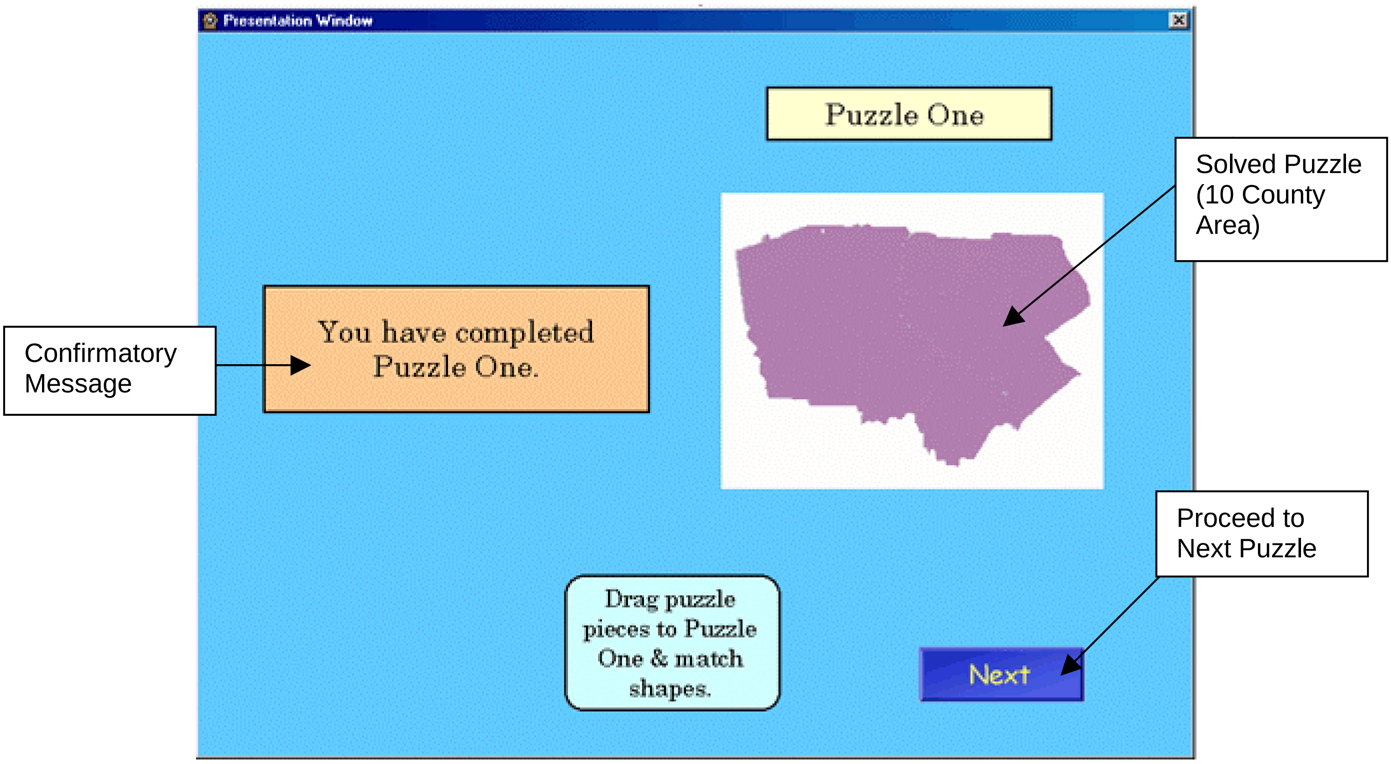
Illustration 1 shows the computer screen that displays the first puzzle presented by the program to all participants.

Illustration 1: Jigsaw Puzzle One, Unsolved



Puzzle pieces were arranged in two columns on the left side of the program window. The order of the pieces from left to right and top to bottom was alphabetical by county name. The learner could select pieces in any order with the computer mouse and move them to the puzzle outline area on the right side of the program window. The puzzle outline represented the overall shape of the completed puzzle. If a puzzle piece were moved to the correct location, the program left it in place within the puzzle outline. If the learner attempted to leave a piece in the wrong location, the program automatically returned the selected puzzle piece to its original location on the left side of the program window. When all puzzle pieces were correctly in place, the program confirmed that the puzzle was solved with an on-screen message (see Illustration 2). The participant then proceeded to the next puzzle. Learners were required to complete the puzzles in the predetermined order, and they could not proceed to subsequent puzzles without finishing an earlier one. The program recorded all learner behaviors: the total number of times the learner selected and moved a piece (both correctly and incorrectly), and the amount of time spent completing each puzzle.

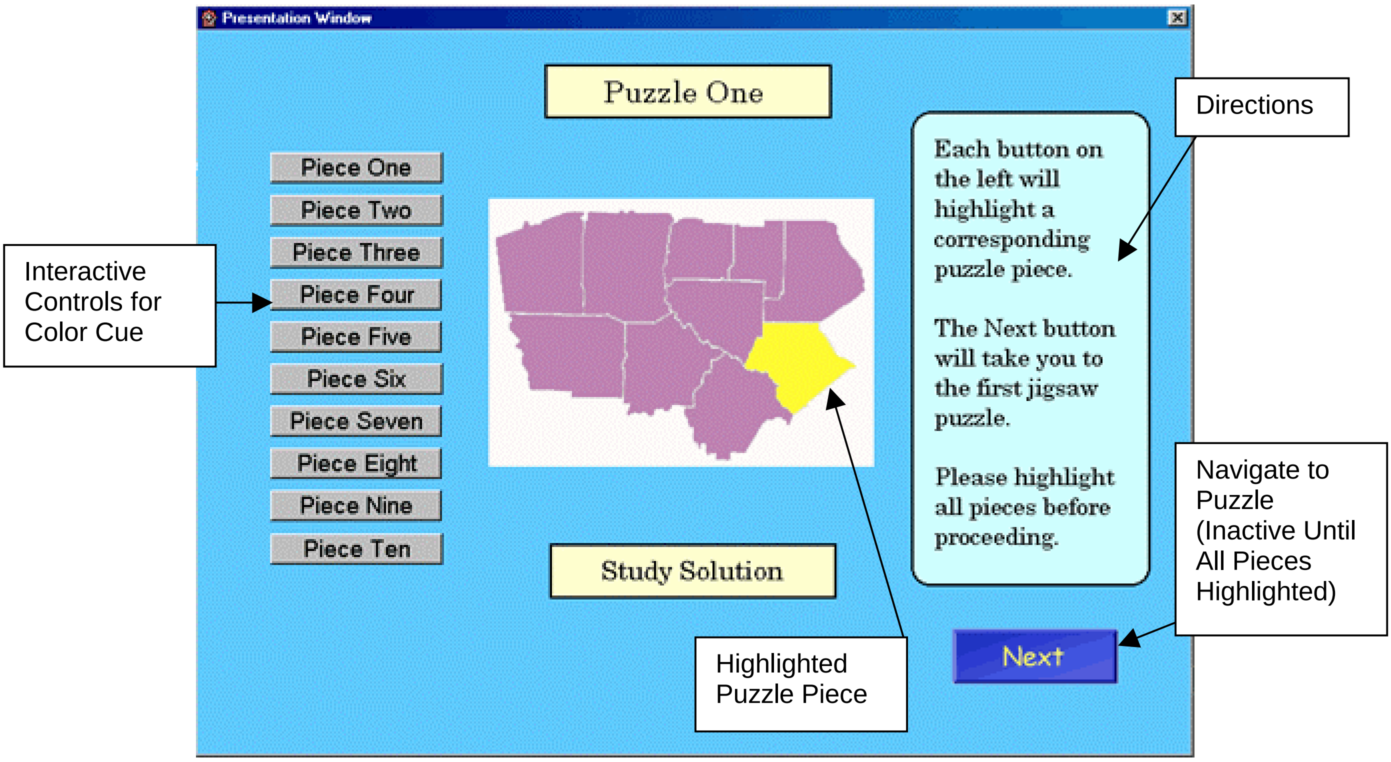
Illustration 2: Jigsaw Puzzle One, Solved



Treatments

Treatment One, Mandatory Interaction: Illustration 3 displays the program screen that contains the interactive conditions for students who are assigned to Treatment 1.

Illustration 3: Treatment One, Mandatory Interaction, Interactive Organizational Aid

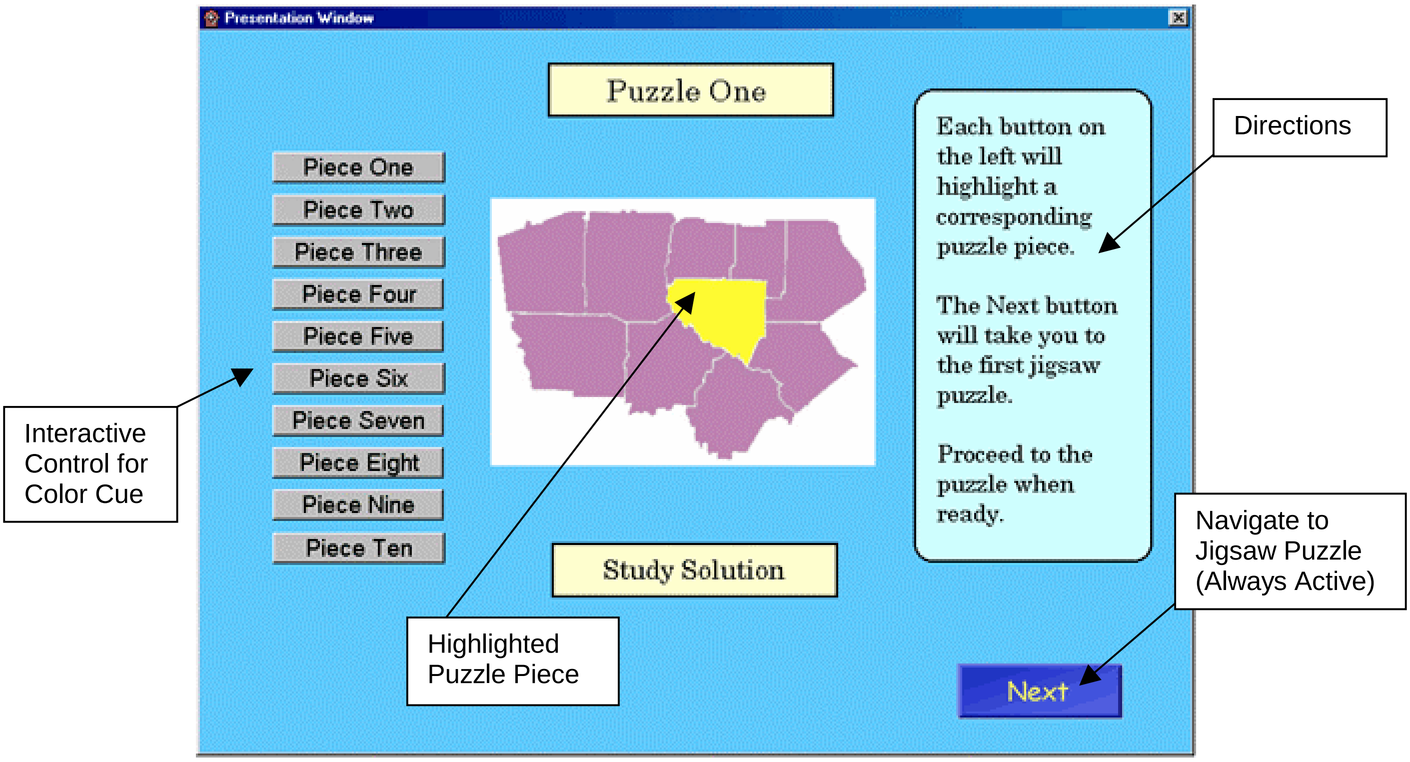


Students were given a solution to study before solving each of the three puzzles. Each piece of the puzzle on the solution screen changed color when the participant pressed a corresponding button labeled “Piece One”, “Piece Two”, etc. through “Piece Ten”. The student was required to press every button and change the color of every puzzle piece at least once before the program allowed the participant to proceed to the actual puzzle exercise. Students could continue to change the color of puzzle pieces on the solution screen as many times as desired so long as each interactive button was activated at least once.

Treatment one was designed to assist learners by providing an organizational structure to the jigsaw puzzle task and by providing the learner with control over the appearance of the puzzle solution. Cues became prominent via color change. Learners were required to apply the highlighting color effect to every puzzle piece in the solution before the program allowed the participant to proceed.

Treatment Two, Optional Interaction: Illustration 4 displays the program screen that contains the interactive conditions for students who are assigned to Treatment 2.

Illustration 4: Treatment Two, Optional Interaction, Interactive Organizational Aid



Students were given a puzzle solution to study before solving each of the three puzzles. Each piece of the solved puzzle changed color when the participant activated a corresponding button on the computer screen. The participant could proceed to the following puzzle activity when ready. The program did not require that the student alter the color of any pieces in the puzzle solution prior to attempting to solve the following puzzle exercise.

Like treatment one, treatment two provided an organizational structure to the visual components of the jigsaw puzzle. The interactive buttons highlighted each piece so that participants' could focus on the components of the puzzle.

Treatment Three, Control Treatment: students were given each of the three puzzles to solve without any interactive, organizational aid available beforehand. Subjects began solving the puzzles immediately after reading a screen containing the directions for the exercise. Illustration 1 shows the display of the computer screen containing the first jigsaw puzzle in the series of three puzzles to be solved.

Cognitive Style Instrument

The Group Embedded Figures Test (GEFT) measured the cognitive style of field dependence/field independence. The GEFT is a timed test that required participants to locate 18 simple geometric shapes located within a drawing of a larger, more complex, patterned geometric shape. Test-takers are considered to tend toward field independence if they locate most of the simple shapes and field dependence if they locate less than half of the simple figures (Witkin et al., 1971). Participants in this study were divided into three categories based on GEFT score: field dependent, field neutral, and field independent. Students within a range of one-half standard deviation above and below the mean were considered field neutral while students scoring below that range were identified as field dependent. Participants scoring above the field neutral range were identified as field independent.

Psychometric Data on the GEFT

The reported split-half reliability estimate of the GEFT in the published test manual, according to the Spearman-Brown formula, is 0.82 for both men and women (Witkin et al., 1971). The manual also reports the validity of the GEFT, determined by comparison of GEFT scores with Embedded Figures Test outcomes as r = -.82 for men and r = -.63 for women (Witkin et al., 1971). In a sample composed of 397 college undergraduates, a significant difference between the means for men of 12 and for women of 10.8 is reported ($p < 0.005$) (Witkin et al., 1971). Other research has not shown significant difference between the sexes (Di Nuovo, 1984); and both male and female undergraduates may be more field independent than first reported (Carter & Loo, 1980). The overall validity and usefulness of the GEFT with undergraduate and other adult populations is supported by a number of examinations of the instrument that establish internal consistency, reliability, and construct validity (Cummings & Murray, 1987; Day, McRae, & Young, 1990; Panek, Funk, & Nelson, 1980).

Procedures

All participants completed Informed Consent Forms as required by Virginia Tech policy. Students were identified using only the last four digits of their Virginia Tech identification numbers. All information collected from students remained confidential and anonymous. Participants completed the computer program and the GEFT at the Center for Instructional Technology computer laboratory located in 220 War Memorial Hall. Students received extra credit in *Introduction to Human Geography* for volunteering.

Participants

Approximately three hundred undergraduates enrolled in two sections of Geography 1004, *Introduction to Human Geography*, offered in the fall semester of 1999 and the spring semester of 2000, were asked to complete the experiment voluntarily. This course satisfies one of the core curriculum requirements for Virginia Tech and draws freshmen through seniors. A majority of the students who typically enroll are not declared geography majors. One hundred thirty nine undergraduate students volunteered to complete the experiment. Of these, 66 (47%) were female and 73 (53%) were male. No student included in the experiment lacked color perception or reported other visual impediments that may have caused difficulties with the puzzle solving task.

Pilot Study

A pilot study was conducted to identify potential difficulties with the administration of the GEFT, the environment in which the experiment was conducted, or the content and structure of the computer-based instrument. Seventeen undergraduates enrolled in Geography 3234, *Geography of Virginia*, completed the GEFT and the computer program. The pilot study occurred in the same computer laboratory used for the experiment. The computer program ran as expected and collected performance data from each student for analysis. Participants were encouraged to both comment on the program and ask questions about procedures, screen design, and directions. Feedback was gathered while students worked through the program's tasks and after they completed the entire exercise.

No technical problems arose during the pilot study. The program recorded all data in an external text file as expected. No participant experienced any difficulty completing the GEFT according to the test manual's instructions. Feedback solicited from the participants resulted in minor but necessary changes to the computer program. The layout of one screen in the program was altered according to their suggestions. (This screen was not part of the puzzle exercise treatments.) Clearer directions for completing the puzzle exercises also resulted from student feedback. Due to the small size of the pilot sample, differences between the treatments for the pilot group could not be meaningfully explored.

Statistical Analysis

The software Statview® was chosen to conduct the all statistical analyses. A multivariate analysis of variance (MANOVA) was the appropriate form of statistical analysis for experimental results since the interaction between two independent, categorical variables (cognitive style and treatment) was expected to determine the values of multiple, correlated, continuous dependent variables (time and accuracy) (Grimm & Yarnold, 1995). The most common procedure for analysis after a significant effect is uncovered by a MANOVA is to conduct numerous, univariate ANOVAs for each of the dependent variables to apportion the explained and unexplained variance on a variable-by-variable basis (Grimm & Yarnold, 1995).

Fisher's Protected Least Significant Difference statistic was chosen as the appropriate post-hoc procedure to make all possible pair-wise comparisons with a multiple t-statistic (SAS Institute, 1998). Fisher's Protected Least Significant Difference (PLSD) is a fairly liberal post-hoc procedure that maintains Type I error at approximately the level of alpha by insisting that the associated main effect of the ANOVA be significant (SAS Institute, 1998). The procedure can accommodate unequal cell sizes.

In order to determine if significant differences existed between field independent and field dependent subjects' activation of interactive buttons in Treatment 2 and Treatment 3, t-tests were used. The t-tests demonstrated whether the means between groups were significantly different at an alpha level of 0.05.

CHAPTER THREE

Results

Differences in group mean scores for 139 participants who solved a series of three visually complex puzzles were examined in relation to cognitive style and treatment using MANOVA. The independent variables in the study were cognitive style (field independent, field neutral, field dependent) and treatment (mandatory interactivity, optional interactivity, no interactivity). The dependent variables were the total amount of time necessary to complete all puzzles and the total number of attempts necessary to complete all puzzles (accuracy). Five experimental hypotheses were evaluated. The hypotheses and the results of the MANOVA are presented after a description of the participants and their cognitive style outcomes.

Group Embedded Figures Test Outcomes

The GEFT includes 18 problems divided into two sections of 9 each. Participants had 5 minutes to complete each section. A perfect score (18) indicates a high level of field independence while very low scores indicate field dependence. The majority of participants, 63, were determined to be field independent. Thirty-seven were field neutral, and thirty-nine were field dependent. The total number of participants was 139, the range of scores was 1 to 18, the mean was 13.62, and the standard deviation was 4.34. Table 2 contains the range of scores by category and the number of students in each category.

Students were categorized such that scores higher than one-half the standard deviation above the mean indicated field independence, scores lower than one-half the standard deviation below the mean indicated field dependence, and scores within one-half standard deviation above or below the mean indicated field neutral status (Moore & Bedient, 1986; Moore & Dwyer, 1991; Moore & Dwyer, 1994). Table 3 (Appendix A) displays the distribution of GEFT scores with the sample's overall tendency toward field independence.

Table 2: GEFT Score Categories and Number of Participants

CATEGORY:	SCORE:	NUMBER OF PARTICIPANTS:
Field independent	16-18	63
Field neutral	12-15	37
Field dependent	0-11	39

Experimental Outcomes

One-hundred thirty nine volunteers completed the experiment. The number of participants assigned to each treatment and their cognitive styles are presented in Table 4.

Table 4: Assignment to Treatments by Cognitive Style

	Treatment			
Cognitive Style	Mandatory	Optional	Control	TOTAL
Field Independent	16	25	22	63
Field Neutral	9	13	15	37
Field Dependent	13	13	13	39
TOTAL	38	51	50	139

Table 5 presents the number of participants assigned to each treatment by cognitive style and the means and standard deviations for their performances on the dependent variable time. Time is reported in seconds and represents the speed exhibited by each group of participants. The fastest overall performance (least time) was exhibited by field independent participants.

Table 5: Group Assignment, Means, & Standard Deviation for Time (seconds)

	Treatment			
Cognitive Style	Mandatory	Optional	Control	*Totals*
Field Independent				
x =	156.42	137.21	143.12	145.58
sd =	36.98	27.48	32.77	32.41
n =	16	25	22	63
Field Neutral				
x =	140.20	178.56	184.93	167.90
sd =	25.94	47.89	57.15	43.66
n =	9	13	15	37
Field Dependent				
x =	196.01	202.95	189.81	196.26
sd =	35.25	36.44	45.08	38.92
n =	13	13	13	39
Totals				
x =	164.21	172.91	172.62	
sd =	32.72	37.27	45.00	
n =	38	51	50	

Table 6 presents the number of participants assigned to each treatment by cognitive style and the means and standard deviations for their performances on the dependent variable accuracy. Accuracy is reported as the total number of puzzle pieces moved to solve all puzzles. The minimum or most accurate possible score was 30, so accuracy reflects the number of errors made by each learner. Lower accuracy scores reflect fewer errors and better accuracy.

Table 6: Group Assignment, Means, & Standard Deviation for Accuracy (number of errors)

Cognitive Style		*Treatment* Mandatory	Optional	Control	*Totals*
Field Independent					
	x =	36.50	35.16	35.64	35.77
	sd =	2.99	2.53	2.70	2.74
	n =	16	25	22	63
Field Neutral					
	x =	37.89	36.23	37.00	37.04
	sd =	4.68	3.44	3.98	4.03
	n =	9	13	15	37
Field Dependent					
	x =	42.23	39.31	36.92	39.49
	sd =	9.26	5.36	4.70	6.44
	n =	13	13	13	39
Totals					
	x =	38.87	36.90	36.52	
	sd =	5.64	3.78	3.79	
	n =	38	51	50	

<u>MANOVA Results</u>

The multivariate F ratios obtained from the MANOVA using the Pillai Trace statistic revealed a significant main effect for cognitive style, $F(4, 260) = 9.41$, $p<.0001$, a significant main effect for treatment, $F(4, 260) = 2.70$, $p<.031$, and a significant interaction effect between treatment and cognitive style, $F(8, 260) = 2.07$, $p<.039$, on both dependent measures of time and accuracy. Follow-up ANOVAs found a significant effect for cognitive style for both the dependent variable time, $F(2, 130) = 20.39$, $p<.0001$, and the dependent variable accuracy $F(2, 130) = 8.19$, $p<.0001$. The ANOVA for the dependent variable time also uncovered a significant interaction effect between cognitive style and treatment, $F(4, 130) = 2.76$, $p<.031$. Follow-up ANOVAs revealed no significant main effect due to treatment for either time or accuracy. Please refer to Appendix A for the results of the MANOVA and the univariate ANOVAs for each dependent variable (Table 6 through Table 8).

Chart 1: MANOVA Adjusted Means, Cognitive Style by Treatment for Time, (seconds)

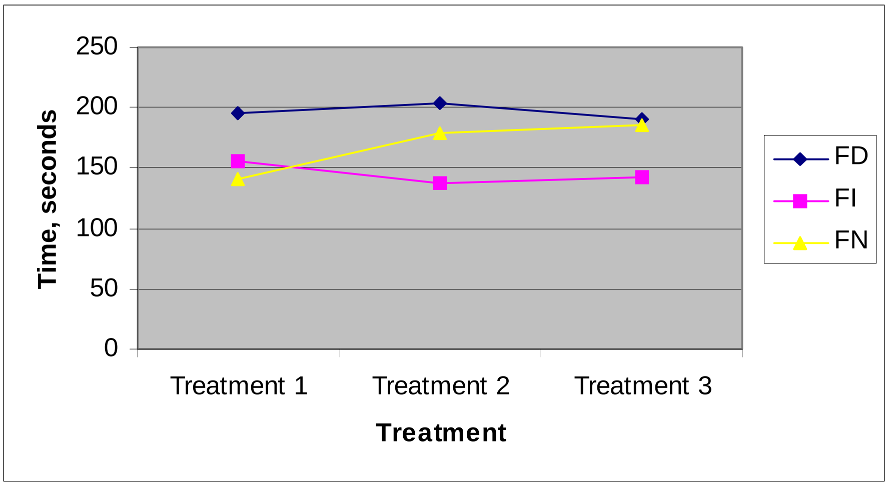
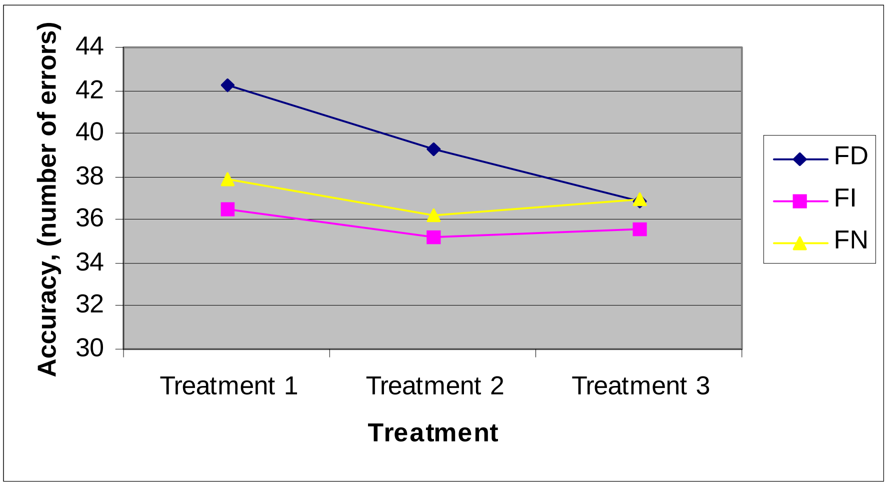


Chart 2: MANOVA Adjusted Means, Cognitive Style by Treatment for Accuracy, (number of errors)



<u>Hypothesis One</u>

Field independent learners will complete puzzles faster than field dependent learners across all treatments.

Fisher's PLSD post-hoc analysis showed significant differences between field independent and field dependent groups for the amount of time needed to solve the puzzles, (F_{crit} = 15.61,p<.0001). Field independent participants (x = 145.58 seconds, sd = 32.41) completed puzzles faster than field dependent students (x = 196.26 seconds, sd = 38.92). Hypothesis one can be accepted. Table 9 (Appendix A) contains the results of the post-hoc analysis for the performance differences between field independent and field dependent students for the variable time.

Hypothesis Two

Field independent learners will complete puzzles more accurately than field dependent learners across all treatments.

Significant differences between the field independent and field dependent groups were uncovered for accuracy in solving the puzzles, (F_{crit} = 1.81, p<.0001). Field independent participants (x = 35.77 attempts, sd = 2.74) were more accurate than field dependent participants (x = 39.49 attempts, sd = 6.44). Hypothesis two can be accepted. Table 10 (Appendix A) contains the results of the post-hoc analysis for the dependent variable accuracy.

Hypothesis Three

Field independent learners will choose to activate more interactive controls than field dependent learners when assigned to treatments with interactive help available.

In a separate analysis, unpaired t-tests were used to examine the choices made by students who were assigned to either treatment one (mandatory interaction) or to treatment two (optional interaction). The t-tests examined the total number of times students activated buttons to highlight a puzzle piece in each organizational aid for each treatment. No significant differences between field independent and field dependent learners were uncovered in any treatment when examining how many times either group chose to use interactive controls (t-value = -0.33, p<.741). Hypothesis three cannot be accepted.

Treatment one required mandatory interaction with the organizational aid, and students were required to activate a minimum total of thirty buttons. Table 11 (Appendix A) contains the results of the t-tests for students assigned to treatment one. Table 12 (Appendix A) contains the means and standard deviations by cognitive style for the students who were assigned treatment one.

Treatment two offered interactivity as an option, but students were not required to activate any specific number of controls. Table 13 (Appendix A) contains the results of the t-tests for students assigned to treatment two. Table 14 (Appendix A) contains the mean and standard deviations by cognitive style for students assigned to treatment two.

Hypothesis Four and Hypothesis Five

> *Field dependent learners assigned to a treatment with mandatory interaction will complete puzzles faster and more accurately than field dependent learners assigned to other treatments.*
>
> *Field dependent learners assigned to a treatment with optional interactivity will complete puzzles faster and more accurately than field dependent learners assigned to the control treatment.*

Unpaired t-tests were used to examine the performance outcomes of field dependent students assigned to each of the three treatments. No significant differences were found between field dependent learners assigned to any treatment with respect to time and accuracy. Hypothesis four and hypothesis five cannot be accepted. Please refer to Table 15 through Table 18 in Appendix A for the results of the unpaired t-tests.

Summary

A MANOVA procedure found a significant main effect for cognitive style, a significant main effect for treatment, and a significant interaction effect between cognitive style and treatment for the dependent variables time and accuracy. Post-hoc analysis established that field independent learners completed the puzzle solving tasks significantly more quickly (required less time) and more accurately (made fewer errors) than field dependent learners. No other significant differences were found between field independent and field dependent participants. All learners chose to activate an approximately equal number of interactive controls when given the opportunity. No statistically significant performance differences were found between field dependent students assigned to different treatments. No group of field dependent learners performed more quickly or more accurately than any other, and field dependent learners performed less well than field independent students.

Chapter Four

DISCUSSION AND CONCLUSIONS

Given the proliferation of hypermedia in the geography classroom (Olson, 1997), the history of computer adaptation in the discipline (Shepherd, 1985; Gold et al., 1991), and the fundamental reliance on visual information in geography (de Blij & Muller, 1997; Fredrich & Fuller, 1997; Parker, 1944; Underwood, 1981; Vegter, 1949), geography educators may fulfill Down's (1994) demand for critical research about learners and educational practices through examinations of the cognitive style field dependence-independence and its relationship to performance in computer-mediated environments. While all geographic exercises are not necessarily linked to visual analysis, a reliance on complex visuals such as maps, photographs, and data models can be traced through the course of geography education. Examinations of field dependence-independence uncover existant individual differences among learners that deserve to be recognized and understood in geographic learning environments.

Field independence / dependence is placed at the center of an examination of interactive hypermedia and its consequences in the geography classroom as cognitive style accounts for visual, perceptual differences among learners. The construct of field style is formulated as a bipolar continuum such that learners can be described by a particular set of characteristics and expected behaviors predicted. The key difference between the two groups rests on levels of visual perceptiveness: field dependent students are less able to distinguish figure / ground relationships and extract a simple shape from a more complex image (Ausburn & Ausburn, 1978; Chinien & Boutin, 1992 / 1993; Davis, 1991; Fritz, 1994; Messick, 1993; Riding & Cheema, 1991; Witkin & Goodenough, 1979; Witkin et al., 1977). Field dependent learners are less skilled at organizing, manipulating and restructuring visual images. They experience difficulty selectively attending to relevant cues if more salient, distracting cues are present (Ausburn & Ausburn, 1978; Burton et al., 1995; Davis, 1991; Witkin & Goodenough, 1979; Witkin et al., 1977). Descriptions of field dependent learners vis-à-vis field independent learners draw distinctions between the two such as passive versus active, non-hypothesis forming versus hypothesis forming and testing, and non-exploratory versus exploratory (Chinien & Boutin, 1992 / 1993; Davis, 1991; Fritz, 1994; Liu & Reed, 1994; Lyons-Lawrence, 1994; Messick, 1993; Post, 1987; Reiff, 1996).

While the theory of field independence / dependence accounts for different levels of visual perceptiveness and restructuring skills between individuals, its influence on outcomes from interactive, hypermedia programs has not been fully explored. Student behavior when using computer programs to learn can be influenced by the cognitive style field independence / dependence (Ayersman, 1993; Chinien & Boutin, 1992; Chou & Lin, 1998; Jonassen & Wang, 1993; Kini, 1994; Leader & Klein, 1996; Liu & Reed, 1994; Lyons-Lawrence, 1994; Myers et al., 1998; Packard et al., 1997; Post, 1987; Small & Grabowski, 1992; Weller et al., 1994; Whyte et al., 1995; Zehavi, 1995). Field independent individuals have been reported to use more interactive elements than field dependent participants (Leader & Klein, 1996; Lin & Davidson-Shivers, 1996; Liu & Reed, 1994; Weller et al., 1994). Research also establishes that field dependent individuals require more time than field independent students to complete tasks in computerized settings (Liu & Reed, 1994) and more time in general to process stimuli (Burton et al., 1995; Davis, 1991).

These differences are key to exploring student performance in geography because of the need to apprehend visual information (de Blij & Muller, 1997; Reardon & Moore, 1988; Underwood, 1981) and the enthusiasm of geography educators for implementing computer-based learning environments (Fielding, 1968; Flowerdew & Lovett, 1992; Foote, 1994; Gold et al., 1991; Maguire, 1989; Maguire, 1992; Nellis, 1994; Olson, 1997; Peterson, 1994; Shepherd, 1985). Geography has not adequately researched the consequences of computer-based instruction (Downs, 1994; Nellis, 1994), and the consequences of cognitive style differences between learners likewise remains largely unexplored. What data are available establishes that field dependent learners generally do not perform as well in geography as field independent students (Grieve & Davis, 1971), and field dependent students are less capable at map reading tasks (Reardon & Moore, 1988; Riding & Cheema, 1991).

Zehavi (1995), Chinien and Boutin (1992), Whyte, et al., (1990/91), Liu and Reed (1994), Leader and Klein (1996), and Chou and Lin (1998) found that field dependent learners performed as well as field independent learners in a hypermedia environment that accommodated their characteristics. This evidence supports Witkin's (1977, 1979) formulation of cognitive style theory such that field dependent learners can perform optimally when learning conditions support them. Without specific intervention, field dependent individuals typically perform less well than field independent students regardless of subject matter or learning environment; although effective interventions are rare and difficult to establish statistically (Davis, 1991).

Research Question One

The cognitive style construct of field independence/dependence asserts that field dependent learners are inherently less successful when asked to perform visual tasks that require recognizing and disembedding elements of a complex image and apprehending the organizational structure of an image (Ausburn & Ausburn, 1978; Messick, 1993; Riding & Cheema, 1991; Witkin & Goodenough, 1979; Witkin et al., 1977; Witkin et al., 1971). The results of this study support the conclusion that field independent individuals apprehend and manipulate visual information significantly faster and more accurately than field dependent learners in a computer oriented setting. Field independent students solved problems presented by a hypermedia program in less time and with fewer mistakes. This evidence supports the formulation of the cognitive style construct and is in agreement with other research findings such as those reviewed by Davis (1991) and discussed in the literature review.

Research Question Two

This study did not find any evidence that field dependent learners are less likely to use learner controls than field independent learners when given the opportunity to interact with an organizational study aid. Neither field dependent nor field independent learners freely chose to interact extensively with the organizational study aids. Students assigned to treatment one, mandatory interaction, tended not to use more learner controls than the minimum number required to complete the exercise. Students assigned to treatment two, optional interactivity, activated approximately two-thirds of the number of learner controls available.

The aid was specifically intended to help field dependent participants by illustrating the structure of the puzzles they were given to solve. Field independent students, while expected to interact more extensively with the aid, may not have viewed it as a necessary form of assistance for solving the puzzles since they are better able to grasp the overall structure of visual information. Each puzzle was relatively small (ten pieces) and may not have sufficiently challenged learners. If the puzzles were perceived to be simple and did not pose a sufficient perceptual challenge, the aid may have been considered unnecessary by all participants.

If field dependent learners perform less well because they tend to be passive and not interact with materials, then the field dependent learners who were assigned to treatment one (mandatory interaction) and compelled to interact with the organizational aid should have experienced a performance boost in either speed or accuracy. This outcome did not occur.

Field dependent participants assigned to treatment two (optional interactivity) were not compelled to interact with the organizational aid and fared no worse on the outcome measures. No significant differences exist between field dependent students assigned to any treatment. Providing a organizational aid that included learner controls over the presence of a disembedding tool revealed that while field dependent students are as likely as other learners to implement those controls, an effect on performance cannot be anticipated. These results together suggest that field dependent students' characterization as more passive or less exploratory than field independent individuals is both not warranted in this study and not responsible for a less accurate and less speedy performance.

Research Question Three

Contrary to the formulation of cognitive style theory such that expected performance differences between field independent and field dependent students can be eradicated if hypermedia programs accommodate field dependent individuals, field independent learners still performed significantly better across all treatments than field dependent learners. Despite providing an organizational aid that emphasized the structure of the jigsaw puzzles by disembedding each piece under the control of the learner, field dependent participants' performance did not improve when assigned to an interactive treatment. The assumption posited by cognitive style theory that field dependent learners benefit from disembedding assistance and organizational structures for visual information cannot be upheld with the results from this study.

Conclusions

The hypermedia program designed for this study did not succeed in supporting the performance of field dependent learners on measures of speed and accuracy when given a map-like task to solve. The organizational aid failed to assist field dependent learners with the puzzle solving tasks. The interactive treatments were constructed according to a central element of field independence / field dependence theory: when field dependent individuals participate with a learning environment that properly accounts for their visual, perceptual abilities, they will solve problems as successfully as field independent learners. In the case of this study, the treatments did not have the desired effect on the accuracy and speed of field dependent learners. The puzzles may have been simple enough that the interactive, organizational aids were unnecessary regardless of the learner's cognitive style. The treatments themselves may have been ineffective for an unknown reason such as the presence of an unrecognized, confounding variable or a relationship between some aspect of the hypermedia program other than the interactive treatments and cognitive style.

Overall, this research supports the conclusion by Davis (1991) that cognitive style alone may determine performance regardless of interventions. The results of this study cannot support the argument that instructional strategies and environments can be formulated to enhance the performance of field dependent learners using interactive hypermedia. Field dependent learners who were assigned to a treatment that provided interactive assistance were expected to perform better than their counterparts assigned to the control treatment. The instrument used in this study failed to achieve those goals. Cognitive style alone accounted for all significant performance differences. While some researchers have succeeded in creating hypermedia programs that boost the performance of field dependent learners (see, for example, Zehavi (1995), Chinien & Boutin (1992), Whyte, et al., (1990/91), Liu & Reed (1994), Leader & Klein (1996), and Chou & Lin (1998), this research points to the difficulty of meeting that objective.

The expectation that field independent learners would use more interactive controls was not borne out. Field dependent individuals used as many interactive controls, and these results counter the common description of field dependent learners as less exploratory. This finding may also be an artifact of the type of hypermedia program provided. The sequence of events was predetermined to be a linear presentation of materials which is a preferred environment for field dependent individuals (Davis & Cochran, 1982; Liu & Reed, 1994; Witkin et al., 1977). The predetermined navigational structure may have allowed field dependent learners to better focus their efforts on interacting with the puzzle exercises by structuring the larger environment for them.

For geography researchers, the results of this study reiterate the importance of cognitive style differences among individuals even as they highlight the difficulty of configuring a learning environment specifically to support field dependent learners. Performance differences between field styles have been established in the traditional geography classroom (Grieve & Davis, 1971) and specifically on map-reading and spatial analysis tasks (Underwood, 1981; Reardon & Moore, 1988). The adaptation of hypermedia technology for instruction does not represent an educational "magic bullet" for geography educators despite the arguments and assumptions common in the literature. (For examples, see Foote, 1994; and Olson, 1997.) This study underscores the fundamental power of cognitive style differences leading to varying performance outcomes despite attempted interventions.

Recommendations for Further Research

While "research suggests that field-dependent students have a difficult time selectively attending to relevant cues" and that "this attentional difficulty could be accommodated by instructional techniques that focus a field-dependent learner's attention on critical features of the information to be learned" (Davis, 1991, p. 167), research that attempts to implement such beneficial instructional scenarios has shown mixed results (Davis, 1991). Some studies reviewed found no significant interactions between treatments intended to compensate for learners' attentional patterns and lack of disembedding skills and the field dependent cognitive style, while a few have found significant relationships between instructional treatments and field dependence. Research has established that when computer-based instruction is developed according to the needs of field dependent students, performance can sometimes be improved (Chinien & Boutin, 1992/1993; Chinien & Boutin, 1992; Davis, 1991; Zehavi, 1995), and that instruction can be developed and evaluated in such a way as to determine its fitness for field dependent learners (Chinien & Boutin, 1992/1993; Chinien & Boutin, 1992).

The results of this study suggest that the design and implementation of an instructional treatment to assist field dependent learners may be more difficult than suggested by the literature describing field dependent students' characteristics and needs. The differences between field independent and field dependent individuals may well be predicated upon 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 (Burton et al., 1995; Davis, 1991; Davis & Cochran, 1982). Future research may be more successful examining the consequences of differences in information processing skills rather than focusing on the development of instructional environments intended to compensate for or overcome the perceptual skills and learning characteristics of field dependent students.

Attempting to use the traits of field dependent learners to guide the creation of a of computer-based environment's structure and learner controls and measure performance outcomes experimentally has not been entirely fruitful. The qualitative, evaluative techniques recommended by Chinien and Boutin (1992) and implemented by Zehavi (1995) may represent another satisfactory direction of inquiry. This type of technique follows upon Flowerdew and Lovett's (1992) fundamental desire to understand the reactions and perceptions of geography students faced with computer-based instruction. Uncovering differences in attitudes that arise from learning with hypermedia (such as done by Lin and Davidson-Shivers (1996)), and exploring the consequences of field dependent learners need for social interaction (such as done by Whyte, et al., (1990/91)) with qualitative methodologies may provide both a broader perspective and better account for all possible relationships and forces that effect learning from hypermedia.

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Appendix A: Statistical Results

CHARTS AND TABLES

Table 3: Frequency Distribution of GEFT Scores

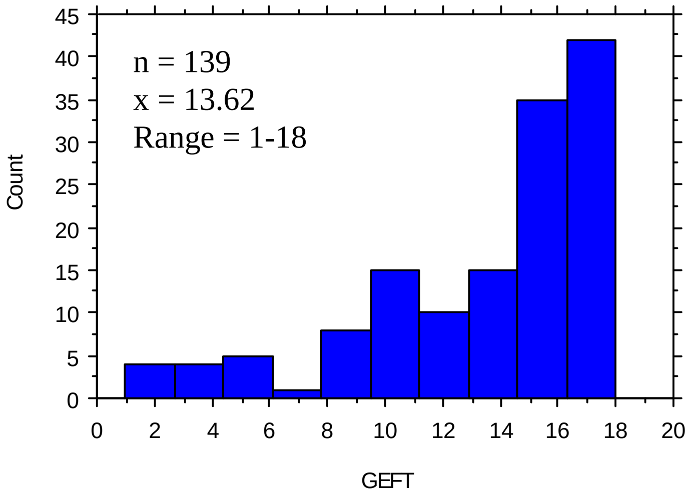

Table 7: MANOVA, Time & Accuracy as Functions of Cognitive Style & Treatment

SOURCE:	*DF*	*F-value*	*P-value*
Cognitive Style	4 / 260	9.413	.0001
Treatment	4 / 260	2.704	.0309
Cognitive Style x Treatment	8 / 260	2.072	.0389

Table 8: ANOVA, Time as a Function of Cognitive Style & Treatment

SOURCE:	*DF*	*SS*	*MS*	*F-value*	*P-value*	*Lambda*	*Power*
Cognitive Style	2	61196.04	30598.02	20.39	.0001	40.79	1.00
Treatment	2	1903.51	951.76	0.63	.5319	1.27	0.15
Cognitive Style x Treatment	4	16539.74	4134.94	2.76	.0306	11.02	0.75
Residual Error	130	195056.50	1500.44				

Table 9: ANOVA, Accuracy as a Function of Cognitive Style & Treatment

SOURCE:	*DF*	*SS*	*MS*	*F-value*	*P-value*	*Lambda*	*Power*
Cognitive Style	2	330.00	165.00	8.19	.0001	16.39	0.97
Treatment	2	125.33	62.67	3.11	.5319	6.22	0.58
Cognitive Style x Treatment	4	94.55	23.64	1.17	.3254	4.70	0.35
Residual Error	130	2617.65	20.14				

Table 10: Fisher's PLSD for the Effect of Cognitive Style on Time (seconds)

	Mean Difference	*Critical Difference*	*P-Value*
FD, FI	52.11	15.61	.0001
FD, FN	24.45	17.59	.0068
FN, FI	27.66	15.87	.0008

Table 11: Fisher's PLSD for the Effect of Cognitive Style on Accuracy

	Mean Difference	*Critical Difference*	*P-Value*
FD, FI	3.82	1.81	.0001
FD, FN	2.54	2.04	.0149
FN, FI	1.28	1.84	.1711

Table 12: T-test Between Cognitive Styles for Number of Interactive Controls Activated in Treatment One

	Mean Difference	*DF*	*t-value*	*P-value*
FD, FI	-5.63	27	-1.63	.1152
FD, FN	-6.54	20	-2.15	.0043
FI, FN	-.875	23	-.23	.8218

Table 13: Means and Standard Deviation, Number of Interactive Controls Activated in Treatment One

COGNITIVE STYLE	*Mean*	*SD*
Field Independent	39.13	10.51
Field Neutral	40.00	6.12
Field Dependent	33.46	7.58

Table 14: T-test Between Cognitive Styles for Number of Interactive Controls Activated in Treatment Two

	Mean Difference	*DF*	*t-value*	*P-value*
FD, FI	-2.04	36	-.33	.7408
FD,FN	-3.39	24	-.66	.5188
FI, FN	-1.35	36	-.22	.8276

Table 15: Means and Standard Deviations for Number of Interactive Controls Activated in Treatment Two

COGNITIVE STYLE	*Mean*	*SD*
Field Independent	22.04	19.86
Field Neutral	23.39	13.24
Field Dependent	20.00	13.12

Table 16: T-tests for Time (seconds) Comparing Treatments for all Field Dependent Students

TREATMENT:	*Mean Difference*	*DF*	*t-value*	*P-value*
Control, Mandatory	-6.20	24	-3.90	.6996
Control, Optional	-13.13	24	-.817	.4221
Mandatory, Optional	-6.94	24	-4.93	.6264

Table 17: Means and Standard Deviations for Time (seconds), All Field Dependent Students

TREATMENT	*Mean*	*SD*
Mandatory Interaction	196.01	35.25
Optional Interaction	202.95	36.44
Control	189.81	45.08

Table 18: T-tests for Accuracy Comparing Treatments for all Field Dependent Students

TREATMENT:	*Mean Difference*	*DF*	*t-value*	*P-value*
Control, Mandatory	-5.31	24	-1.84	.0776
Control, Optional	-2.39	24	-1.21	.2395
Mandatory, Optional	2.92	24	.985	.3343

Table 19: Means, Standard Deviations of Accuracy for all Field Dependent Students

TREATMENT	*Mean*	*SD*
Mandatory Interaction	42.23	4.70
Optional Interaction	39.31	9.26
Control	36.92	5.36

Appendix B: Description of Authoring Environment

The hypermedia instrument was created using Macromedia's Authorware® program for designing and packaging stand-alone executable files. Authorware is a visual programming environment that consists of prepackaged "off the shelf" functions represented by program icons and an authoring language for creating scripts. The completed Authorware file was packaged as an executable program and installed on twelve computers using the Windows operating environment in the Center for Instructional Technology, 220 War Memorial Hall. Illustrations of the program, screen by screen, are found in Appendix C.

All graphics and text were developed using Authorware's tools except for the puzzle pieces and puzzle solution images. Authorware recorded all data and generated an external text file containing the outcome measures for each participant. This external file was saved on the hard drive of the computer running the program and was retrieved after every participant completed the program. Authorware's internal random number generator determined which treatment was assigned to any given participant to insure randomization. Recording the amount of time spent solving each of the three puzzle exercises, tracking the number of buttons activated, and recording the number of puzzle pieces moved across the screen to solve each puzzle also utilized internal Authorware functions and code.

The practice puzzle and three jigsaw puzzles function according to the properties of Authorware that control moving objects via the computer mouse. A simple drag / drop mechanism insures that correctly placed pieces remain in the puzzle solution. The highlighting effects available through the organizational aid were created using a show / erase sequence of commands that determine whether or not the image of the highlighted puzzle piece is visible. The navigation through each of the three treatments was handled by Authorware's framework icon and its associated capabilities.

Puzzle Graphics

The images used to compose the jigsaw puzzles were created in Adobe Photoshop®. The puzzle pieces and puzzle outlines were created using an image of the State of Georgia and its counties found at the University of Texas at Austin's online map collection available on the world wide web at: http://www.lib.utexas.edu/Libs/PCL/Map_collection/county_outline.html. This single, large, transparent image was downloaded and edited in Photoshop.

Three ten county areas on the map were identified, and each ten county area was selected using Photoshop's tools and filled with a solid grey color to form the puzzle backgrounds. The shapes of individual counties were selected, colored pink, and saved as separate images to be used as puzzle pieces. The yellow highlighted versions of the puzzle pieces were created the same way.

The practice puzzle was created from a snowflake shape found in a commercially available clip-art collection. Using Photoshop's tools, the snowflake image was divided into fourths and the original color pattern changed to solid blue to create the puzzle pieces. The snowflake background was created by simply filling the original snowflake shape with a solid purple color. All of the puzzle graphics were saved in either .jpeg or .gif format to minimize file sizes and to avoid any potential cross-platform difficulties.

Appendix C: Illustrations of Hypermedia Program Computer Screens Using Treatment Two (Optional Interactivity)

Illustration 5: Initial, Introductory Screen of Program

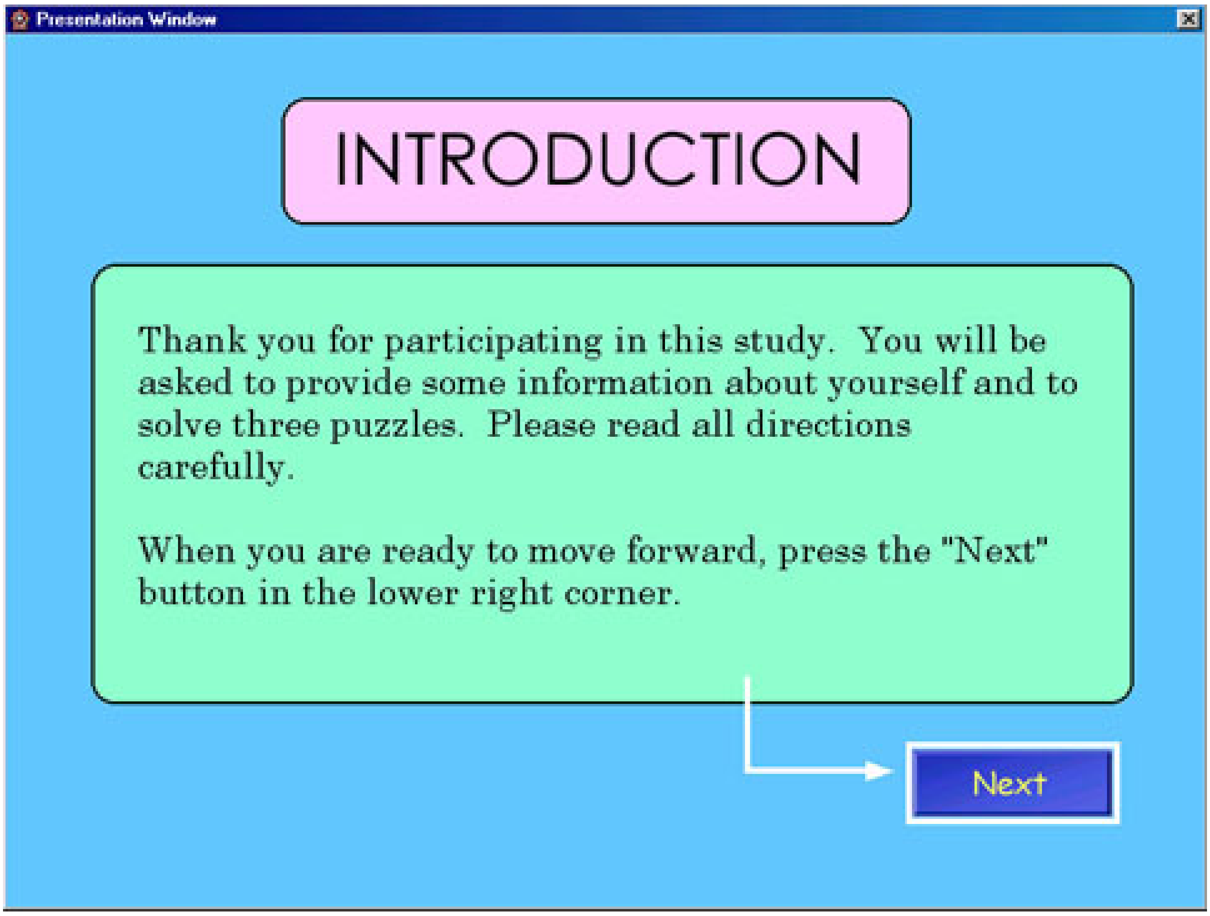

Illustration 6: First Directions Screen

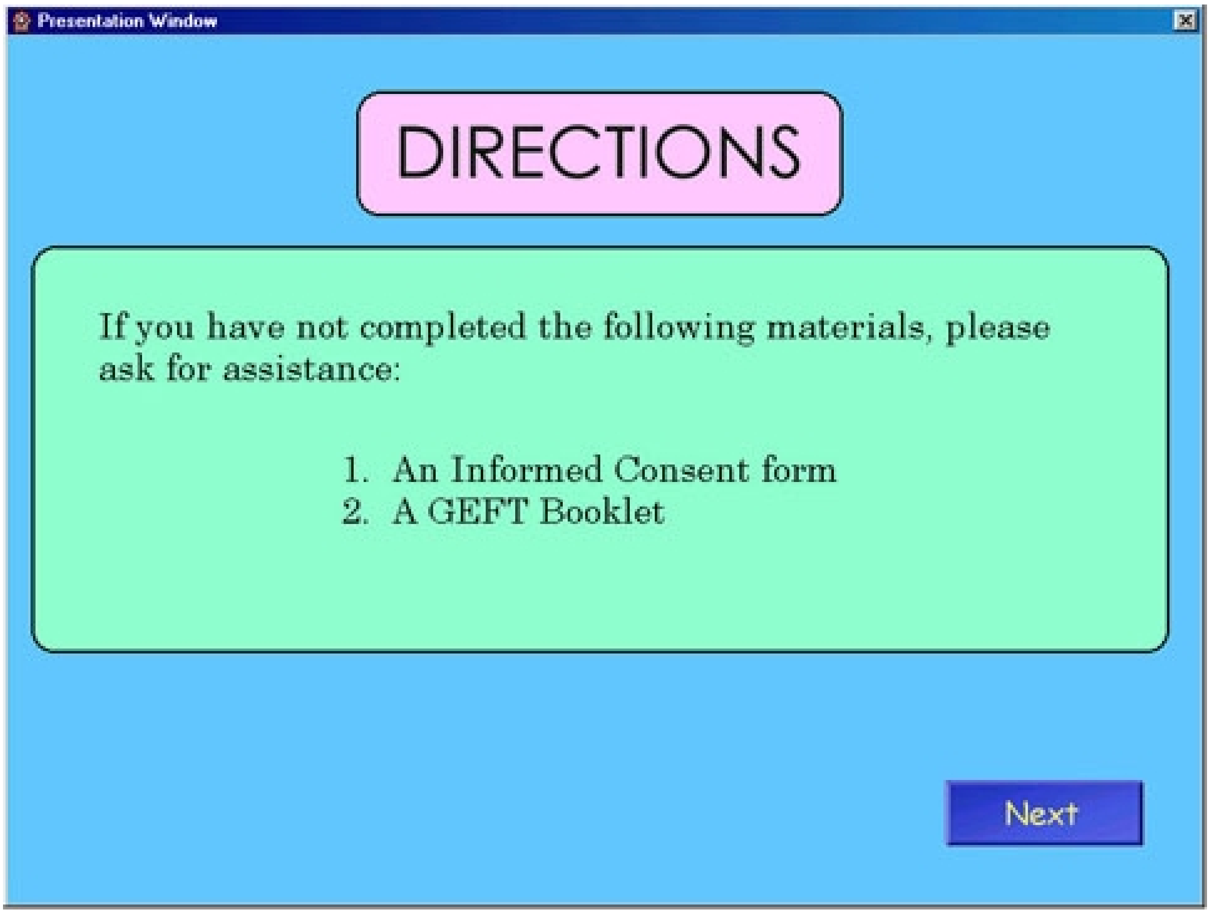

Illustration 7: Second Directions Screen

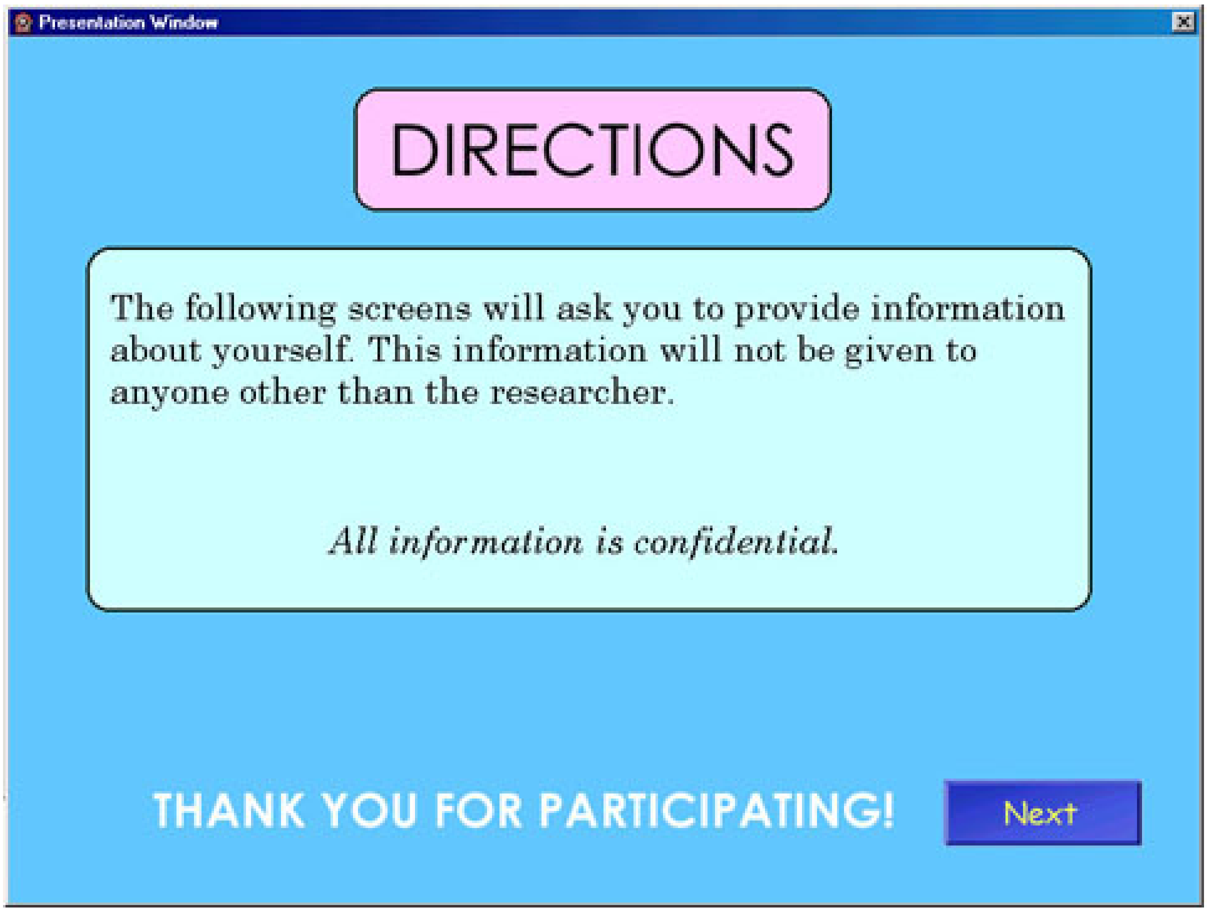

Illustration 8: First Student Information Screen

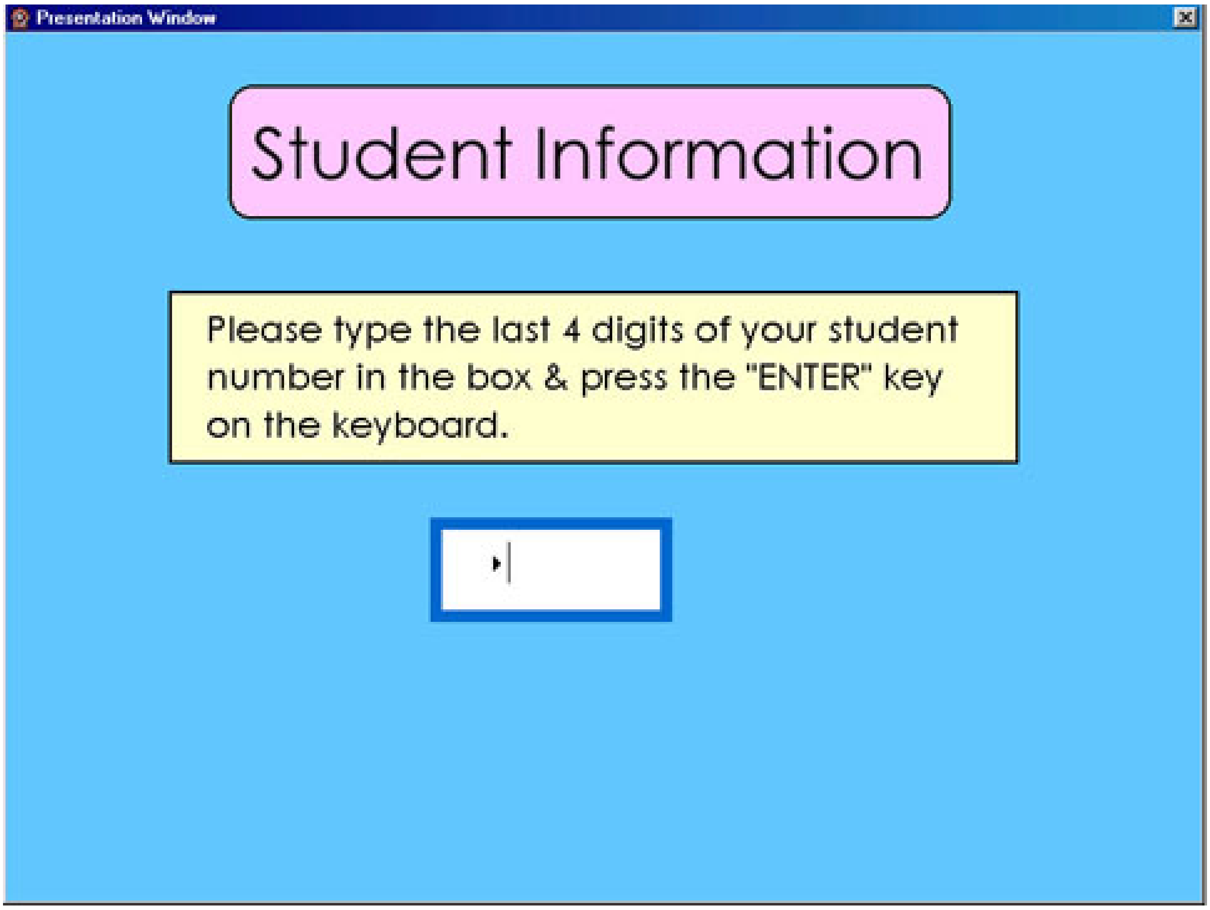

Illustration 9: Second Student Information Screen

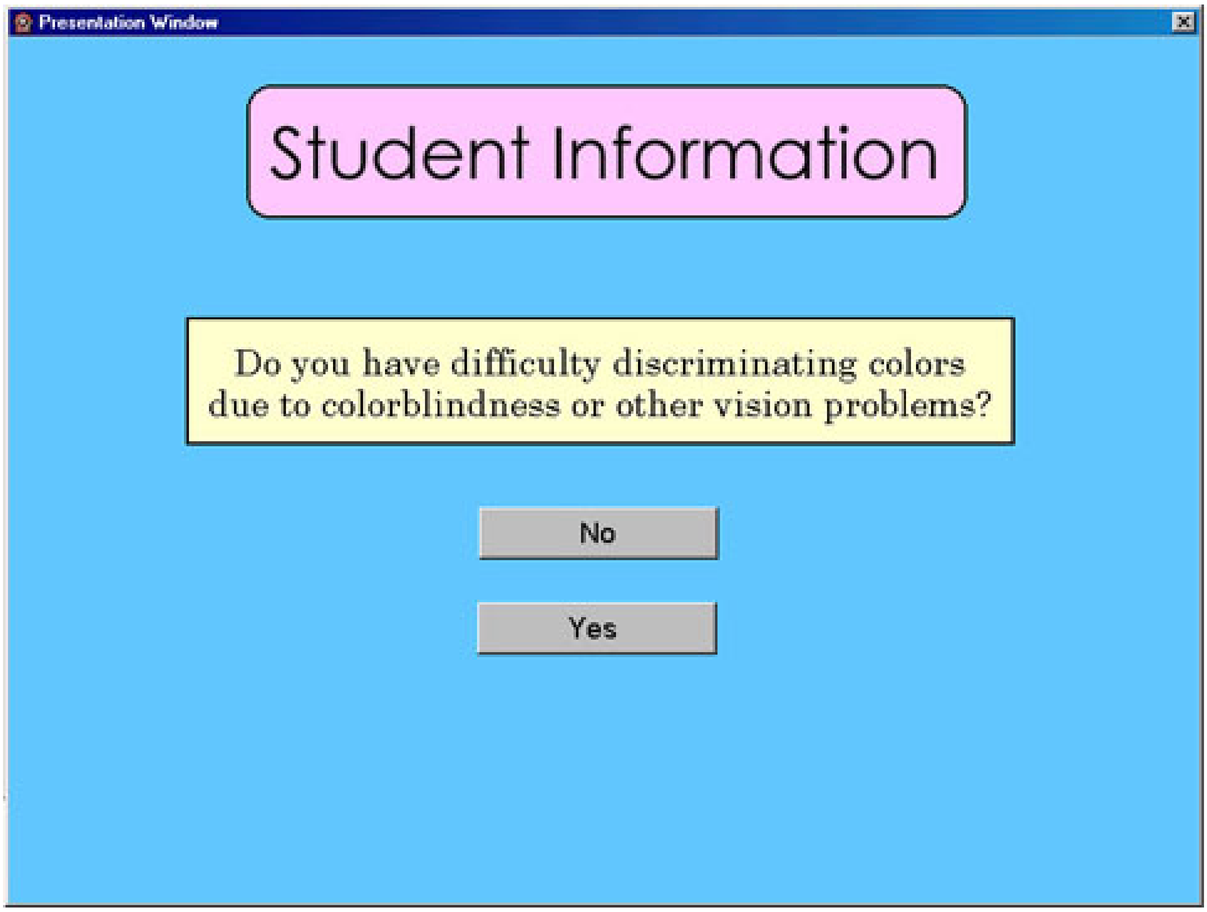

Illustration 10: Third Student Information Screen

Illustration 11: Fourth Student Information Screen

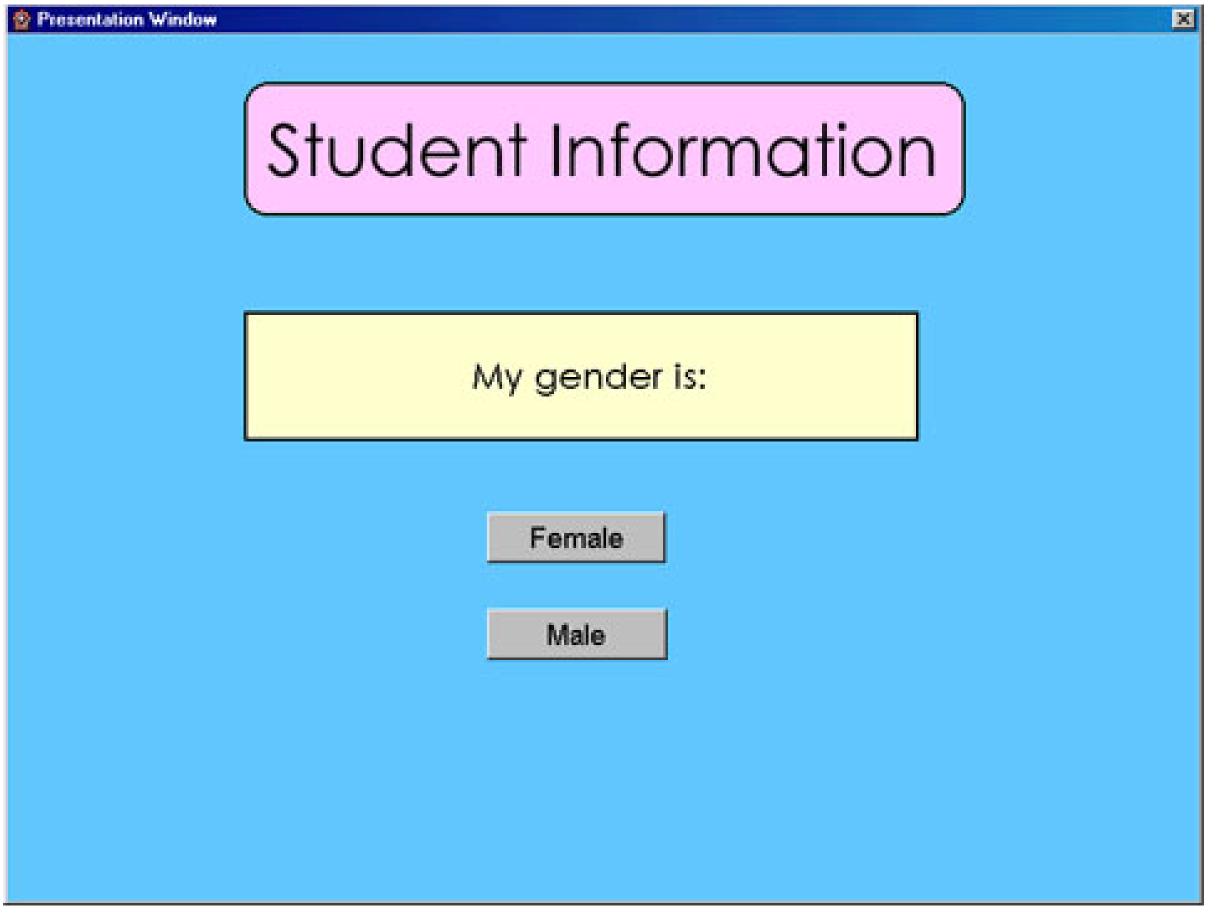

Illustration 12: Practice Puzzle Directions

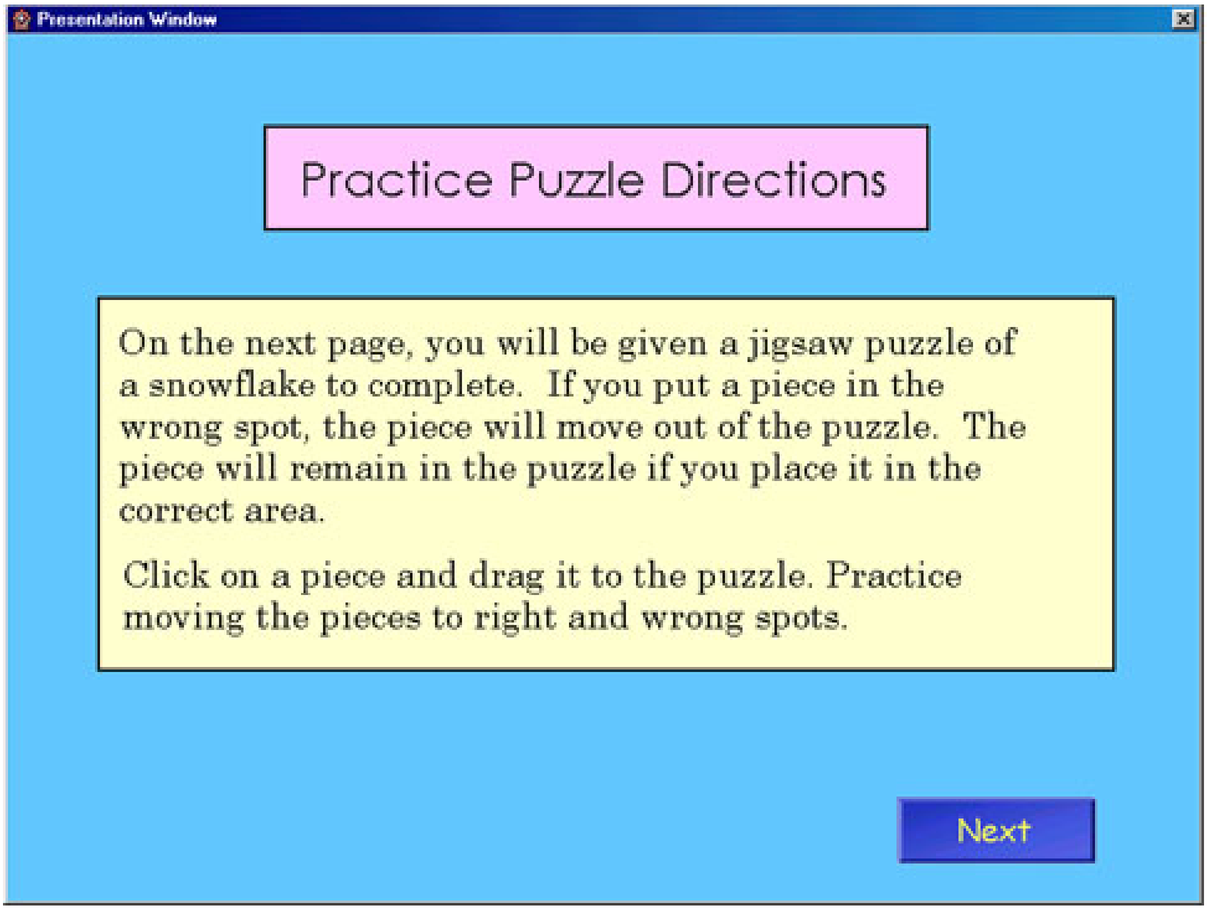

Illustration 13: Initial Practice Puzzle Screen, Unsolved Puzzle

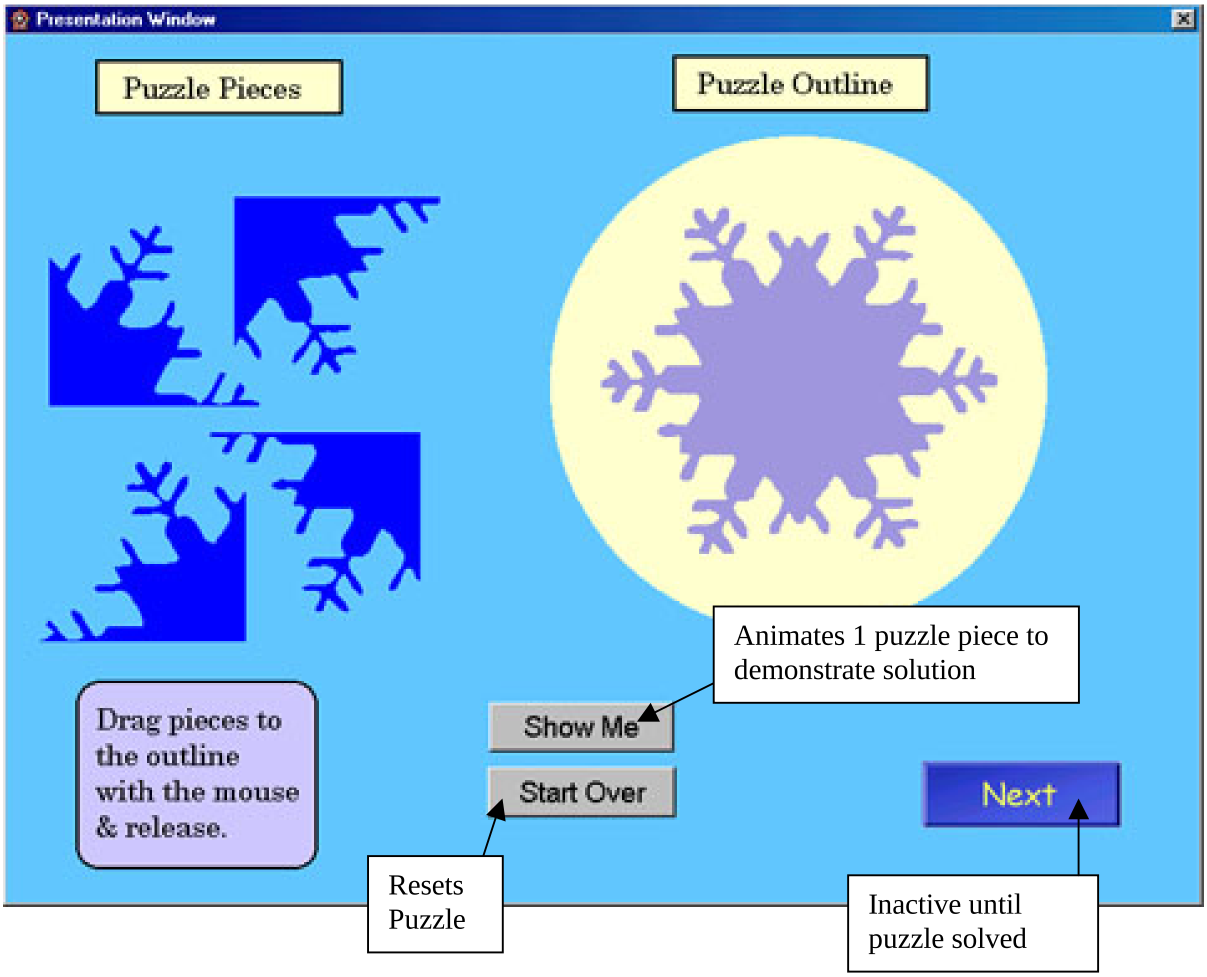

Illustration 14: Final Practice Puzzle Screen, Solved Puzzle

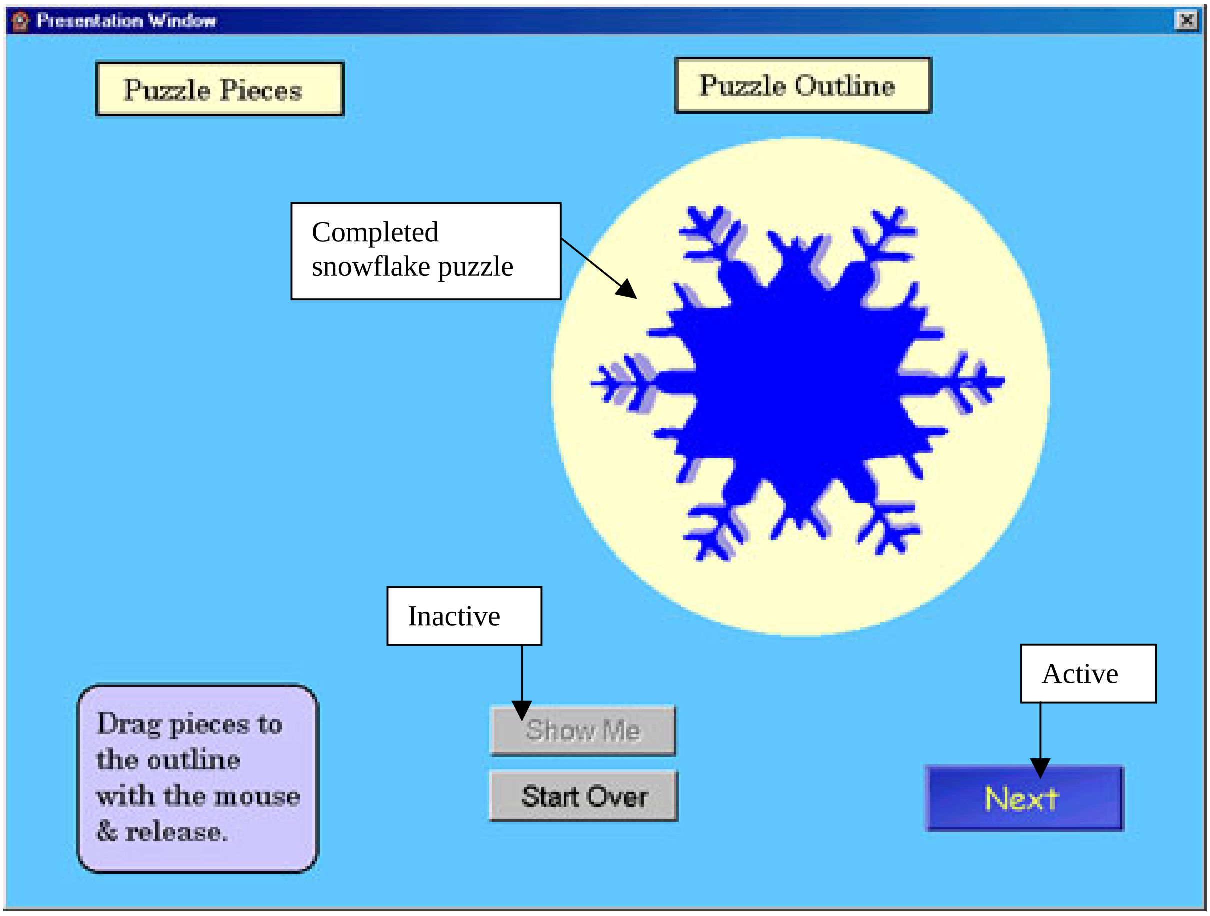

Illustration 15: Directions for Beginning the Jigsaw Puzzle Exercises

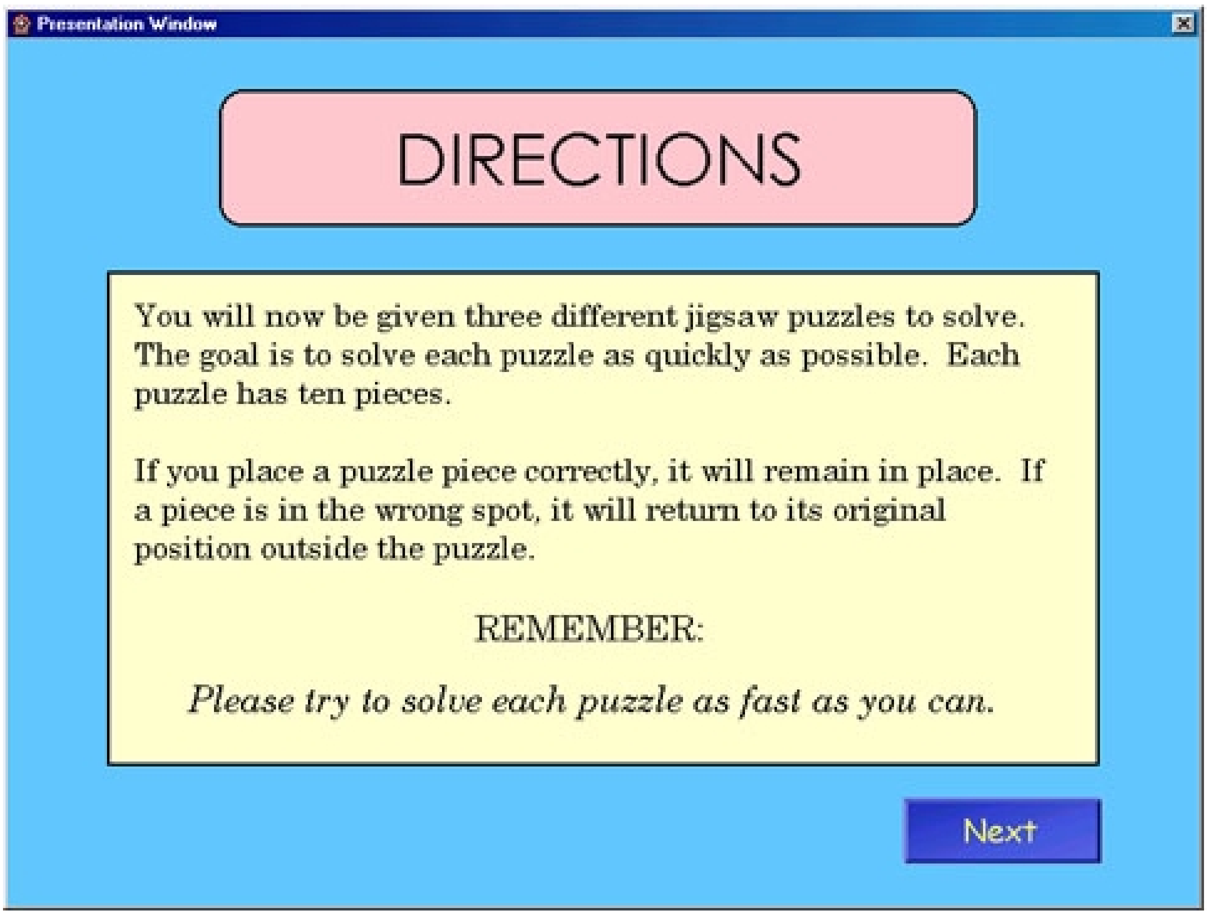

Illustration 16: Interactive Study Aid for Puzzle One, Treatment Two

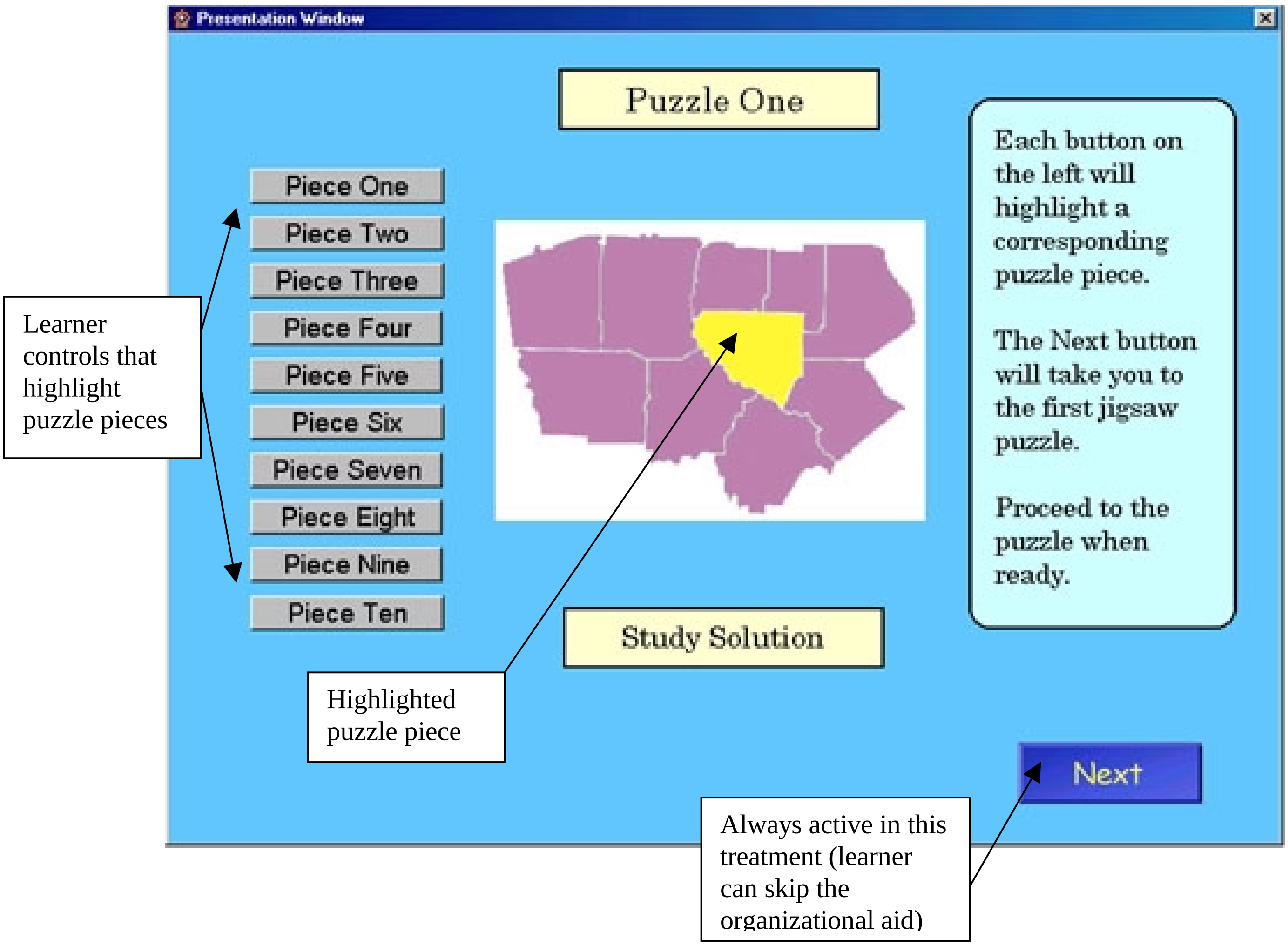

Illustration 17: Unsolved Puzzle One

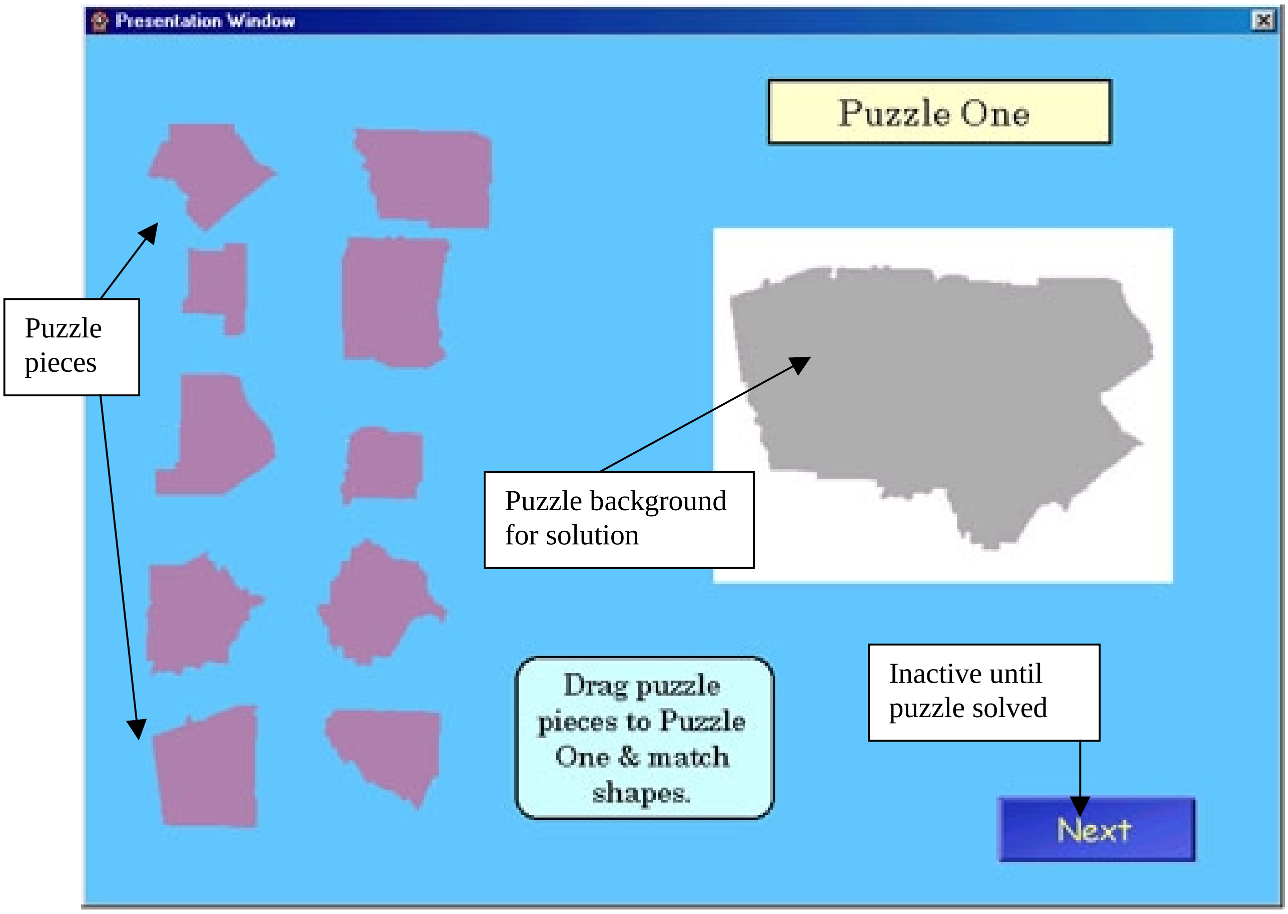

Illustration 18: Solved Puzzle One

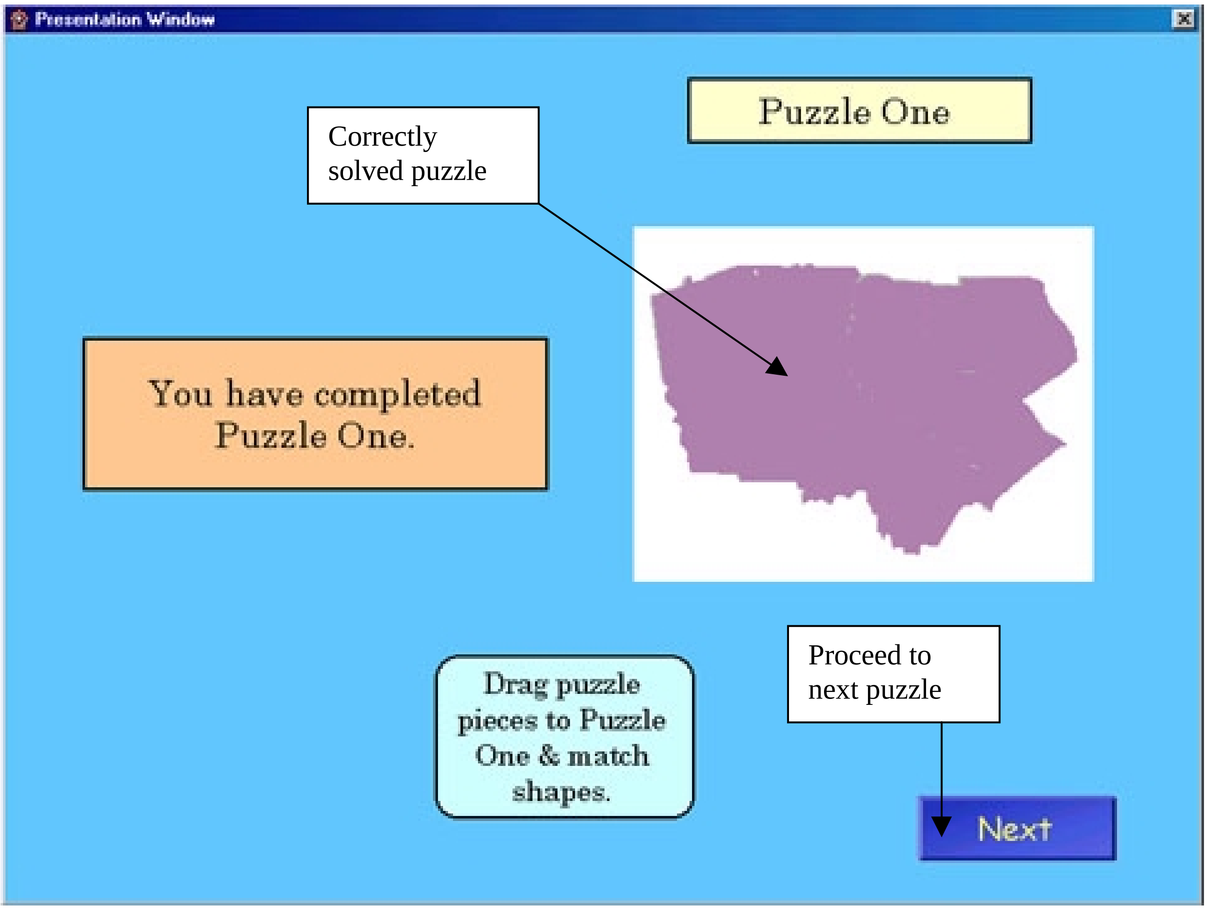

Illustration 19: Interactive Aid for Puzzle Two, Treatment Two

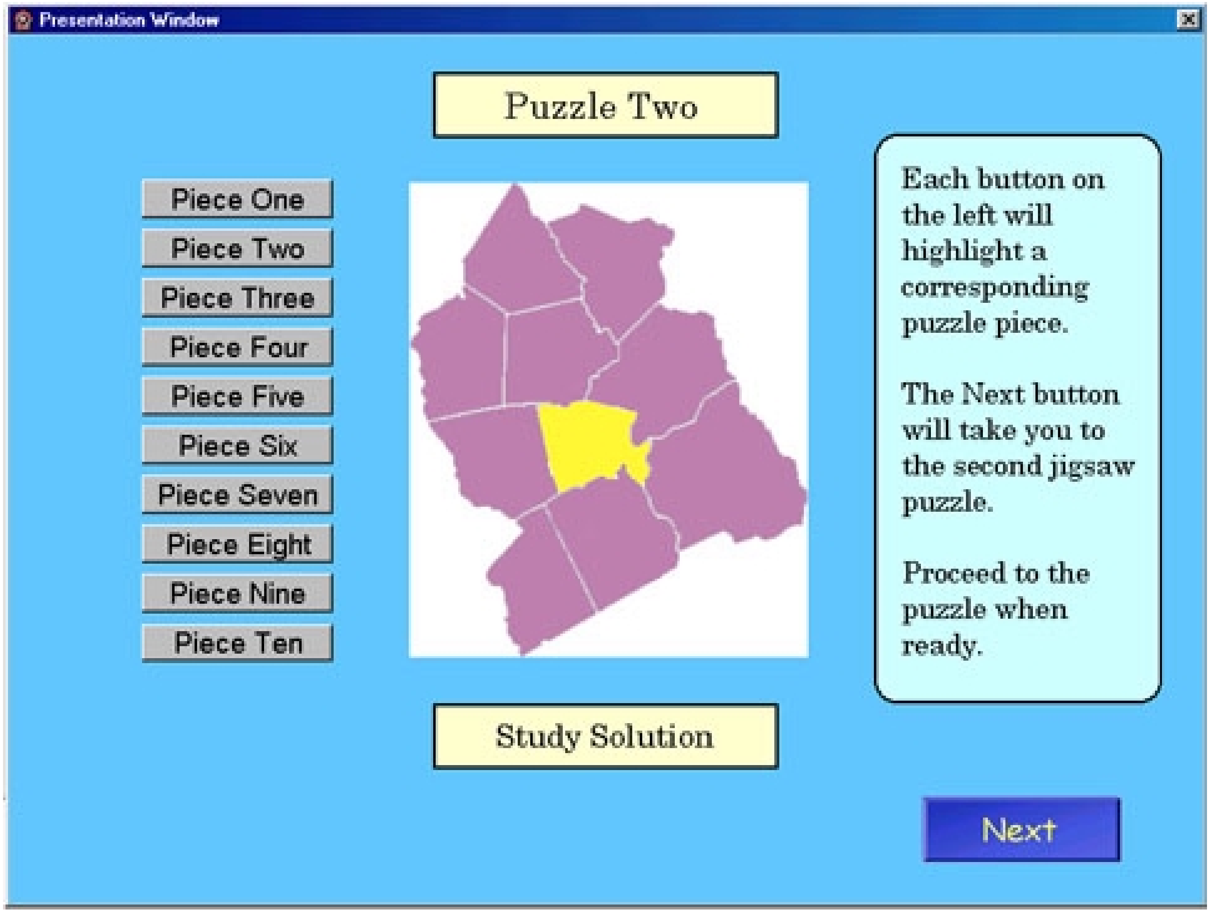

Illustration 20: Unsolved Puzzle Two

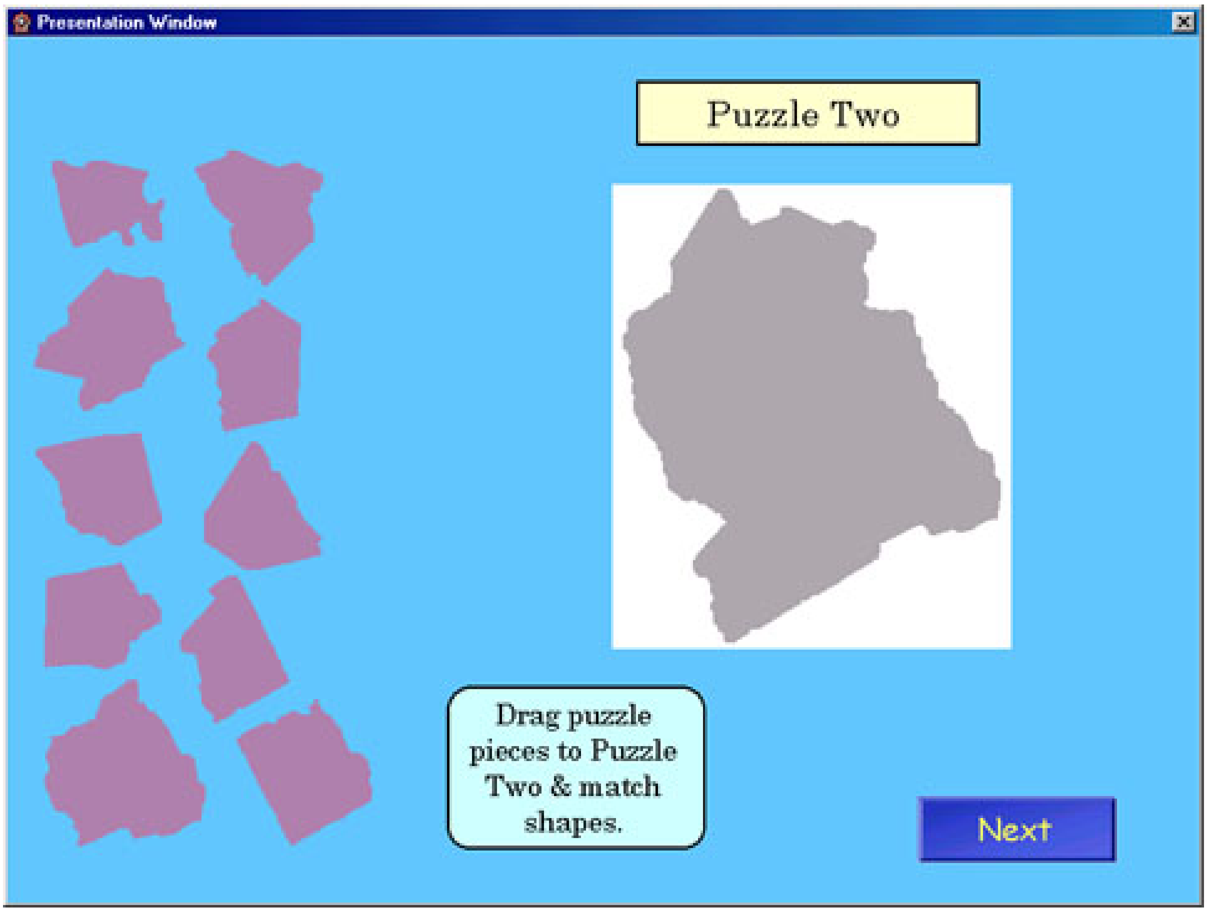

Illustration 21: Solved Puzzle Two

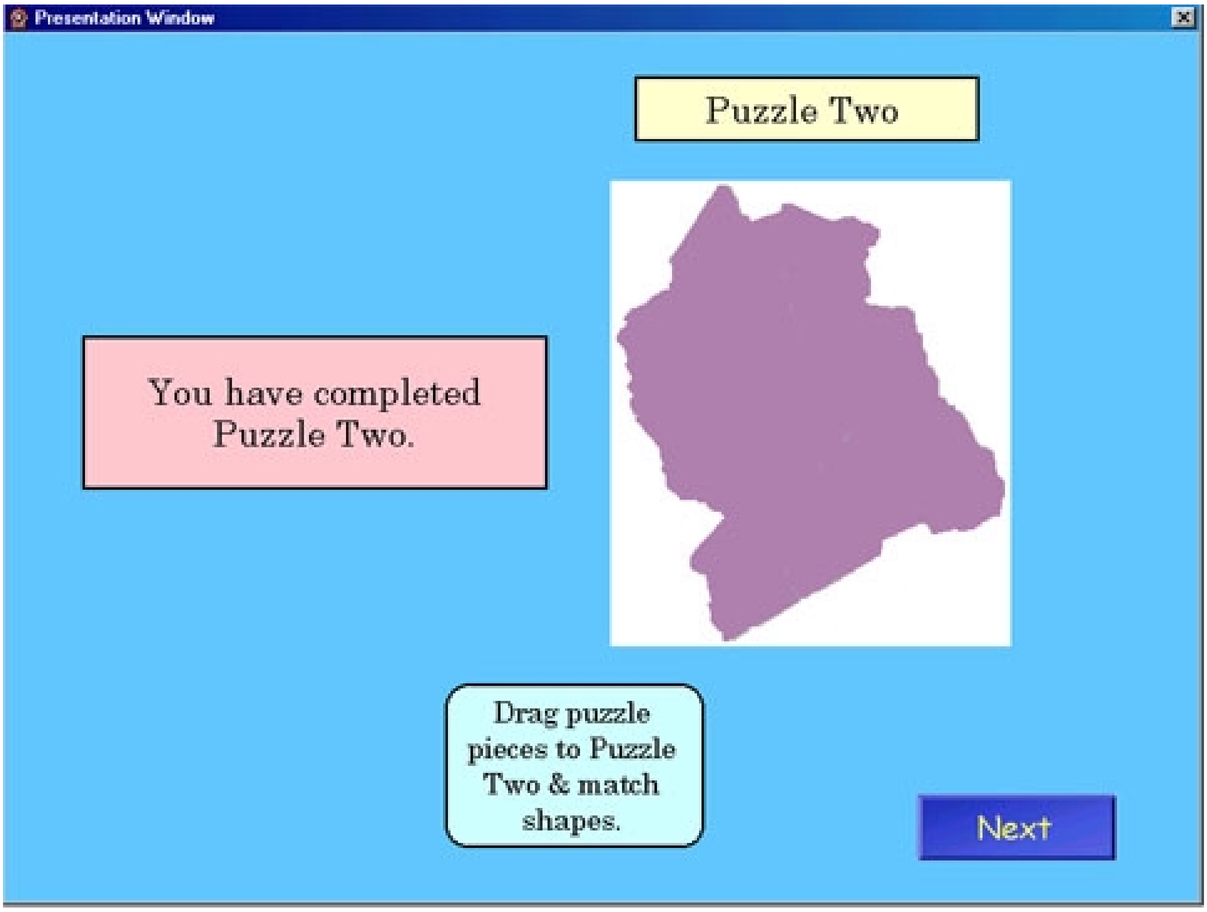

Illustration 22: Interactive Aid for Puzzle Three, Treatment Two

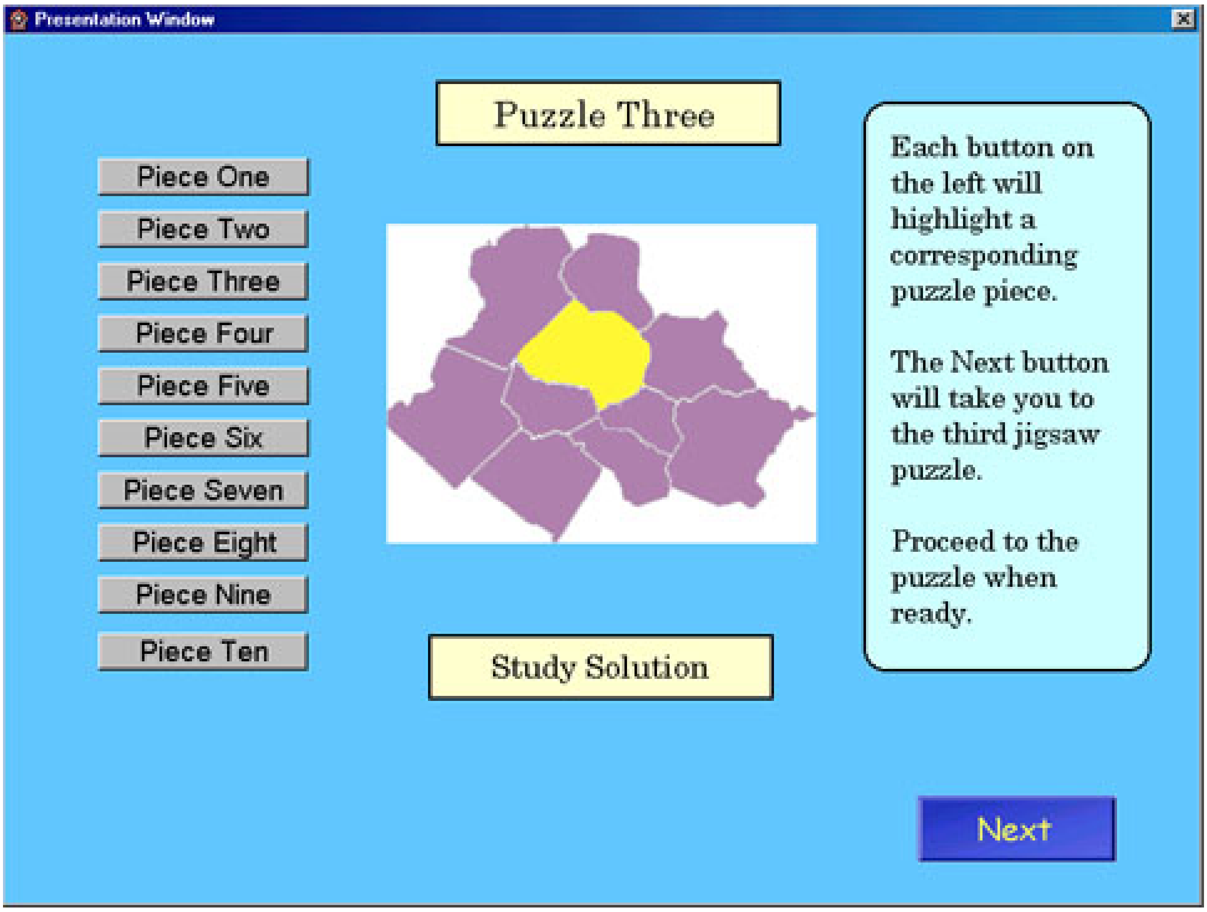

Illustration 23: Unsolved Puzzle Three

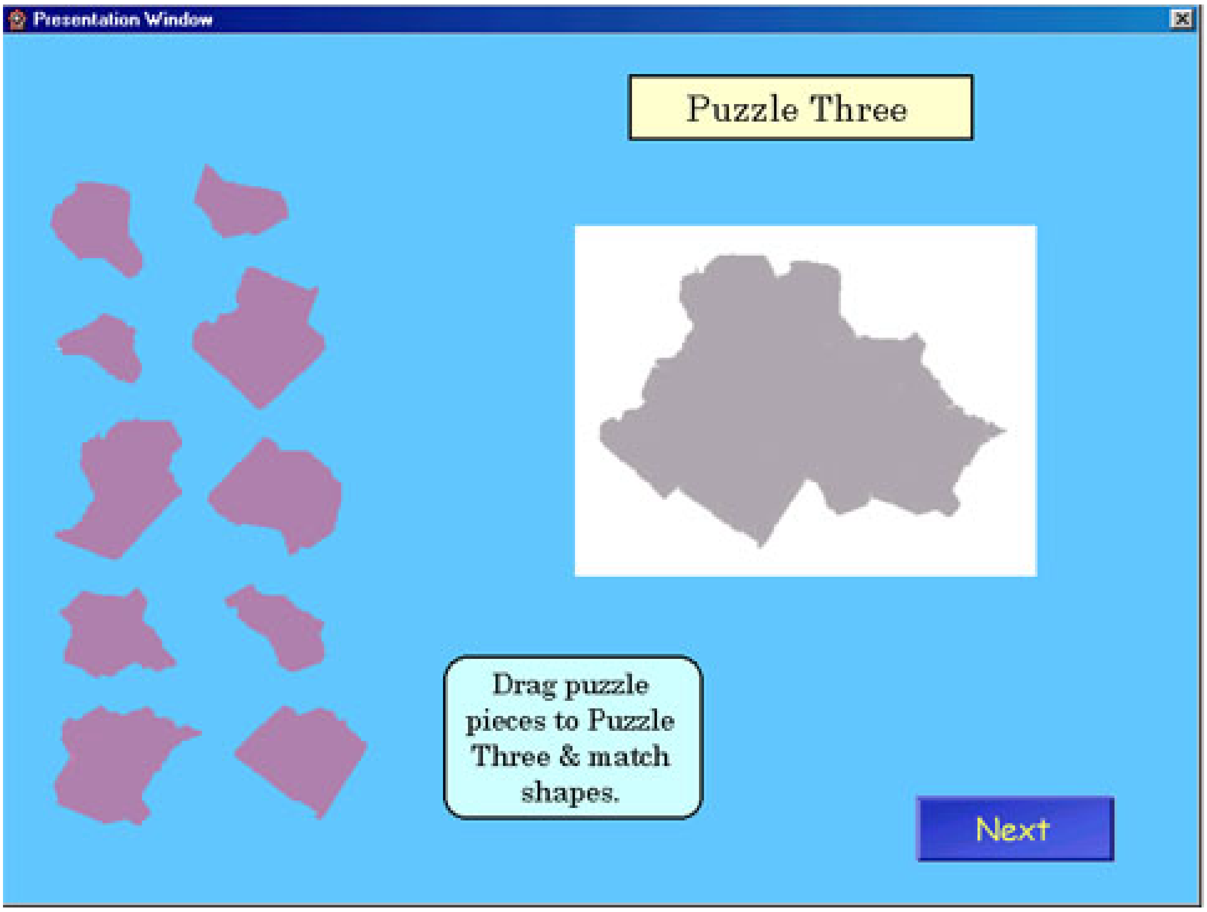

Illustration 24: Solved Puzzle Three

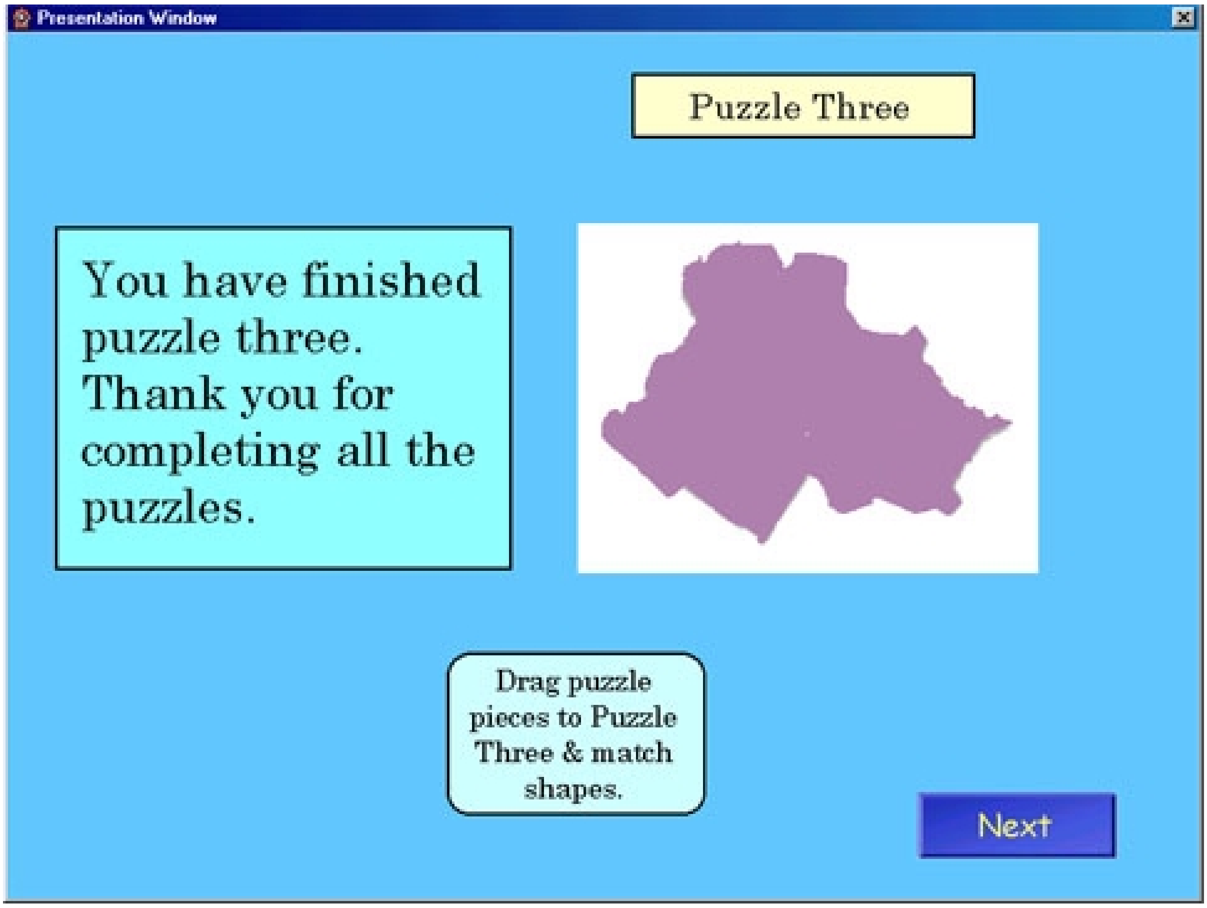

Illustration 25: Final Screen with Exit Directions

Appendix D: Informed Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Informed Consent for Participants
of Investigative Projects

Title of Project: Field Dependence-Independenc and Computer-based Instruction in Geography

Investigator(s): Judith Hall (Ph.D candidate) & Dr. John Burton (advisor)

I. The Purpose of this Research/Project

All students enrolled in Introduction to Human Geography (Geography 1004) are invited to participate. This project explores the use of interactivity and performance by students with different cognitive styles in a hypermedia-based environment. The goal of the proposed experiment is to describe the relationship between the cognitive style of field independence / dependence, the use of interactive screen elements, and performance on a task that requires visual discrimination. Exploring the use of features available in hypermedia systems is an emerging endeavor, and very little research has directly addressed the use of computers in geography education. This project merges ongoing research in the instructional uses of hypermedia with the need to find effective practices for computer-based learning in geography.

II. Procedures

Participants will be asked to complete the Group Embedded Figures Test (GEFT) using the exam booklet provided and a pencil. Administration of the GEFT requires approximately 15 minutes and will take place in 220 War Memorial Hall. Next, participants are expected to complete a computer-program developed by the researcher. Each participant may spend as much time as s / he would like to complete the program. The program is available in the Teaching and Learning computer lab located in 220 War Memorial Hall. The computer lab is available Monday through Thursday from 8:00 am until 10:00 pm, Friday from 8:00 am until 4:30 pm, and Sunday from 2:00 pm until 8:00 pm. The investigator will be available to assist participants with questions and technical problems.

III. Risks

There are no risks to any participants.

IV. Benefits of this Project

No benefits accrue to individual subjects. No promise or guarantee of any benefit has been made to any person in an effort to encourage participation in this research. The research project itself helps to advance the understanding of appropriate instructional design for learners with different cognitive styles.

Participants may learn their cognitive style as measured by GEFT and their performance on the computer-based exercise if they would like to request their scores from the researcher after the completion of the project.

V. Extent of Anonymity and Confidentiality

Participants will be asked to identify themselves by using the last four digits of their social security numbers. Participants will not be asked to provide complete social security numbers, names, or other unique identifications. The researcher will not be able to identify any individual participant by name or in any other conclusive way. Only Dr. Robert Morrill, who is responsible for assigning credit to students who complete the project, will know which students chose to participate. The identifying numbers will only be used to match cognitive style scores from the GEFT with performance measures from the computer-based exercise. At no time will the researcher release the results of the study to anyone other than individuals working on the project unless participants' written consent is first obtained. Final publication of research results will not identify participants in any way except to describe the sample population as a whole.

VI. Compensation

Students may receive the equivalent of homework credit from Dr. Robert Morrill for participating in this study. Students who choose not to participate will not be penalized in any way. Credit options for all assignments are explained in the syllabus for Geography 1004.

V. Freedom to Withdraw

Subjects are free to withdraw from this study at any time without penalty. If participants choose to withdraw, they will not be penalized by reduction in points or course grade. Subjects are free not to answer any questions or respond to experimental situations that they choose without penalty.

VIII. Approval of Research

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University, by the Department of Teaching and Learning.

IX. Subject's Responsibilities

I voluntarily agree to participate in this study. I have the following responsibilities:
I will complete the Group Embedded Figures Test as directed by the researcher.
I will complete the computer-based exercise provided for me at the Teaching and Learning computer lab, 220 War Memorial Hall.

X. Subject's Permission

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project.

____________________________ ____________________________

Signature Date

Should I have any questions about this research or its conduct, I may contact:

Judith Hall	231-5587 (juhall@vt.edu)
Investigator(s)	Phone
Dr. John Burton	231-5587 (jburton@vt.edu)
Faculty Advisor	Phone
__________________________	____________________
E. R. Stout Chair, IRB, Research Division	