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# The Dynamic Graphic Organizer and its Influence on Making Factual, Comparative, and Inferential Determinations within Comparative Content

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# The Dynamic Graphic Organizer and its Influence on Making Factual, Comparative, and Inferential Determinations within Comparative Content

by

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## Dedication

I dedicate this dissertation to my wonderful wife, Mara. Without her love and selfless encouragement, this endeavor would not have been possible.

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Abstract

By augmenting an existing static medium (a graphic organizer) with attributes such that learners were able to sort or rearrange information in multiple ways, two new types of "dynamic" graphic organizers were created. An experiment was performed to investigate the effectiveness of these dynamic graphic organizers as instructional tools. One-hundred-sixty-one students were recruited for participation in the study from a two-year community college and a four-year public university in the southeast United States. Participants were randomly assigned to one of three graphic organizer treatment groups: static, sortable, and shuffle-sortable. Response accuracy and response latency measurements for three types of mental tasks (factual, comparative, and inferential) were compared across the three treatment groups.

A multivariate analysis of variance showed no significant difference between the three graphic organizer types for response accuracy. A within-groups analysis of variance showed no significant differences in response accuracy between mental tasks within the static or sortable treatment groups. However, analysis of variance indicated that accuracy for inferential judgments was lower than that for factual judgments in the shuffle-sortable group. With respect to response latency, a multivariate analysis of variance revealed no significant difference between the three treatment groups. A within-groups analysis of

variance showed significant differences in response latency between factual and inferential judgment-making for both the sortable and shuffle-sortable treatments. The sortable treatment had the most pronounced differences in latency between mental tasks, whereas no significant differences in response latency were observed within the static treatment.

Participants in the two dynamic treatments reported much higher percentages of affirmative responses to the question, “Did you think your graphic organizer was an effective instructional tool?” with 82.7% and 81.5% responding “yes” for the Sortable and Shuffle-sort groups, respectively, and only 60.0% responding “yes” for the Static group.

The graphic organizers in the study are known as adjunct displays and therefore each was associated with an accompanying text passage. Participants had the capability of viewing the accompanying text passage at will within the constraints of a five-minute graphic organizer study period. Analysis of variance revealed that participants in the shuffle-sortable group spent significantly less time viewing the text passage than participants in the static group, possibly because the overhead associated with the shuffle-sortable graphic organizer’s user interface controls consumed time or mental resources that would have otherwise been used to view the text.

The results of this study suggest that dynamic graphic organizers are equivalent to traditional static graphic organizers, at least for the educational subject matter used in this study (comparative text comprising 204 words describing six fictitious species of fish, their attributes, and the relationships between these attributes) for measures related to accuracy. Additionally, participants in the two dynamic graphic organizer treatments took

advantage of the affordances offered by those treatments (88.5% of the Sortable group sorted, 75.9% of the Shuffle-sort group sorted, and 88.9% of the Shuffle-sort group shuffled). This study may benefit both instructional designers and educational researchers as new curricula are designed and new instructional tools are studied, respectively.

# Chapter One: Introduction

Researchers have long sought ways to help readers both recall the information contained in texts but also to better understand the relationships between the ideas and concepts contained therein. Simultaneously, educators have continued to identify best practices to follow when integrating sound instructional practices with educational technologies in ways that most effectively enhance student learning (Kealy, 2001).

Commonly studied instructional strategies have included underlining, note-taking, outlining, using bold typeface for keywords, and summarizing (Wade, Trathen, & Schraw, 1990). These strategies are characterized by their tight coupling with the text itself (e.g., boldface typeface is simply a special attribute of the text). In contrast, another category of instructional strategies includes adjunct (that is, separate from the text) displays such as photographs and maps; these types of displays elaborate text by presenting information, such as spatial relationships, that would be difficult or cumbersome to convey through words alone. Finally, a third category of instructional strategies exists, one which Rieber (1994) classifies as "arbitrary graphics." These types of adjunct displays are not representational in nature but instead depict objects, concepts, or their relations using various configurations of text, lines, symbols and/or the spatial arrangement of these elements. Examples of arbitrary graphics include concept maps, tree diagrams, and graphic organizers, the subject of this study. (A graphic organizer is an array-like arrangement of key terms or concepts that also appear in an informationally equivalent accompanying text.)

*Context of the Problem*

A large body of research "suggests that adjunct displays facilitate reading comprehension almost without exception," (Robinson & Schraw, 1994, p. 399). This facilitative advantage is known as the adjunct display effect (Robinson, Katayama, & Fan, 1996; Robinson, Robinson, & Katayama, 1999). Despite numerous studies, however, there is still much to be investigated when considering how best to configure a display such that it communicates information most effectively. For example, textbook authors (one of the primary creators of graphic organizers), often implement inappropriate types of graphic organizers, at least in part because educational researchers have not identified which type of graphic organizer is best suited for a particular educational application (Robinson, 1998).

A static graphic organizer is already an effective instructional device owing to its inherent visual argument (Waller, 1981) and computational efficiency (Larkin & Simon, 1987). However, the inert nature of graphic organizers may limit their potential as they exist today on the printed page or in static computer-based displays. One promising area of investigation involves augmenting a graphic organizer with a computational capability such that learners can reorder or otherwise reconfigure the graphic organizer's elements. Doing so (that is simply reconfiguring the elements in a display) can significantly improve that display's usefulness for learners (Winn, 1991, 1993). Similarly, reordering and grouping the elements of an array-like display can sometimes lead to new insights and reveal relationships between those elements (Wainer, 1992). Furthermore, imbuing a graphic organizer with an interactive, dynamic attribute may enable a learner to overtly uncover relations among the elements of the subject matter, thus exploiting generative learning theory (Wittrock, 1991). In other words, this interactive component will transport the learner from role of passive recipient to that of active participant, thus enabling the learner to construct meaningful information thereby satisfying this basic tenet of generative learning theory (Grabowski, 2004). Finally, this area of inquiry seems well-suited for investigation, as “relatively few research studies have focused on ways to make the reading of on-screen text an active experience” (Crooks, White, Barnard, 2007, p. 369).

Adding an interactive, computational capability to graphic organizers would be of little interest to educational practitioners if instructional materials existed only on the printed page. Fortunately, the trend toward ubiquitous computing in schools and the home (at least in the United States) continues to be positive, thus ensuring that instructional designers and other educational practitioners have the technological infrastructure in place to deliver dynamic graphic organizers. As one example of this trend toward increased availability of computing resources, distance education enrollment at colleges in the United States more than tripled from school years 1994-95 to 2000-01 (Kiernan, 2003). As another example, there is some degree of computer presence in virtually all K-12 schools in the U.S. today (Morgan, 2006). Finally, the U.S. Census Bureau reports that (as of 2003) nearly 62% of U.S. households owned at least one computer and nearly 55% of U.S. households had Internet access (Day, Davis, & Lewis, 2005).

*Purpose of Research*

The purpose of this study was to investigate the effects of dynamic graphic organizers on learners’ ability to encode, recall, and apply factual, comparative, and inferential material contained in expository text having the comparative organizational structure. The overarching goal of the study was to investigate the effects of using generative learning theory to augment a previously static instructional device: the graphic organizer. By doing so, the researcher aimed to fill an existing gap in the research literature, as well as provide instructional designers and other educational practitioners with an evidence-based tool that can be incorporated into learning materials.

Graphic organizers are also useful for presenting information of varying intellectual complexity. For example, a single graphic organizer might convey three distinct, increasingly complex, types of information: (1) factual (e.g., fish species *x* is black); (2) comparative (e.g., fish species *x* is black and fish species *y* is white); and (3) inferential (e.g., darker colored species of fish tend to swim at greater depths than lighter colored ones). As depicted in Table 1, a mapping can be established between the three levels of intellectual complexity noted (factual, comparative, and inferential) and the graduated levels of abstraction codified in Bloom's Taxonomy (Bloom, 1956). That is, remembering *factual* information would map to *knowledge* on Bloom's Taxonomy, *comparing* would map to *comprehension/application*, and *inferring* would map to *analysis/synthesis*.

Table 1.
*Mapping of Mental Tasks to Original and Revised Bloom's Taxonomies*

| **Mental Tasks Performed by Participants in Proposed Study** | **Original Bloom's Taxonomy (Bloom, 1956)** | **Revised Bloom's Taxonomy (Krathwohl, 2002)** |
|---|---|---|
| Remembering (Facts) | Knowledge | Remembering |
| Comparing | Comprehension | Understanding |
| | Application | Applying |
| Inferring | Analysis | Analyzing |
| | Synthesis | Evaluating |
| | Evaluation | Creating |

The two types of dynamic graphic organizers investigated in the study were, first, a sortable graphic organizer, that is, one whose rows can be reordered (sorted) under learner control. The second type of dynamic organizer was a “shuffle-sort” graphic organizer, that is, one whose columns can be arbitrarily rearranged by the learner.

*Research Questions*. The guiding research question was: What are the effects of a dynamic sortable graphic organizer or dynamic shuffle-sort graphic organizer on learners’ ability to accurately make factual, comparative, and inferential determinations related to an expository text having a comparative organizational structure? More specifically, the research questions addressed in the study were:

1) Is there a significant difference in accuracy for factual judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer?
2) Is there a significant difference in accuracy for comparative judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer?
3) Is there a significant difference in accuracy for inferential judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer?

*Hypotheses*. Because of the increasing intellectual complexity of the three mental tasks (factual, comparative, inferential) accuracy was expected to decrease across those measures for each of the three graphic organizer treatments. However, the decrease was not expected to be equal across the three treatments. That is, an ordinal interaction between graphic organizer treatment and mental task was expected. Specifically, accuracy for factual judgments was predicted to be similar for each of the three treatments. Accuracy for comparative judgments was predicted to be similar for both dynamic graphic organizer treatments, with both treatments being significantly better than the static graphic organizer treatment. For inferential judgment-making accuracy, the dynamic shuffle-sort treatment was predicted to be significantly better than the dynamic sortable graphic organizer while the dynamic sortable graphic organizer treatment was predicted to be significantly better than the static treatment.

Response latency, that is, the difference between the time a question was displayed and the time a participant responded to that question, was expected to vary with the complexity of mental tasks. That is, response latency for inferential judgments was expected to be greater than response latency for comparative judgments which was expected to be greater than response latency for factual judgments.

Limitations and Delimitations

Generalizing the results of this study should be done with care. Any attempt to do so should recognize that the participants were drawn only from undergraduate college students at two urban postsecondary education institutions in the southeastern United States. Generalizing results to populations with different characteristics may require additional research. Similarly, generalizing the results to graphic organizers representing other types of instructional materials should be done with caution, as the instructional material in the study was characterized by a specific organizational structure, size, and reading level.

*Summary*

This chapter has provided an introduction to the research, a context explaining why this study is important, goals that the proposed research have addressed, specific research questions and hypotheses, and finally limitations and delimitations of the study.

*Definition of Terms*

Comparative Organizational Structure: Meyer, Brandt, & Bluth (1980) proposed a model to classify informational text into five different organizational structures: description, sequence, causation, problem/solution, and comparison. Each organizational structure is characterized by its purpose and by its "signals", that is by words and phrases that provide clues to a reader about the structure of a given passage. The prose passage that serves as a component of the instructional materials in the current study falls into the "comparative" organizational structure (a structure characterized by the use of signal phrases such as "whereas" and "in contrast").

Generative Learning Theory: A learning theory founded by Wittrock, in which the learner becomes an active participant in the learning process, working to construct meaningful understanding, rather than being a passive recipient of information (Grabowski, 2004). Generative learning has been called "the practical cousin of constructivism" (Bonn & Grabowski, 2001, p. 1) as both generative learning and constructivism focus on "constructing meaningful understanding of information found in the environment" (p. 1). The following Wittrock quotation helps to convey the gist of this theory of learning: "Although a student may not understand sentences spoken to him by his teacher, it is highly likely that a student understands sentences that he generates himself" (1974b, p. 182).

Graphic organizer: A static graphical or spatial representation of text concepts. Graphic organizers use relative spatial location to convey concept relations (Robinson, Corliss, Bush, Bera, & Tomberlin, 2003).

Graphic organizer (sortable): A dynamic graphic organizer whose *rows* may be reordered (say, by ascending or descending order) under learner control.

Graphic organizer (shuffle-sort): A dynamic, sortable graphic organizer whose *columns* may be arbitrarily reordered (that is, shifted toward the right or left) under learner control.

Response latency: The difference (in seconds) from the time a criterion question was displayed and the time a participant responded to that criterion question.

*Organization of Remaining Chapters*

This dissertation is organized into five chapters. In this, the first chapter, introductory material is presented. The second chapter reviews related literature and provides a theoretical framework for the study. The third chapter details the method used during the investigation. In the fourth chapter, results of the study are presented. Finally, the fifth chapter contains a discussion and summary of the research.

# Chapter Two: Literature Review

Graphic organizers and their precursor, the advance organizer, have been studied by educational researchers for nearly fifty years. This chapter first presents a historical overview of graphic organizer development, followed by a review of relevant graphic organizer research.

## *Graphic Organizer Origins*

Ausubel (1960) first used the term *advance organizer* in the title of his study intended to investigate the proposition that introducing concepts prior to the learning of "meaningful verbal material" (p. 267) would enhance the "incorporability" of that material. Since then, advance organizers (and their many derivatives) have become a frequently used instructional strategy; in fact, the advance organizer is cited as one of the "100 universal principles of design" by Lidwell, Holden, & Butler (2003, p. 16).

Ausubel's original advance organizer study was designed to test the hypothesis that "the learning of unfamiliar but meaningful verbal material can be facilitated by the advance introduction of relevant subsuming concepts (organizers)" (Ausubel, 1960, p. 267). Participants in this study studied a 2,500-word passage detailing the metallurgical properties of steel—retention of the material was tested three days later by means of a multiple-choice instrument. In the cited paper Ausubel wrote, "Comparison of the mean retention scores of the experimental and control groups unequivocally supported the hypothesis" (p. 271). Ausubel's rationale for using organizers introduced prior to learning involved his assertion that learners must either create a new schema or activate an existing schema before they can learn new material (Robinson, 1998). Ausubel, Robbins, and Blake believed that meaningful materials were "invariably related to an existing cognitive structure that is hierarchically organized in terms of highly stable and inclusive conceptual clusters under which are subsumed less stable and more specific illustrative data" (1957, p. 335).

Barron's 1969 study advanced Ausubel's work by introducing the notion of a "structured overview." These structured overviews were hierarchical representations of a "taxonomy of content to be taught in a given length of time" (Barron, 1969, p. 32). These outline-like structured overviews served to preserve the attributes of an advance organizer by "relating new content information to relevant subsuming concepts that have been previously learned" (p. 33) while giving learners an idea how the new learning unit related to the course in its entirety.

The term "graphic organizer" seems to have first appeared in the literature in 1970 when Barron described graphic organizers as descendents of the structured overview (Barron, 1970). These original graphic organizers were diagrams comprised of nodes (representing concepts) with straight and circular vectors connecting some nodes. The original graphic organizer paper also operationally defined graphic organizers by providing a *Steps in Constructing and Using Graphic Organizers* procedure as an appendix.

According to Robinson (1998) structured overviews metamorphosed into graphic organizers because the former proved more effective as a postreading aid than it had as a prereading aid (overviews are typically given in advance of reading, hence the shift in nomenclature).

*Modern Graphic Organizer Research*

*Reviews/Critiques*. Moore and Readence (1984) performed a meta-analysis of 23 studies that included graphic organizer interventions. In this synthesis of the 23 studies, they computed an average effect size of 0.22, with a standard deviation of 0.58. They concluded that learners who received a graphic organizer intervention outperformed control-group learners by roughly two-tenths of a standard deviation. They further noted that graphic organizers produced a larger effect size when vocabulary was an outcome (M = 0.68, SE = 0.19) versus when comprehension was an outcome (M = 0.29, SE = 0.06). This meta-analysis also suggested that "graphic post organizers seem to produce greater effects than graphic advance organizers" (p. 15).

A somewhat later analysis was performed by Dunston (1992). In this critique of graphic organizer research, she found results consistent with the results of Moore and Readence (1984). The synthesis also suggested that graphic organizers tended to produce greater effects when training in their use was offered, they were constructed by students, they were used with more capable students, and they were used with descriptive texts.

*Significant studies*. Larkin and Simon's (1987) non-empirical paper titled "Why a display is (sometimes) worth 10,000 words," although not explicitly related to graphic organizers, provided several foundation concepts that are relevant today in graphic organizer research. In this paper, Larkin and Simon considered two forms (sentential and diagrammatic) of an external problem representation taken from the real world (the problem domain involved a system of weights, pulleys, and ropes). They concluded that diagrams are often superior to verbal descriptions for three reasons: (1) diagrams group like information, thus reducing search burden on learners; (2) diagrams typically place relevant information near a single element, thus eliminating the extra step that would be required were the information to be placed remotely with a symbolic label; and (3) diagrams are more suited to representing perceptual inferences. Notable contributions from this work include the taxonomy of sentential (sequential) displays and diagrammatic displays (where information is not sequential but instead is indexed by location within a plane). Larkin and Simon explicated the differences in computational efficiency and informational equivalency between these types of displays by working through representative math and physics problems. Larkin and Simon indicated that, "two representations are informationally equivalent if all the information in the one is also inferable from the other, and vice versa" (p. 67). Two representations are computationally equivalent if and only if they are informationally equivalent and "any inference that can be drawn easily and quickly from the information given explicitly in the one can also be drawn easily and quickly from the information given explicitly in the other, and vice versa" (p. 67). The significance of this study in graphic organizer (and other) research would be difficult to overstate. In fact, Robinson (2008) cites the paper as the one having the greatest influence on his research career. In addition, a search performed by means of the Google Scholar web site (http://scholar.google.com/) reveals that Larkin and Simon (1987) has been cited at least 1340 times by researchers from the fields of educational technology, human factors, cognitive psychology, artificial intelligence, and many other disciplines.

Robinson and Schraw (1994) investigated the computational efficiency of three informationally equivalent instructional treatments: a matrix-like graphic organizer, an outline, and plain expository text. For each of the three treatments, participants studied an expository text for a fixed time period. Following the study period, the graphic organizer and outline treatment groups received those displays, respectively, while the text-only group received the text again for study. Participants were instructed to not only study specific information but to also look for relations within the material. The results suggested that matrices were more computationally efficient than both outlines and text, even when the time to view the displays was reduced. However, when testing was delayed the matrix's advantage disappeared; Robinson and Schraw (1984) believed this to be a result of the "matrix communicating the information too effectively, resulting in little effort during encoding and low durability of the memory traces" (p. 410).

Robinson and Skinner (1996) investigated whether graphic organizers were easily searchable because of fewer words or because of computationally efficient indexing. Their work built upon Robinson and Schraw (1994) and was intended to examine "how quickly and accurately various displays are searched" (p. 170). In each of the three experiments, a shorter search time and/or fewer errors for a given display would imply its greater computational efficiency. The results from this study suggested that the graphic organizer treatment groups found the answer to a pattern question more quickly than both the outline and text treatment groups. Robinson and Schraw concluded that the facilitative advantage of graphic organizers is a result of their computationally efficient indexing and not because they comprise fewer words than an accompanying text.

Kiewra, Kauffman, Robinson, Dubois, and Staley (1999) performed three experiments comparing informationally equivalent text, outline, and matrix displays. Their results revealed that both the outline and matrix displays outperformed the text display with respect to relational learning (with the matrix display outperforming the outline). The matrix display appeared to be more computationally efficient than both the text and outline displays.

Spears and Kealy (2005) explored the use of “retinal variables” (e.g., size and color) to improve a graphic organizer’s effectiveness toward helping learners perform higher-order thinking skills such as inference-making. Using retinal variables, rather than plain text, it was reasoned, would make a stronger visual argument. No differences in inferential judgment performance were observed for the retinal variable treatments versus the text-only treatment. However, participant response latency for inference questions was significantly longer, leading to the conclusion that nonverbal elements introduced with the retinal variables may have impeded processing time with no comparable benefits in accuracy.

Robinson, Katayama, Beth, Odom, Hsieh, Vanderveen, and Katayama (2006) investigated text comprehension and graphic note taking using partially completed graphic organizers in a study designed around three quasi-experiments and one true experiment. This study is relevant because normally static graphic organizers were imbued with metacognitive, constructivist attributes, in a conceptual manner not unlike the current study. In the partially completed graphic organizer tasks, participants achieved increased overall performance on quizzes in all experiments. Also, participants showed a propensity for note-taking on graphic organizers, as this activity increased over the course of each of the experiments.

Kauffman and Kiewra (2009) by means of two experiments studied the relative benefits of signaling, extraction, and localization with respect to standard text, text with ideas extracted, an outline with ideas localized topically, and a matrix that localized ideas both topically and categorically. Results from the first experiment suggested that the matrix display outperformed the listed alternatives because of its ability to “localize” related information within topics and categories. In the second experiment, the researchers compared four manifestations of informationally equivalent matrices—the matrices differed in that topics and categories were ordered either logically or randomly. Participants were tested on local relations, global relations, and facts. For local relations, a significant main effect was observed for topic only (a fact which is consistent with the proposed research’s assertion that reducing the distance between similar topics, thereby reducing or removing intervening information, may contribute to improved learning). Global relations results also revealed a main effect for topical organization.

*Generative Learning*

Generative learning has been described as “the practical cousin of constructivism” (Bonn & Grabowski, 2001, p. 1). Wittrock is credited with the founding of generative learning theory. Although the fundamental premise of generative learning is that learners tend to synthesize meaning and relationships consistent with prior knowledge (Wittrock, 1974a), the theory is a comprehensive one; it “builds upon knowledge about the processes of the brain and upon cognitive research on comprehension, knowledge acquisition, attention, motivation, and transfer” (Wittrock, 1992).

Lee and Grabowski (2009) theorized that students would learn complex material related more effectively with generative learning (the researchers also investigated generative learning plus metacognitive feedback as an additional treatment). In the cited study, 36 participants were tested for prior knowledge, then studied material related to the human heart while using either static visual instructional material, the same material with a generative learning component, or the same material with a generative learning component and metacognitive feedback. The generative learning treatment scored significantly better on a recall test than the static visual group. The generative learning with metacognitive feedback group scored significantly better than both the static visual group and the generative learning group.

*Schema Theory*

Knowledge is stored in long-term memory in the form of schemata (Sweller, van Merriënboer, & Paas, 1998). A schema helps an individual categorize things according to attributes. Schemata may help reduce redundancy in the orderly representation of an individual's knowledge. For example, when learning the "tree" schema a child associates various tree schema elements such as "has leaves" and "grows in the ground." When encountering a new type of tree, the child invokes the tree schema, closely followed by the association of new facts (e.g., "bears fruit") to be incorporated into the tree schema.

Schemata provide the elements of knowledge—it is through the progressively complex building of higher-level schemata (based upon lower-level schemata) that an individual achieves the capability for increasingly sophisticated mental performance (Sweller, van Merriënboer, & Paas, 1998). Besides helping to reduce redundancy, schema-based knowledge acquisition helps reduce cognitive load by reducing the number of interacting elements that working memory must simultaneously store (Sweller & Chandler, 1994).

Schema theory is especially relevant to graphic organizer research because graphic organizers display concepts spatially, thus facilitating reading comprehension by activating prior knowledge more quickly than text alone (Robinson, 1998). Schema theory also dovetails well with generative learning, as it (generative learning) emphasizes both the categorization of information into schemata as well as the active construction of relations among concepts and experience toward the achievement of full comprehension

(Wittrock, 1991).

*New Literacy*

Traditional literacy, that is the ability to read and write, has customarily been described as text-based and alphabetic (Ihator, 2001). So-called “new literacies” refer to digitally mediated literacies, and the semiotic understandings necessitated by this form of media (Haunstetter, 2008). Texts or related media that exploit these new literacies allow learners, by keying, clicking, cropping, or dragging, to “create a diverse range of meaningful artifacts using a strictly finite set of physical operations or techniques” (Lankshear & Knobel, p. 7). Because of the affordances brought forth by these new literacies, learners are presented with a fundamentally different set of conditions when viewing a text. Where before a text was most likely linear and unchanging, today’s “new” text might be reconfigurable in tens, hundreds, or even thousands of ways. Learners presented with this type of dynamic material have a greater need to independently think, adapt to novel situations, and problem-solve within those situations (Haunstetter, 2008).

The static and dynamic graphic organizers that served as the fundamental instructional devices for the present study represent a microcosm of traditional versus new literacies. While the static graphic organizer in the study models traditional text (unchangeable with no requisite digital technology) the two dynamic graphic organizers in the study model new literacy materials (malleable and dependent on digital technology and its complementary user controls).

*Theoretical Framework*

An ongoing goal of educational researchers is and has been to devise ways such that learners can both recall the information contained in text as well as better understand the relationships between the concepts and ideas in that text. Over the last several decades, researchers have studied various instructional strategies (adjunct aids in this case) with these goals in mind. Commonly investigated strategies have included underlining, note-taking, outlining, using bold typeface for keywords, and summarizing (Wade, Trathen, & Schraw, 1990).

Besides the above-noted "embedded" instructional strategies, many types of adjunct (that is, accompanying or separate) displays have also been used to improve the recall or understanding of information contained in text. Pictures, photographs, and maps are examples of displays that augment text by presenting information that would be difficult to present using only words.

A wholly different category of adjunct display is one that Rieber calls "arbitrary" graphics (1994, p. 29). Exemplars of this type of adjunct display include outlines, flowcharts, bar charts, line graphs, and graphic organizers. The inherent structure of these arbitrary graphics allows them to function as useful adjuncts to textual material. Certain graphic organizers exhibit a structure that may be especially useful to learners who are encoding or recalling information contained in text. Array-like graphic organizers, in particular, have been shown to provide support to learners (Robinson & Schraw, 1994; Robinson & Skinner, 1996). This type of graphic organizer spatially arranges key terms such that their relative placement represents the relationships between those terms. Information in this type of display can be indexed by a two-dimensional location; it is therefore a diagrammatic representation (Larkin & Simon, 1987). (By contrast, a display whose elements appear in a single, linear sequence is referred to as a sentential representation.)

This type of graphic organizer is similar to a table—both are two-dimensional, static matrix-like depictions of information, each orienting its individual elements in a plane. Graphic organizers and tables often differ, however, in their potential for precisely representing data. A table allows a reader to get single point values most accurately but provides the least integrative information (Guthrie et al., 1993), whereas a graphic organizer may better represent what Shah and Hoeffner refer to as the “qualitative gist of relationships depicted in the data” (2002, p. 53).

Graphic organizers have the ability to help learners see conceptual relationships at a glance, thus allowing them (graphic organizers) to function as effective alternatives for extracting meaning from a text. For example, locating a single fact, the smallest unit of information in an information array (Wainer, 1992), is a simple process for a learner with access to a graphic organizer. Similarly, learners are also better able to make comparative judgments using a graphic organizer than they would be able to with text only (Robinson & Schraw, 1994).

Several theoretical explanations have been offered to explain the effectiveness of graphic organizers. These include visual argument, dual coding, conjoint retention , and schema theory, as discussed in the following paragraphs.

Visual argument relies on the visuospatial properties of graphical organizers to facilitate side-by-side comparisons by learners (Robinson, Robinson, & Katayama, 1999; Robinson & Kiewra, 1995; Vekiri, 2002). Graphic organizers appear in a form that requires “minimal computation or untangling by the learner to discover relations among concepts or the text’s structure” (Robinson & Kiewra, 1995).

Dual coding refers to encoding of verbal and visual information through separate processing channels (Paivio, 1986). Because graphic organizers comprise both verbal and visual information, dual coding has been cited as a theoretical explanation for the effectiveness of graphic organizers (Schwartz, Ellsworth, Graham, Knight, 1998). Owing to the bi-representational (verbal and visual) nature of graphic organizers, some researchers (Kealy, Bakriwala, & Sheridan, 2003; Robinson, Corliss, Bush, Bera, & Tomberlin, 2003) consider them to be a form of multimedia and therefore subject to many of Mayer's (2001) multimedia principles.

The conjoint retention hypothesis (Kulhavy, Lee, & Caterino, 1985) is "essentially a rendition of dual coding theory" (p. 29) in that verbal and spatial elements are encoded by means of separate memory channels. It goes beyond dual coding, however, by stating that spatial information (typically a map) is encoded in an intact form as a verbal as well as a spatial format; text not associated with the spatial information is encoded only verbally. Conjointly retained information may be more likely to be recalled than non-conjointly retained information (Robinson, Robinson, & Katayama, 1999).

Schema theory says that knowledge is stored in long-term memory in the form of schemata (Sweller & Chandler, 1994). A schema helps a learner categorize new concepts. For example, a learner who encounters a new teacup can simply incorporate that information into his or her "cup" schema, thus avoiding the overhead of learning all the basic details related to "cup" (only the new details relevant to "teacup" need be catalogued). Because graphic organizers display concepts spatially, they can activate prior knowledge (that is, an existing schema) more quickly than expository text would. Once the prior knowledge has been activated, the learner is able to incorporate the new information into the existing schema (Robinson, 1998).

Educational researchers recognize that the effectiveness of media used to deliver and support instruction can be improved through message design (Fleming & Levie, 1978). Sometimes, simply reconfiguring the elements in a display can significantly improve that display's usefulness for learners (Winn, 1991, 1993). For example, reordering and grouping the elements of a table may lead to new insights and reveal relationships between those elements (Wainer, 1992).

From time to time opportunities may arise such that new technologies can be exploited to enhance an existing medium with improved cognitive capacity and instructional potential (Kozma, 1991). For example, hypertext technology has enabled the use of hyperlinks in formerly static text, thereby altering the way this text is read and mentally processing. Following this model, one might look for other opportunities where the addition of processing capabilities might complement those of the learner (Kozma, 1991). Many studies have been undertaken to examine the processing capabilities of the computer and to demonstrate how these capabilities can influence the mental representations and cognitive processes of learners (Kozma, 1991). One high level finding is that some learners will learn a particular task or concept regardless of the delivery mechanism, while others will be able to take advantage of a particular medium's characteristics to help construct knowledge (Kozma, 1991). This premise informs the proposed study, and helps provide a rationale for the proposed introduction of two types of interactivity into a formerly static medium.

One medium that may benefit from the addition of processing capabilities is the graphic organizer. This static, matrix-like informational display is already an effective instructional medium owing to its inherent visual argument (Waller, 1981) and computational efficiency (Larkin & Simon, 1987). Graphic organizers are also useful for presenting information of varying intellectual complexity. For example, a single graphic organizer might convey three distinct types of information: (1) factual (e.g., fish species *x* is black), (2) comparative (e.g., fish species *x* is black and fish species *y* is white); (3) inferential (e.g., darker colored species of fish tend to swim at greater depths than lighter colored ones). Interestingly, a mapping can be established between the three types of information noted (factual, comparative, and inferential) and the graduated levels of abstraction codified in Bloom's Taxonomy (Bloom, 1956). That is, remembering *factual* information would map to *knowledge* on Bloom's Taxonomy, *comparing* would map to *comprehension/application*, and *inferring* would map to *analysis/synthesis*.

Another way to consider the three above-noted types of information would be to use Wainer's (1992) scheme. Wainer compares increasingly complex types of information to increasingly complex parts of speech. When considering Wainer's nomenclature, a *fact* might correspond to a noun, a *comparison* might correspond to an adjective-noun construct, and an *inference* might correspond to an adjective-noun-verb construct.

For this study, the following nomenclature was used to distinguish the three types of information just discussed. Factual information (Robinson & Schraw, 1994) was used to convey an atomic and objective fact, for example, "Ponef swims at a depth of 600 feet." Comparative information refers to concept comparisons along a single attribute. An example of a comparison question is, "Which swims at a lesser depth (Goken or Taroz)?" A learner responding to this type of query needs three elements of factual information (Robinson & Schraw, 1994): (a) Goken swims at 200 feet, (b) Taroz swims at 400 feet, and (c) 200 is less than 400 and therefore Goken swims at a lesser depth than Taroz.

Inferential information refers to information involving elements of two attributes with an indirect link. An example of an inference question is, “Lesser-depth fish tend to be ____ in size (smaller/larger).” Responding to this question implies a five-step process (Robinson & Schraw, 1994), to wit: (a) 200 feet is “lesser depth,” (b) Latuk and Goken swim at 200 feet, (c) Latuk and Goken are 40 inches in size, (d) an inference must be computed that 40 inches is small, (e) finally, an inference must be computed that 40 inches is not 90 inches.

By preserving the inherent benefits of the graphic organizer while enhancing it with the integration of two distinct reordering capabilities two new types of dynamic instructional displays were realized: a “sortable” graphic organizer and a “shuffle-sort” graphic organizer. Investigating the effectiveness of these dynamic graphic organizers as instructional media tools was the focus of this research.

These newly created dynamic graphic organizers allowed, under learner control, the reconfiguration of their elements thus altering the way the presented content could be read and mentally processed. For example, relationships between items physically distant (as they might be in a static graphic organizer) may be less discernable by a learner than relationships between adjacent items (as they might be in a dynamic graphic organizer). Allowing a learner to reorder elements in a graphic organizer, and thereby facilitating the discovery of relationships that otherwise might go undetected, may encourage the process of generative learning, that is the dynamic construction of meaning by building relationships (Wittrock, 1992). Similarly, allowing a user to reorient elements of a graphic organizer such that related items are physically nearer to each other (thus decreasing the semantic distance of those elements) may be useful for making trends in the displayed information more apparent, while also improving a learner's ability to make inferential judgments (Winn & Holliday, 1982). Finally, providing a facility whereby learners can overtly manipulate graphic organizer element positions may encourage mindful, effortful actions, thus contributing to learning and transfer (Salomon & Globerson, 1987).

# Chapter Three: Method

*Research Design and Participants*

Participants were volunteer students from a public four-year research university and a two-year community college, both located in an urban area of the southeastern United States. Most participants received extra course credit for participation. Some participants received only snacks for their participation. A small number received a token cash payment for their participation.

*Materials and Measures*

*Displays*. The graphic organizers in the study were two-dimensional, matrix-like configurations of text. These graphic organizers contained information about various fictitious species of fish, including the size, color, preferred depth, and diet for each species represented. This type of graphic organizer is often used to convey factual, comparative, and inferential information. Figure 1 is a representation of the static graphic organizer from that treatment group (it includes numeric prefixes in certain columns such that the elements of the graphic organizer can be sorted when used in a sortable treatment group). Robinson and Schraw's (1994) text passage and static graphic organizer served as a foundation for this study. Besides Robinson and Schraw, other researchers have performed studies using these materials or derivatives thereof, including Robinson & Skinner (1996), Kiewra, et al. (1999), and Spears & Kealy (2005).

| DEPTH (ft.) | SPECIES | GROUPING | COLOR | SIZE (in.) | DIET |
|---|---|---|---|---|---|
| 200 | Latuk | 1-Solitary | 6-Black | 40 | 1-Algae |
| 200 | Goken | 2-Small | 5-Brown | 40 | 1-Algae |
| 400 | Taroz | 1-Solitary | 4-Blue | 60 | 2-Shrimp |
| 400 | Kupod | 3-School | 3-Orange | 60 | 2-Shrimp |
| 600 | Ponef | 2-Small | 2-Yellow | 90 | 3-Flounder |
| 600 | Somet | 3-School | 1-White | 90 | 3-Flounder |

*Figure 1. A static graphic organizer*

The graphic organizers functioned as adjunct learning materials to a 204-word text passage that provided 30 facts about six fictitious species of fish. Robinson and Schraw (1994) used this text passage in their adjunct displays study; their version was adapted from a similar text passage used by Friedman & Greitzer (1972) in “Organization and Study Time in Learning from Reading.” A representation of the Robinson and Schraw text passage is shown in Appendix A.

The organizational structure of this text passage falls within the *comparison* structure when evaluated against the five structures described by Meyer (1980). Several textual signals (Meyer & Poon, 2001) are contained in the passage that would provide clues to a reader about the passage’s comparison organizational structure. Example signals include “they differ in several ways”, “whereas”, “vary along different dimensions”, “for example”, and “in contrast.” With respect to the readability of the text passage, it scores a Flesch-Kincaid Grade Level of 6.1 as calculated by the Microsoft Office Word 2007 computer program. A reading level of grade 6.1 would be characterized as “fairly easy” by Flesch (1949, p. 149).

The readability level of the text passage is not viewed as a limitation for several reasons: First, this 204-word passage or its derivatives have been used in many studies, including Robinson & Schraw (1994), Robinson & Skinner (1996), Kiewra et al. (1999), Spears & Kealy (2005), Spears, Motes, & Kealy (2005), and Spears, Hubbard, & Kealy (2007). Second, text passages with reading levels of grades 6-9 are frequently used in studies of this type, even studies that use undergraduate college students as participants, e.g., Griffin & Robinson (2005) provided materials with a grade level of 6.6 and Kealy, Bakriwala, & Sheridan (2003) used a grade level of 9.5. Finally, using a text passage with a higher (say, college-level) readability score might have been unwise, considering the 2006 ACT assertion that, "Only 51 percent of 2005 ACT-tested high school graduates are ready for college-level reading" (ACT, 2006, p. 1).

A subset of this study's research goals were investigated by Spears, Hubbard, and Kealy (2007). That study served as a pilot for the current study. Appendix D contains several representative screen captures of the pilot study's instrument (a computer program). The current study's instrument is substantially similar; the major difference is the inclusion of the new shuffle-sort experimental treatment. Additional differences are documented in Appendix B. In the pilot study, a sortable graphic organizer was compared to an informationally equivalent static graphic organizer to determine its influence on learners' comparison- and inference-making. Although analysis of variance (ANOVA) revealed no differences between the two treatments, several lessons were learned—these lessons have been incorporated into the current study's design, as discussed in the following paragraphs.

One observation from the pilot study was a strong ceiling effect (nearly every participant scored 13, 14, or 15 out of 15 possible points) on accuracy for both comparative and inferential judgments. On post-study analysis, it became clear that this was a result of the study's design, which involved simultaneous presentation of the graphic organizer and criterion questions (typically, the graphic organizer and/or text are presented to participants prior to the presentation of the criterion questions). In the current study, the design was changed such that criterion questions were presented only after the graphic organizer and informational text had been studied by the participants (an intervening mental task was presented as well to help clear participants' short-term memory).

A second (and more promising) observation from the pilot study relates to the willingness of the sortable graphic organizer treatment's participants to use the sortability feature (M=14.54 sort events, SD=11.42). The pilot study's instrument counted the number of times each participant "clicked" a sort button; each of these clicks was considered a sort event. Interestingly, nine of the thirteen participants in the sortable graphic organizer treatment group sorted the graphic organizer 10 or more times; two participants sorted it more than 30 times.

In the current study, three treatment groups were used, in which the degree of interactivity available to the learner was varied. The first group involved a conventional static graphic organizer, where no interactive component was available and the distances between graphic organizer elements was fixed. The second group studied a dynamic graphic organizer that provided some interactivity; that is, participants had the ability to sort graphic organizer rows by clicking one of the graphic organizer column headings. Also in the second group, the distance between any two graphic organizer elements varied as a function of the graphic organizer's sort order. Figure 2 is a representation of a sortable graphic organizer. The third group studied s a dynamic graphic organizer providing a still higher level of interactivity than the second group; that is, participants had the ability to both sort graphic organizer rows and "shuffle" individual graphic organizer columns in either horizontal direction. Also in the third group, the distances between any two graphic organizer elements varied as a function of the graphic organizer's sort order (for rows) and shuffle order (for columns). The three graphic organizers were informationally equivalent. Figure 3 is a representation of a shuffle-sort graphic organizer.

| DEPTH (ft.) | SPECIES | GROUPING | COLOR | SIZE (in.) | DIET |
|---|---|---|---|---|---|
| 200 | Latuk | 1-Solitary | 6-Black | 40 | 1-Algae |
| 200 | Goken | 2-Small | 5-Brown | 40 | 1-Algae |
| 400 | Taroz | 1-Solitary | 4-Blue | 60 | 2-Shrimp |
| 400 | Kupod | 3-School | 3-Orange | 60 | 2-Shrimp |
| 600 | Ponef | 2-Small | 2-Yellow | 90 | 3-Flounder |
| 600 | Somet | 3-School | 1-White | 90 | 3-Flounder |

Reset

*Figure 2. A sortable graphic organizer*

| ◀▶ | ◀▶ | ◀▶ | ◀▶ | ◀▶ | ◀▶ |
|---|---|---|---|---|---|
| **DEPTH (ft.)** | **SPECIES** | **GROUPING** | **COLOR** | **SIZE (in.)** | **DIET** |
| 200 | Latuk | 1-Solitary | 6-Black | 40 | 1-Algae |
| 200 | Goken | 2-Small | 5-Brown | 40 | 1-Algae |
| 400 | Taroz | 1-Solitary | 4-Blue | 60 | 2-Shrimp |
| 400 | Kupod | 3-School | 3-Orange | 60 | 2-Shrimp |
| 600 | Ponef | 2-Small | 2-Yellow | 90 | 3-Flounder |
| 600 | Somet | 3-School | 1-White | 90 | 3-Flounder |

Reset

*Figure 3. A shuffle-sort graphic organizer*

Three treatments (static, sort, shuffle-sort) were decided upon although a four-treatment design (static, sort, shuffle-sort, shuffle-only) was briefly considered. One reason for doing so is that the shuffle capability can be thought of as an "enabler" for the sortability feature of a dynamic graphic organizer. It (shuffling) allows a participant to move items of interest closer to each other (thus decreasing semantic distance) but has limited use otherwise. A second reason for this decision is that there is some precedent for experimental designs in which experimental attributes are "added" to treatments. As one example, Lee and Grabowski's (2009) study on generative learning includes three treatments in the following progression: materials with no generative learning, materials with generative learning, and finally materials with generative learning and metacognitive feedback.

The displays, materials, and criterion questions in the current study were derived from similar components used in previous studies (e.g., Robinson & Schraw, 1994; Robinson & Skinner, 1996; Spears & Kealy, 2005; and Spears, Motes, & Kealy, 2007).

*Computer programs*. A computer program served as both the instructional delivery mechanism as well as the measurement and recording instrument. A single version of this computer program was developed; this version was capable of programmatically performing the random assignment of participants to groups then taking the appropriate treatment-dependent and treatment-independent actions thereafter. The primary treatment-dependent functions of the program included the presentation of the example graphic organizer, the actual graphic organizer, and the accompanying participant instructions. The primary treatment-independent functions of the program included presentation of general information, criterion questions, and ancillary questions. The program also recorded (both locally and remotely) all participant responses.

The computer program's source code was primarily written in the Microsoft Visual C# programming language. The program was tested on several systems running the Windows XP operating system along with the Microsoft .NET Framework (the program required the Microsoft .NET Framework in order to execute). Additional source code, written using the JavaScript programming language, provided specific interactivity elements in the graphic organizer displays for the two interactive treatments groups.

The computer program was also responsible for navigation and pacing related to the flow of screens presented to participants. Informational screens typically had a *Next* button that participants were free to click at their convenience. Other screens (e.g., demographic survey and criterion questions) required completion of one or more fields before the *Next* button became active. The graphic organizer screen had a fixed display time (5:00 minutes) with no *Next* button—once the study time expired, the subsequent screen was presented. No *Back* button was provided on any screen; the experimental program's flow was designed to be linear and unidirectional.

The experimental program was also responsible for saving and transmitting information collected from participants. Various everyday user interface controls (e.g., radio buttons, text boxes, navigation buttons) were used for the explicit collection of data from participants during the study. Temporal data was also collected using various time-based controls and timers. Examples of collected temporal data include start and stop times for a study session, total time spent viewing the graphic organizer's accompanying text passage, and latency ("think time") for every criterion question. Finally, the experimental program recorded various participant interaction events, including the number of times a participant sorted a graphic organizer (in either the sortable treatment or the shuffle-sort treatment) and the number of times a participant reordered columns (in the shuffle-sort treatment).

Because of the criticality of preserving all collected data, the experimental program saved data in three locations, two geographically remote from the first, to provide redundancy. At the end of each participant's session, a comma-separated variable file was prepared and attached to an email sent to the researcher's email account. A copy of this email was contained in a Google email (gmail) account dedicated to use by the experimental program. Finally, a local copy of the comma-separated data file was written to the local workstation's hard drive such that it could be accessed in the event that network issues prevented emails from being sent.

*Design*. The study's design involved three Display treatment groups (static graphic organizer vs. dynamic sortable graphic organizer vs. dynamic shuffle-sort graphic organizer). The independent variable, Display, was varied between subjects. It is a categorical variable, having three conditions; Table 2 shows the three treatment groups, and the mapping of these groups to the independent variable.

Table 2.
*Independent Variable*

| *Display* | *Static* | *Sortable* | *Shuffle-Sort* |
|---|---|---|---|
| Abbreviation | ST | SO | SH |

The dependent variables in the study were participant accuracy for making *factual*, *comparative*, and *inferential* judgments. As shown in Table 3, all three are ratio scale variables. Each of these variables can have the values 0 to 15 inclusive. Each point on this scale represents a correct response to one of the criterion questions related to this measure (there are fifteen factual questions, fifteen comparison questions, and fifteen inference questions, thus the maximum of fifteen points for each scale). The value of this dependent variable was derived programmatically during the study (that is, the computer program that administered the factual, comparative, and inferential criterion questions also objectively scored participant responses to these questions).

The remaining dependent variable was response latency. This is also a ratio scale variable, but its value can range from 0 to 999 seconds, inclusive, depending on the number of seconds a participant takes to choose a response after a criterion question has been displayed.

Table 3.
*Dependent Variables*

| Variable Name | Abbreviation | Scale | Possible values | Scored by |
|---|---|---|---|---|
| Fact Accuracy | FA | Ratio | 0-15 correct | Computer program |
| Comparison Accuracy | CA | Ratio | 0-15 correct | Computer program |
| Inference Accuracy | IA | Ratio | 0-15 correct | Computer program |
| Fact Latency | FL | Ratio | 0-999 seconds | Computer program |
| Comparison Latency | CL | Ratio | 0-999 seconds | Computer program |
| Inference Latency | IL | Ratio | 0-999 seconds | Computer program |

An *a priori* power analysis, based on an alpha level of α = .05, an estimated medium effect size, multivariate analysis of variance of three groups, and a preferred power of 0.8, yielded a desired sample size of 52 participants per group, or 156 total participants for the three groups (Cohen, 1992, p. 158).

The criterion items of interest involved learner accuracy related to factual judgments, comparative judgments, and inferential judgments. In other words, criterion questions measured learner performance related to increasing levels of intellectual complexity or abstractness. The accuracy of participant responses related to factual, comparative, and inferential judgments was measured as participants were queried by the computer program. (These queries were designed to elicit participant responses related to the factual, comparative, and inferential information contained in the instructional materials.)

These criterion questions, or substantially similar variations, have been used in many prior studies, including Robinson & Schraw (1994), Robinson & Skinner (1996), Kiewra et al. (1999), Spears & Kealy (2005), Spears, Motes, & Kealy (2005), and Spears, Hubbard, & Kealy (2007). In the current study, the criterion questions comprise 15 questions designed to measure factual judgment-making, 15 questions designed to measure comparative judgment-making, and 15 questions designed to measure inferential judgment-making from the participants.

The validity of the criterion questions has been demonstrated by their use in the multiple prior studies just cited. The criterion questions used in the study are presented in Appendix C. Upon inspection, one can see that each question has been designed to measure a learner’s accuracy in recalling facts, making comparisons, or making inferences related to studied material. An example of a factual query might be, “What color is Taroz?” The participant would then be presented with two on-screen choices: Blue/Brown. An example of a comparative query might be, “Which is smaller in size?” The participant would then be presented with two on-screen choices: Ponef/Latuk. An example of an inferential query might be, “Prawn-eating fish tend to swim at a ______ depth.” The participant would then be asked to choose either “lesser” or “greater.”

In each of the above three examples, the participant would choose one of two presented responses, which would then be evaluated programmatically. A correct response would be internally recorded as “1” and an incorrect response would be recorded as “0.”

The totality of facts and implicit/explicit relationships required to respond correctly to the criterion questions is present in both the 204-word text passage as well as in each of the graphic organizer treatments (they are all informationally equivalent). No special prior knowledge is required or expected of the participants. In fact, fictitious species of fish were used rather than existing species to help prevent participants from exploiting prior knowledge during the study.

Response latency was also measured and recorded. Response latency represents the elapsed time, in seconds, from when a question was displayed on the screen to when the participant entered a response to that question. Response latency was recorded and summarized for each question type (factual, comparative, inferential).

*Procedure*. Figure 4 graphically depicts the experiment’s procedural sequence, while the narrative description follows: As participants arrived for an experimental session, they were seated at computer workstations where the experimental program had previously been installed. Before each research session, the program on each workstation was launched by the researcher. The program was installed on computer workstations such that participants could not readily see the screens of other participant workstations. Once seated, participants saw only a dialog prompting for a password. Participants were given a brief overview of the task, including an overview of Institutional Review Board policies regarding human volunteer participants. Participants were asked to place any papers, books, or similar materials aside before beginning the study. (During the study sessions, the researcher observed the participants to ensure that notes and similar external aids were not used.)

Once any procedural questions were addressed, participants were given a password that allowed them to complete the login dialog. Immediately upon accepting the password the computer program randomly assigned the participant to one of the three treatment groups (participants did not know this). Participants were then asked to complete a brief demographic survey by providing their gender, major, and name of the institution where the study was taking place. The computer program then provided participants with on-screen instructions, a brief introduction to graphic organizers, and an opportunity to practice with the treatment-dependent user interface controls that the participant would encounter during the study. Participants were also given an opportunity to see sample questions for each of the three question types. Both the example graphic organizer and associated example questions pertained to a topic unrelated to the material contained in the experimental portions of the proposed study. (The example graphic organizer and sample questions described species of buffalo.) The example instructional material also contained at least one trend, which was annotated for the participants' benefit. Similarly, annotations were provided that illustrated the linkage between a graphic organizer and its accompanying text passage.

Participants in the two dynamic graphic organizer treatments received instructions relevant to their respective graphic organizer treatments. Those in the dynamic sortable group received instructions related to sorting the rows of their graphic organizer. Those in the dynamic shuffle-sort group received the sortable group instructions, augmented by instructions related to rearranging the columns of their graphic organizer. Participants in the dynamic graphic organizer groups were encouraged to practice using the newly described controls before proceeding. All participants were asked to study the instructional materials for facts as well as trends contained in the materials.

Depending upon the outcome of the random assignment that the program had just performed, participants in each treatment group were then presented with either an onscreen static graphic organizer, an onscreen dynamic sortable graphic organizer, or an onscreen dynamic shuffle-sort graphic organizer. In the dynamic graphic organizer conditions, participants had access to user interface controls such that the graphic organizer information could be sorted or shuffle-sorted (depending on treatment) under participant control. Participants in the two dynamic graphic organizer treatments also had a "Reset" button available—by clicking that button a participant would cause the graphic organizer to revert to its original, i.e., default, state. Each treatment group was given five minutes of graphic organizer study time. While studying the graphic organizer, participants had the ability to invoke the display of the accompanying 204-word text passage—this was accomplished by using the mouse to click a button labeled, *Show Text*. Participants were also presented with a visual indicator of the time remaining in the graphic organizer study period.

After the five-minute study period, participants were presented with an interpolated arithmetic task to ensure that short-term memory had been cleared. The interpolated memory task screen comprised six columns, each containing four sets of two-digit integers. Participants were required to mentally compute the sum of each column's four numbers, then use the keyboard to enter *Y* or *N* to indicate whether the displayed sum was correct or incorrect, respectively.

At the conclusion of the interpolated memory task, participants were presented with 15 onscreen factual-judgment criterion questions, 15 comparative-judgment criterion questions, and 15 inferential-judgment criterion questions in a random sequence. The random sequence was prepared before data collection commenced—each participant received the identical sequence of 45 criterion questions. Appendix C shows the criterion questions sorted by category as well as by random sequence as delivered to participants. As each criterion question was displayed, a pair of radio buttons were displayed, one with the correct response and one with a distractor. A *Next* button was also displayed on the screen; however, this button was not active until a participant selected one of the two radio buttons. As each criterion question screen was completed by the participant, his or her responses were evaluated and stored by the program. Correct responses were recorded with a value of 1, and incorrect responses were recorded with the value of 0. The response latency was also recorded for each criterion question. (Response latency is defined as the difference in seconds between the time a criterion question was displayed and the time the participant clicked the *Next* button. )

As participants completed the criterion questions, two progress indicator messages were displayed: the first was after 15 questions and the second after 30 questions. The questions were intended to give the participants feedback such that they had some perception of making progress through the 45 criterion questions.

Upon completion of the criterion question segment of the experiment participants were asked to answer several ancillary questions. These questions were intended to elicit information from participants that might be useful during data analysis and interpretation.

The first ancillary question presented to participants was the yes/no query, “While studying the fish material, did you notice any trends or relationships?” Two radio buttons (labeled *Yes* and *No*) were presented below the question, along with a *Next* button. The Next button did not become active until the participant selected one of the radio button choices.

Participants were then asked, “Please list any trends about the fish that you may have noticed.” A free-form text entry area was provided below the question in which participants could enter text. This screen also contained a *Next* button, which was always active, thus giving participants the ability to skip this question.

Participants were then asked, “Please list any tricks or mental strategies that you used while studying the material.” A free-form text entry area was provided below the question, along with an always-active *Next* button.

Participants were then presented with the query, “Do you think that the graphic organizer you just studied was an effective instructional tool?” Two radio buttons (labeled *Yes* and *No*) were presented below the question, along with a *Next* button. The *Next* button did not become active until the participant selected one of the radio button choices.

Finally, participants were presented with a debriefing screen. On this screen, participants were provided with details about the goals of the experiment. Participants were also thanked for their participation and given the researcher's contact information which could be used if participants had questions or needed further information about the study

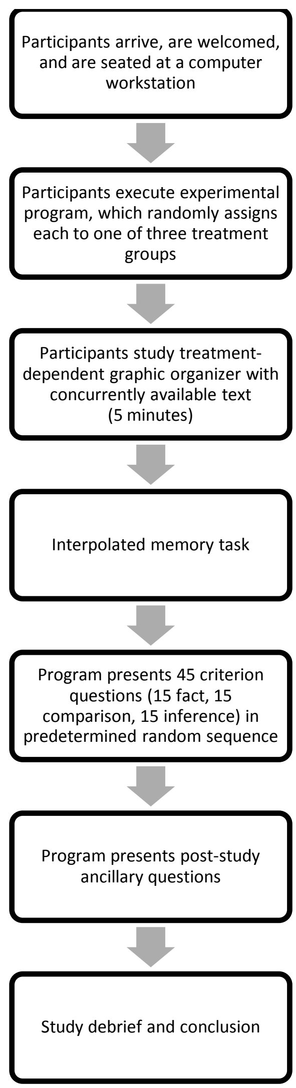


*Figure 4. Steps in the experimental process*

# Chapter Four: Results

This chapter details the data analyses performed on the collected data. Data were collected from 161 research participants; each participant was assigned to one of three experimental treatments which varied graphic organizer (display) type. Dependent measures included accuracy for factual judgments, accuracy for comparative judgments, and accuracy for inferential judgments. The results of this study are based on multivariate analysis of variance (MANOVA) procedures using the above-noted treatments and dependent measures. The level of significance for all statistical analyses was $\alpha = 0.05$. All data analyses were conducted using IBM's SPSS Statistics 18 application program.

*Overall Descriptive Statistics*

Each of 161 research participants attended one of many one-hour research study sessions offered during the fall semester of 2009 at a two-year community college and a public four-year university, both located in an urban area of the southeast United States. As participants arrived at a study session, they were seated at computer workstations and asked to follow on-screen instructions provided by the research application program. Participants were randomly assigned by the application program to one of the three treatment groups. Participant gender was not considered during this random assignment procedure. However, participant gender was recorded. Table 4 shows the participant distribution by treatment group. All participants completed the study, so no mitigation procedures for missing data were performed.

Table 4.
*Participant Distribution to Treatment Groups*

| Treatment | Females | Males | Total |
|---|---|---|---|
| Static (ST) | 37 (67%) | 18 (33%) | 55 |
| Sortable (SO) | 34 (65%) | 18 (35%) | 52 |
| Shuffle-sort (SH) | 38 (70%) | 16 (30%) | 54 |
| Total | 109 (68%) | 52 (32%) | 161 |

The desired number of participants per treatment group was 52. Because random assignment does not guarantee an equal number of participants per group, the group sizes were monitored closely during the data collection period. A pure random assignment scheme was used for participants 1 through 144, when it was discovered that the shuffle-sort treatment group was beginning to outpace the other two groups (the shuffle-sort group had 54 participants, versus 45 participants for each of the other two groups). To mitigate this unequal rate of growth, a restricted random assignment procedure was performed on the final 17 participants, such that they were randomly assigned to one of the two remaining unfilled groups. When each group's size was equal to or greater than the target group size of 52 participants, the data collection procedure was concluded.

The General Linear Model (GLM) procedure for MANOVA was used to examine the study data. The Type III sums-of-squares was selected because it represents variation attributable to an effect after correction in the model—it is also robust to unequal sample sizes. MANOVA has a number of assumptions, including:

1. Sample size
2. Independence
3. Normality
4. Multivariate Outliers

The sample size assumption states that each cell must have more cases than the number of dependent variables. In this study, the number of dependent variables was 3 and each cell contained at least 52 cases, so this assumption was met.

The independence assumption states that each observation is independent of all other observations. Similarly, independence requires that no observation depends on selection of one or more earlier cases (as in a before-after or repeated measures design). In this study, the independence assumption was met because participants did not communicate with each other during the study. Also, participants were seated such that they could not easily view the displays of other research computers. Finally, this study was neither a before-after nor a repeated measures design. Therefore, the independence assumption was met.

The normality assumption in MANOVA is robust in the face of most violations of this assumption if sample size is greater than or equal to 20 cases per cell and there are no multivariate outliers. Samples sizes were significantly greater than 20 so this component of the normality assumption was satisfied. The presence of multivariate outliers was checked by calculating the Mahalanobis distance using IBMs SPSS Statistics 18. The maximum computed Mahalanobis distance was 12.997, which was less than the critical value of 16.27 (Pallant, 2005, p. 251) thus showing that no substantial multivariate outliers were present in the data.

Normality was also considered by examining skewness and kurtosis values for each of the nine dependent measures. Of the nine data sets, seven were slightly negatively (rightward) skewed. The remaining two sample sets were slightly positively (leftward) skewed. All nine data sets exhibited platykurtic shapes, with negative kurtosis values. All skewness and kurtosis values were well within the acceptable range of -2 to +2 inclusive thus demonstrating that no sample sets violated the normality assumption.

*Accuracy*

Response accuracy was captured by the research instrument for each question. Participants were presented (by use of radio button user interface controls) with two possible responses for each of the 45 criterion questions. The instrument programmatically evaluated participant responses. Correct responses were scored as 1 while incorrect responses were scored as 0. For each participant, sums of accuracy responses for each judgment type (factual, comparative, and inferential) were computed. Descriptive statistics have been provided for each accuracy measure, as shown in Table 5. Figure 5 graphically depicts the mean accuracy measures for each judgment type and graphic organizer type.

Table 5.
*Descriptive Statistics for Accuracy Dependent Measures by Treatment*

| Treatment | DV | M (%) | SD (%) | n | Skewness | Kurtosis | Min. | Max. |
|---|---|---|---|---|---|---|---|---|
| Static | F | 69.5 | 22.2 | 55 | -.18 | -1.04 | 3 | 15 |
| | C | 68.6 | 18.5 | | -.14 | -.48 | 3 | 15 |
| | I | 68.3 | 20.2 | | -.35 | -.95 | 4 | 15 |
| Sortable | F | 64.6 | 18.1 | 52 | -.21 | -.27 | 4 | 15 |
| | C | 63.3 | 21.0 | | .15 | -1.09 | 4 | 15 |
| | I | 63.6 | 20.5 | | -.19 | -1.11 | 3 | 14 |
| Shuffle-sort | F | 70.1 | 21.5 | 54 | -.15 | -.93 | 4 | 15 |
| | C | 65.3 | 19.5 | | -.15 | -.40 | 2 | 15 |
| | I | 58.0 | 20.7 | | .40 | -1.06 | 4 | 14 |

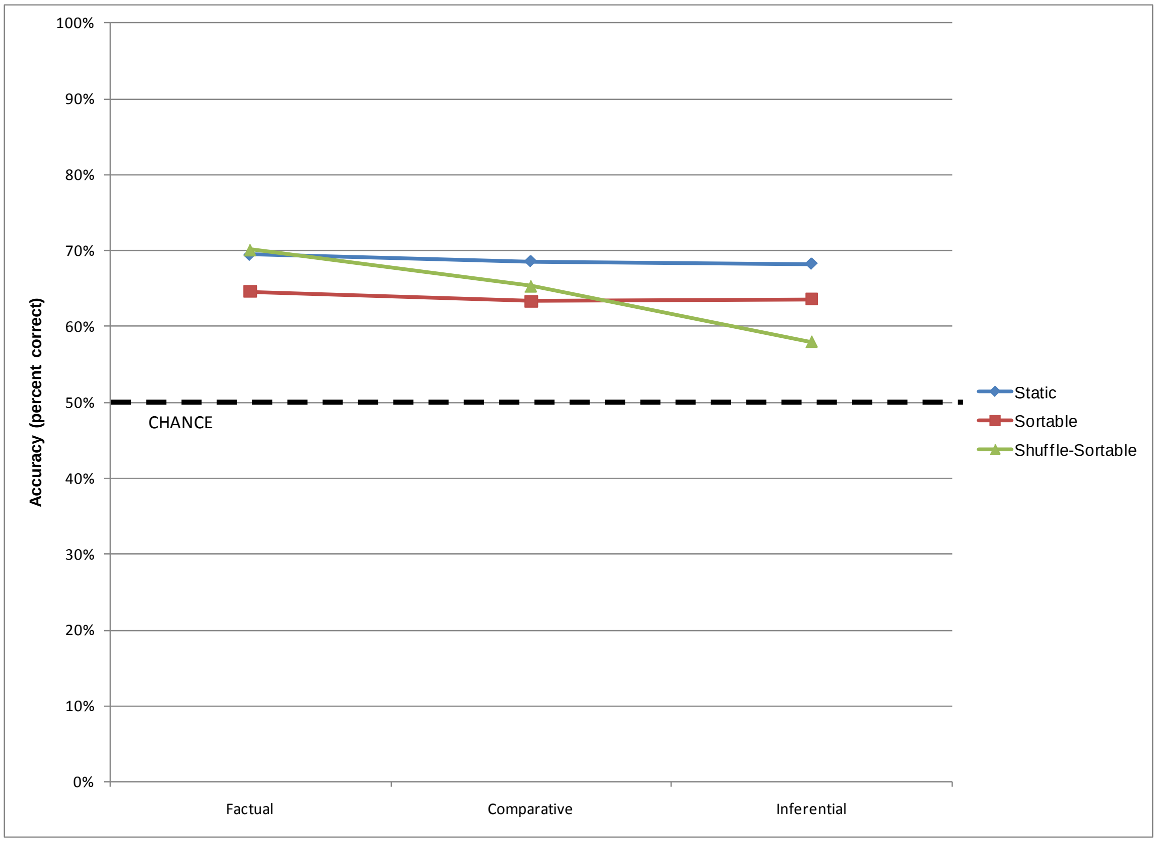


*Figure 5. Mean Accuracy for mental task by graphic organizer type*

*Multivariate Analysis of Variance*

A one-way between-groups multivariate analysis of variance was performed to investigate accuracy differences between the graphic organizer types. Dependent variables were Factual, Comparative, and Inferential judgment making. The independent variable was graphic organizer type. Preliminary assumption testing was conducted to check for sample size, normality, independence, and multivariate outliers, with no serious violations noted.

The null hypothesis tested in this analysis stated that mean accuracy did not differ across the groups, that is:

$$\mu_0 = \mu_1 = \mu_2$$

There was a statistically significant difference between graphic organizer types on the combined dependent variables: $F(6, 312)=2.378$, $p=.029$; Wilks' Lambda=0.914; partial eta squared=.044. However, when the dependent variable results were considered separately, none of the differences reached statistical significance using a Bonferroni-adjusted alpha level of 0.017. Therefore, the null hypothesis that accuracy did not differ across graphic organizer types was not rejected.

As noted previously, a restricted random assignment procedure was performed such that the last 17 participants in the study were randomly assigned to one of two (rather than three) possible groups. This restricted random assignment procedure was undertaken to remedy the observed unequal growth rates of the three experimental groups (the Shuffle-sort group size was outpacing both the Static and Sortable groups). To mitigate this potential threat to internal validity, a second MANOVA was performed using only participants 1-144 (that is, only the participants that had been assigned to groups using a 1/3 chance of being assigned to any particular group). The results of this MANOVA were not materially different from the MANOVA above that was based on all participants: There was a statistically significant difference between graphic organizer types on the combined dependent variables: $F(6, 278)=2.378$, $p=.024$; Wilks' Lambda=0.901; partial eta squared=.051. However, when the dependent variable results were considered separately, none of the differences reached statistical significance using a Bonferroni-adjusted alpha level of 0.017. Therefore, the null hypothesis that accuracy did not differ across graphic organizer types was also not rejected for this second, restricted, data set.

*Analysis of Variance*

Because of the increasing intellectual complexity of the three mental tasks (factual, comparative, inferential), accuracy was expected to decrease across those measures for each of the three graphic organizer treatments. To test this prediction, within-group analyses of variance were performed across the three measures for each of the three graphic organizer treatments, with the following results:

A one-way analysis of variance comparing factual, comparative, and inferential accuracy for the Static graphic organizer revealed no statistical difference between the measures, with $F(2, 162) = 0.05, p=.950$.

A one-way analysis of variance comparing factual, comparative, and inferential accuracy for the Sortable graphic organizer revealed no statistical difference between the measures, with $F(2, 153) = 0.06, p=.941$.

A one-way analysis of variance comparing factual, comparative, and inferential accuracy for the Shuffle-sortable graphic organizer revealed a statistical difference between the measures, with $F(2, 159) = 4.723, p=.01$. Once this difference was noted, a Tukey HSD (honestly significantly different) follow-up procedure was performed to investigate the pair-wise comparisons among the accuracy results for this (the shuffle-sortable) graphic organizer type. The results showed that inferential accuracy was significantly lower than factual accuracy (*mean difference* = -1.81, $p$=.007).

*Latency*

Response latency, that is, the difference in seconds between the time a question was displayed to a participant and the time a participant responded to that question, was captured by the research instrument for each criterion question. For each participant, sums of latency values for each judgment type (factual, comparative, and inferential) were computed. Descriptive statistics were prepared for each latency measure, as shown in Table 6. Figure 6 graphically depicts the mean latency measures for each judgment type and graphic organizer type.

Table 6.
*Descriptive Statistics for Latency by Treatment*

| Treatment | DV | M | SD | n | Skewness | Kurtosis | Min. | Max. |
|---|---|---|---|---|---|---|---|---|
| Static | F | 91.53 | 44.67 | 55 | 1.31 | 1.60 | 25.45 | 223.48 |
| | C | 85.48 | 38.13 | | .25 | -.61 | 24.44 | 170.62 |
| | I | 104.01 | 48.00 | | 1.77 | 5.81 | 27.67 | 311.69 |
| Sortable | F | 77.32 | 31.23 | 52 | 1.10 | 1.78 | 30.59 | 187.05 |
| | C | 73.26 | 30.61 | | 1.14 | 1.74 | 22.02 | 169.89 |
| | I | 97.97 | 34.92 | | .466 | -.75 | 33.50 | 166.53 |
| Shuffle-sort | F | 80.20 | 28.43 | 54 | .36 | -.65 | 27.44 | 142.38 |
| | C | 80.08 | 30.52 | | .49 | -.73 | 31.10 | 146.54 |
| | I | 99.15 | 35.89 | | .60 | .37 | 30.54 | 207.27 |

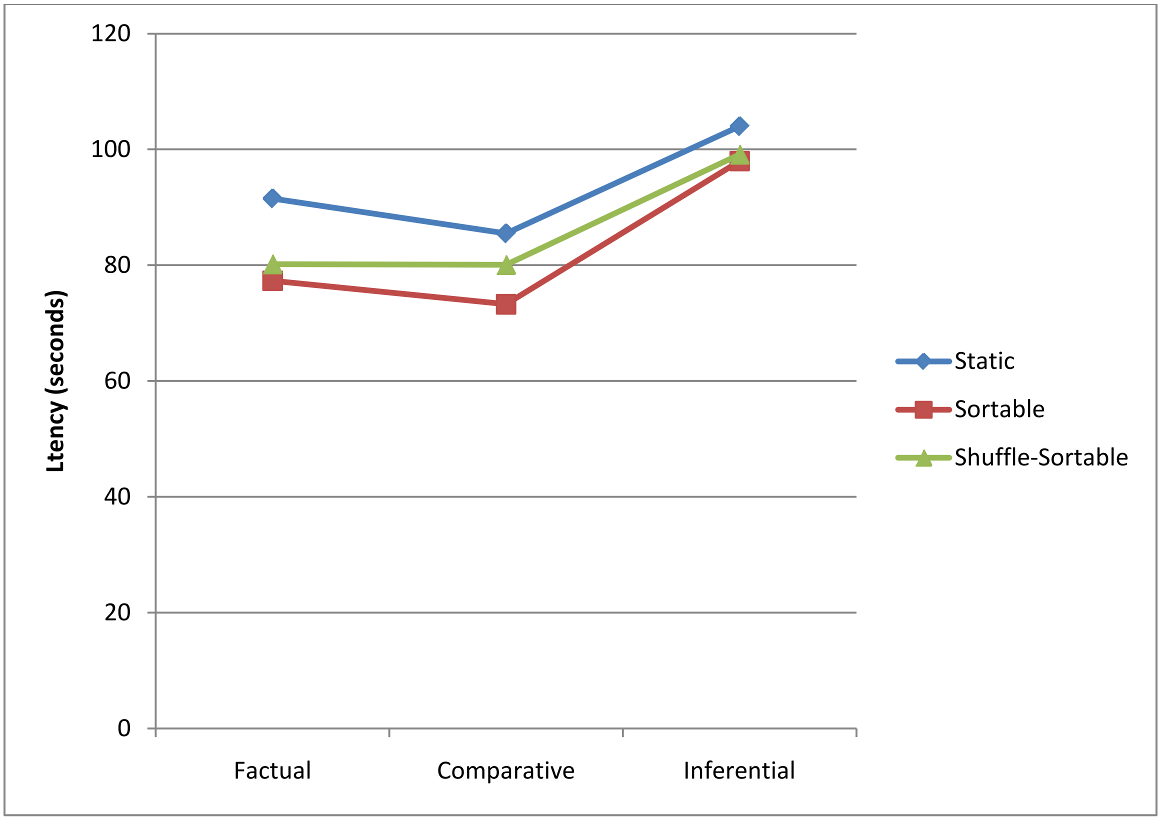


*Figure 6. Mean Latency in Seconds by Graphic Organizer Type*

*Multivariate Analysis of Variance*

A one-way between-groups multivariate analysis of variance was performed to investigate latency differences between the graphic organizer types (latency is defined as the time, in seconds, between the time a question was displayed and the time a participant responded to the question). Dependent variables were Factual Latency, Comparative Latency, and Inferential Latency. The independent variable was graphic organizer type. Preliminary assumption testing was conducted to check for independence, normality, and multivariate outliers with no serious violations noted.

The null hypothesis tested in this analysis stated that mean latency did not differ across the groups, that is:

$$\mu_0 = \mu_1 = \mu_2$$

The multivariate analysis of variance showed no significant difference between graphic organizer types on the combined dependent variables: $F(6, 312)=1.31$, $p=.25$; Wilks' Lambda=0.951; partial eta squared=.025. Therefore, the null hypothesis that latency did not differ for the graphic organizer types was not rejected.

*Analysis of Variance*

A within-groups analysis of variance was performed to investigate latency differences within each graphic organizer type. Dependent variables were Factual Latency, Comparative Latency, and Inferential Latency. The independent variable was judgment type.

A one-way analysis of variance comparing factual, comparative, and inferential latency for the Static graphic organizer revealed no statistical difference between the measures, with $F(2, 162) = 2.56$, $p=.08$.

A one-way analysis of variance comparing factual, comparative, and inferential latency for the Sortable graphic organizer revealed a significant difference between the measures, with $F(2, 153) = 8.79$, $p=.00$. Once this difference was noted, a Tukey HSD follow-up procedure was performed to investigate the pair-wise comparisons among the latency results for this (the sortable) graphic organizer type. The results showed that inferential latency was significantly higher than comparative latency (*mean difference* = 24.71, $p=.00$). The results also showed that inferential latency was significantly higher than factual latency (*mean difference* = 20.65, $p=.004$).

A one-way analysis of variance comparing factual, comparative, and inferential latency for the Shuffle-sortable graphic organizer revealed a significant difference between the measures, with *F(2, 159) = 6.448, p=.002*. Once this difference was noted, a Tukey HSD follow-up procedure was performed to investigate the pair-wise comparisons among the latency results for this (the shuffle-sortable) graphic organizer type. The results showed that inferential latency was significantly higher than comparative latency (*mean difference* = 19.08, *p*=.006). The results also showed that inferential latency was significantly higher than factual latency (*mean difference* = 18.96, *p*=.006).

*Text Viewing Time*

Text viewing time (TextTime) represents the time, in seconds, that a participant spent viewing the text passage that was available during the graphic organizer study period. Participants viewed the text passage by using the mouse to click and hold a button labeled *Show Text*. Participants were free to view the text as often and for as long as they wished (within the constraints of the five-minute graphic organizer study period). For each participant, sums of each text-viewing event were computed. Descriptive statistics were prepared for the text viewing times, as shown in Tables 7 and 8 (owing to the presence of several outliers and extreme outliers, the data is presented both with and without the outliers).

Table 7.
*Descriptive Statistics for TextTime (sec) by Treatment*

| Treatment | M | SD | N | Skewness | Kurtosis | Min. | Max. |
|---|---|---|---|---|---|---|---|
| Static | 94.18 | 113.80 | 55 | 2.70 | 7.22 | 0 | 540.62 |
| Sortable | 59.66 | 46.59 | 52 | 1.94 | 7.28 | 0 | 271.70 |
| Shuffle-sort | 55.06 | 74.47 | 54 | 2.12 | 12.02 | 0 | 424.14 |

Table 8.
*Descriptive Statistics for TextTime (sec) by Treatment (minus outliers)*

| Treatment | M | SD | n | Skewness | Kurtosis | Min. | Max. |
|---|---|---|---|---|---|---|---|
| Static | 56.96 | 35.11 | 47 | .18 | -.62 | 0 | 126.65 |
| Sortable | 52.20 | 32.66 | 49 | .21 | -.39 | 0 | 124.02 |
| Shuffle-sort | 37.40 | 31.66 | 50 | .57 | -.53 | 0 | 111.63 |

Figure 7 graphically depicts the mean text viewing times (with and without outliers) for each graphic organizer type.

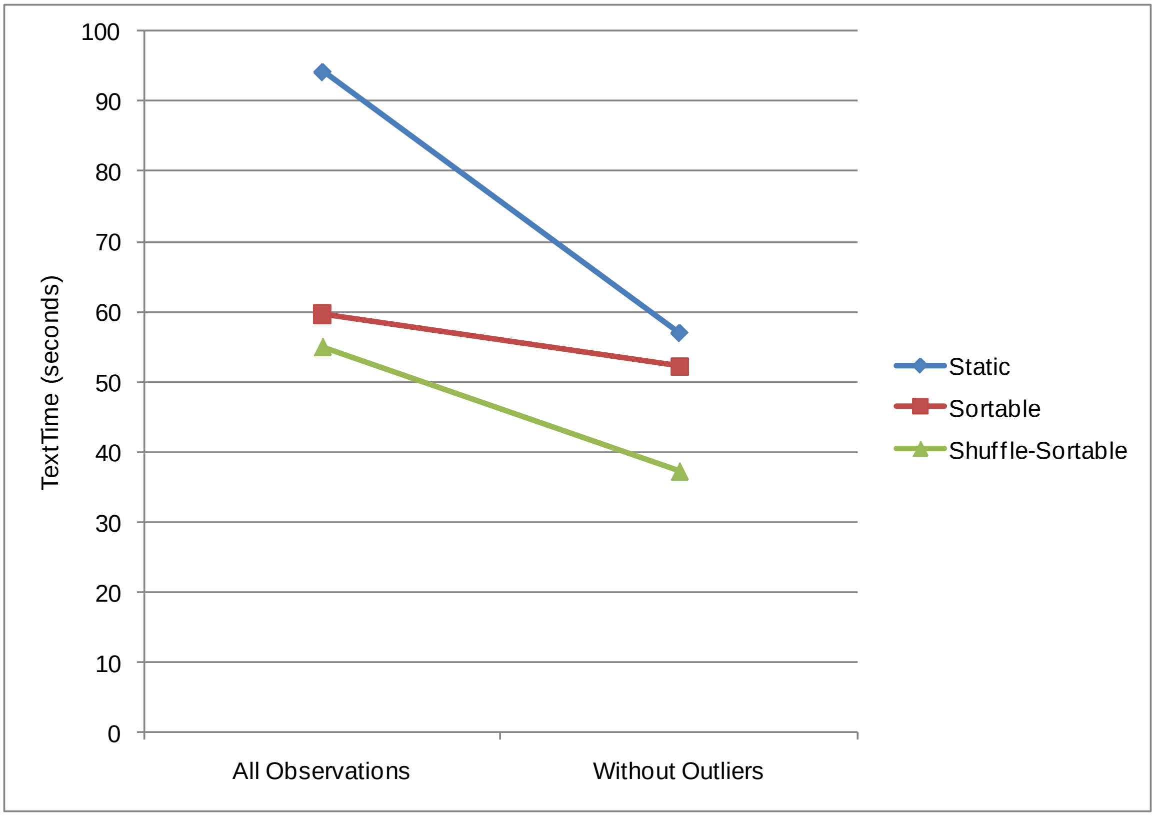


*Figure 7. Mean TextTime (with and without outliers)*

*Analysis of Variance*

A one-way analysis of variance comparing TextTime (that is, the amount of time a participant viewed the text passage during the graphic organizer study time) among the three graphic organizer types revealed a statistically significant difference between groups, $F(2, 158) = 3.550$, $p=.031$. Once this difference was noted, a Tukey HSD follow-up procedure was performed to investigate the pair-wise comparisons among TextTime results for the three graphic organizer types. The results showed that participants in the Shuffle-sortable group spent significantly less time viewing the text than participants in the Static group (*mean difference* = -39.06, $p$=.042).

Because of the number of outliers and extreme outliers present in the TextTime data, a second one-way analysis of variance was undertaken with all outliers and extreme outliers removed. (The procedure of removing the outliers and extreme outliers reduced the group sizes by 8, 3, and 4 participants for the Static, Sortable, and Shuffle-sort groups respectively.) This analysis of variance comparing TextTime among the three graphic organizer types still revealed a statistically significant difference between groups, $F(2, 143) = 4.46, p=.011$. Once this difference was noted, a Tukey HSD follow-up procedure was performed to investigate the pair-wise comparisons among TextTime results for the three graphic organizer types. The results showed that, even with outliers and extreme outliers removed, participants in the Shuffle-sort group spent significantly less time viewing the text than participants in the Static group (*mean difference* = -19.56, $p$=.012).

To probe for potential relationships between TextTime and overall accuracy, a 2-tailed Pearson's correlation coefficient analysis was performed. For this analysis, potential correlations between TextTime and Factual Accuracy, Comparative Accuracy, and Inferential Accuracy were considered. There was a significant weak negative correlation between TextTime and Factual Accuracy, $r(161) = -.17, p = .018$. There was also a significant weak negative correlation between TextTime and Comparative Accuracy, $r(161) = -.22, p = .005$. Finally, there was also a significant weak negative correlation between TextTime and Inferential Accuracy, $r(161) = -.23, p = .004$.

### *Click Events*

Click events represent overt actions taken by participants to either sort the rows in a graphic organizer (for the sortable and shuffle-sort treatment groups) or "shuffle" the columns (for the shuffle-sort treatment only). The opportunity for types of click events varies qualitatively by graphic organizer type. That is, the Static graphic organizer type has neither sort nor shuffle capability and therefore can have no associated click events; the Sortable graphic organizer type has only a sort capability and therefore can have only click events of type *sort*; finally the Shuffle-sort graphic organizer type has both sort and shuffle capabilities and therefore may have click events of the *sort* and/or *shuffle* types.

Descriptive statistics are shown in Tables 9 and 10 for click events of types *sort* and *shuffle* respectively. As shown in the tables, participants made use of the available user interface controls afforded by each treatment.

For the Static treatment group, neither sorting nor shuffling were possible, so these numbers were zero for those treatments as expected.

For the Sortable treatment group, participants sorted their graphic organizers about 12 times (M = 12.15, SD = 11.79) with a max of 45 and a min of 0. Six participants (11.5%) did no sorting. The remaining 46 participants (88.5%) sorted from 2 to 45 times each.

For the Shuffle-sort treatment group, participants sorted their graphic organizers about 8 times (M = 7.85, SD = 10.08) with a max of 45 and a min of 0. Thirteen participants (24.1%) did no sorting. The remaining 41 participants (75.9%) sorted from 1 to 45 times each. The Shuffle-sort treatment also afforded participants with the capability of "shuffling" columns in a horizontal direction. Participants shuffled their graphic organizers about 10 times (M= 10.13, SD = 8.02) with a min of 0 and a max of 34. Six participants (11.1%) did no shuffling. The remaining 48 participants (88.9%) shuffled from 2 to 34 times each.

The above findings suggest evidence of mindful, effortful actions, which Saloman and Globerson (1987) say should contribute to both learning and transfer. Learners took such mindful, effortful actions 88.5% of the time for the Sortable treatment and 88.9% of the time for the Shuffle-sort treatment.

Table 9.
*Descriptive Statistics for Sort Clicks by Treatment*

| Treatment | M | SD | n | Skewness | Kurtosis | Min. | Max. |
|---|---|---|---|---|---|---|---|
| Static | NA | NA | NA | NA | NA | NA | NA |
| Sortable | 12.15 | 11.79 | 52 | 1.29 | .86 | 0 | 45 |
| Shuffle-sort | 7.85 | 10.08 | 54 | 2.12 | 4.68 | 0 | 45 |

Table 10.
*Descriptive Statistics for Shuffle Clicks by Treatment*

| Treatment | M | SD | n | Skewness | Kurtosis | Min. | Max. |
|---|---|---|---|---|---|---|---|
| Static | NA | NA | 55 | NA | NA | NA | NA |
| Sortable | NA | NA | 52 | NA | NA | NA | NA |
| Shuffle-sort | 10.13 | 8.02 | 54 | 1.17 | 1.20 | 0 | 34 |

*Ancillary Questions*

At the conclusion of the criterion question portion of the research study participants were asked a series of ancillary questions, that is, questions that were not intended to be part of the formal statistical analysis just presented. Many of these questions were intended to elicit amplifying data from participants—data that might be useful when interpreting the results from the formal analysis. Other questions were provided to give participants an opportunity to offer their own insights related to their treatment-specific graphic organizers. The following sections provide the results for the ancillary questions.

*Trends YN*

The first ancillary question presented to participants was the yes/no query, “While studying the fish material, did you notice any trends or relationships?” Two radio buttons (labeled “Yes” and ”No”) were presented below the question. Participants overwhelmingly responded affirmatively to this question. All participants answered this question, as the *Next* button did not become active until a response was provided. Of the treatment groups, 87.3% of the Static group responded “yes,” 88.5% of the Sortable group responded “yes,” and 90.7% of the Shuffle-sortable group responded “yes.” These data are shown in figure 8.

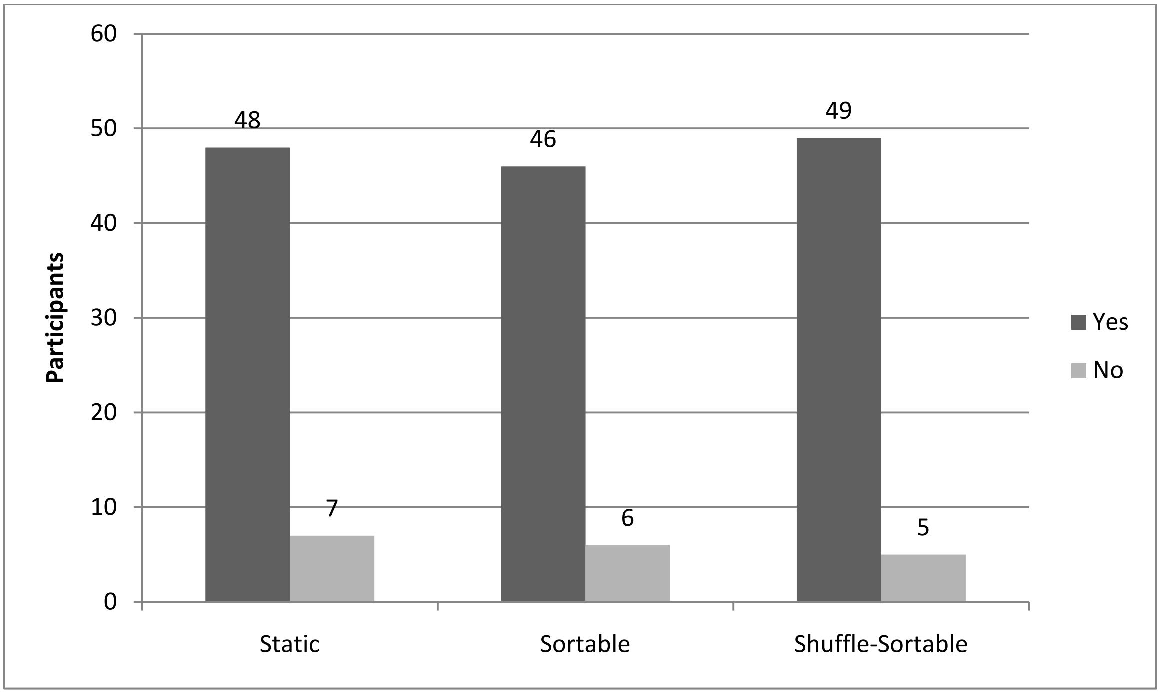


*Figure 8. Participant responses to Trends Y/N question*

The above figure depicts the number of affirmative and negative participant responses, by treatment group, to the question, “While studying the fish material, did you notice any trends or relationships?”

*Trends Found*

Participants were then asked, “Please list any trends about the fish that you may have noticed.” A free-form text entry area was provided below the question. The *Next* button was always active for this screen, so participants who chose to skip this response were able to do so (139 of the 161 participants , or roughly 86%, chose to provide a response to this question).

In order to score the free-form responses to this question a coding strategy was followed. The researcher, without knowledge of the groups corresponding to each participant response, independently scored each response on a numeric integer scale of 0-4 inclusive. A grading rubric was prepared, which would award one point for each correctly identified trend. An example of participant response that would earn one point for a correctly identified trend might be, “lighter colored fish tend to swim deeper.” The maximum of four points were awarded for a response in which the participant correctly identified trends related to depth, size, color, diet, and social grouping. Participants who stated the same trend in two ways were awarded only one point. Table 11 below depicts the descriptive statistics for the participant results to the Trends Found ancillary question.

Table 11.
*Descriptive Statistics for Trends Found*

| Treatment | M | SD | n | Skewness | Kurtosis | Min. | Max. |
|---|---|---|---|---|---|---|---|
| Static | .84 | 1.09 | 55 | .79 | .95 | 0 | 3 |
| Sortable | .88 | 1.23 | 52 | .95 | .61 | 0 | 4 |
| Shuffle-sort | .74 | 1.09 | 54 | 1.47 | 1.52 | 0 | 4 |

*Mental Strategies Used*

Participants were then asked, “Please list any tricks or mental strategies that you used while studying the material.” A free-form text entry area was provided below the question. The *Next* button was always active for this screen, so participants who chose to skip this response were able to do so (134 of the 161 participants, or about 83%, chose to provide a response to this question).

To analyze the strategies participants reported using to remember the study material information, each participant’s response was examined, without knowledge of participant treatment group. During this examination, one or more codes were assigned based on keywords or apparent meanings present in the participant responses. The codes were taken from two prior graphic organizer studies (Spears & Kealy, 2005; Spears, Motes, & Kealy, 2005). One new category, SO, was added to capture participant responses related to graphic organizer sorting as a strategy used during study time.

| | |
|---|---|
| AC | acronyms or initials |
| CA | categorical assignment |
| CL | counting of letters on the display |
| CO | colors used – observing those |
| GA | game related |
| KW | key words |
| LE | letters of alphabet appearing on the display |
| ME | memorized the information provided |
| PA | patterns |
| RE | repetition of the information provided |
| RL | relationships – noting those evident |
| RS | rhyme or song |
| SA | sound-alike words |
| SO | sorted chart |
| VC | visualizing the chart |
| x | no meaningful response |

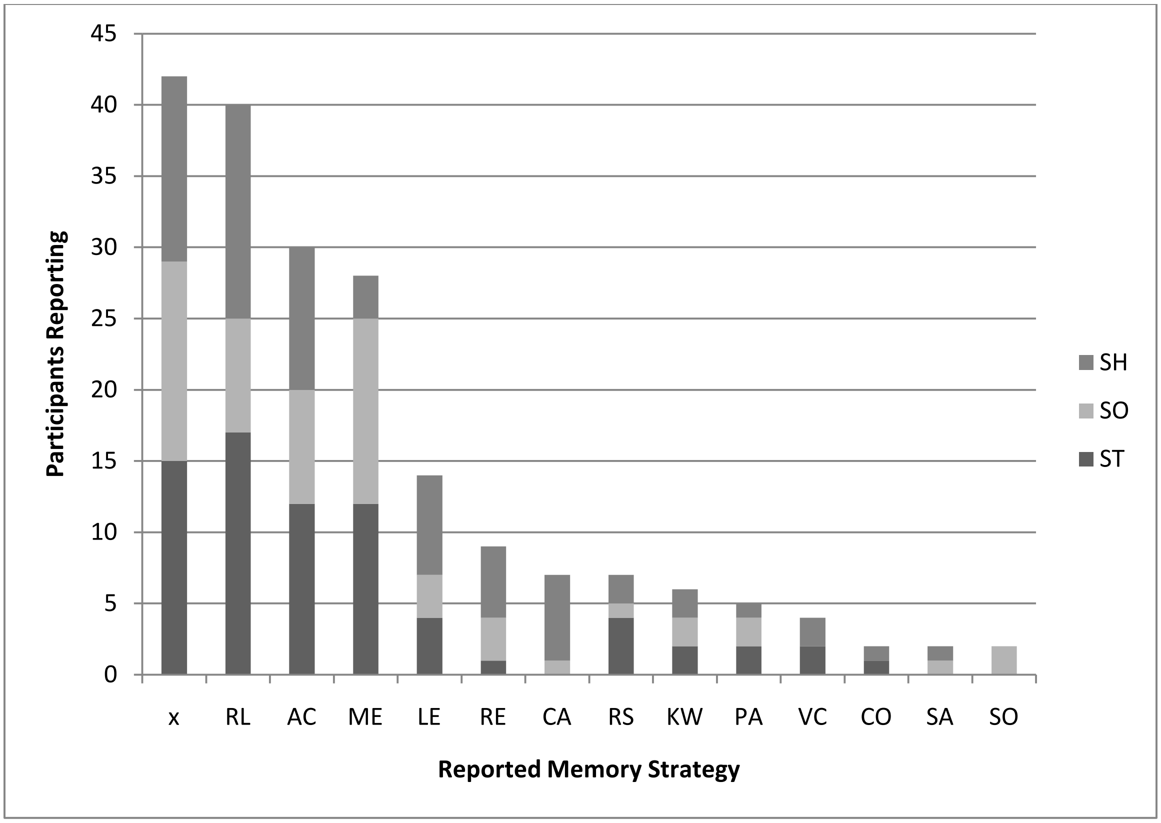


*Figure 9. Aggregate Reported Memory Strategies*

By visual inspection of figure 9, one may see that the four most popular valid strategies overall were “relationships—noting those evident” (RL), “acronyms or initials” (AC), “memorized the information provided” (ME), and “letters of alphabet appearing on display” (LE). Together, these strategies comprised roughly 72% of reported valid strategies. (The “no meaningful response” (x) category included blank responses as well as non-blank responses in which no study strategy was discernable.)

When considering the strategies with respect to treatments, the strategies seem to be distributed more or less equally across treatments. One interesting observation is that the shuffle-sortable treatment appears to have more “letters of alphabet” (LE), “repetition of the information provided” (RE), and “categorical assignment” (CA) reports when compared to the static and sortable treatments. Also worth noting is the strategy called "sorted chart" (SO) that was reported only by two sortable graphic organizer treatment participants.

*Effectiveness Query*

Participants were then presented with the query, "Do you think that the graphic organizer you just studied was an effective instructional tool?" Two radio buttons (labeled *Yes* and *No*) were presented below the question, along with a *Next* button. The *Next* button did not become active until the participant selected one of the radio button choices.

All participants answered this question so there were no missing data. Of the given responses, the two dynamic graphic organizer treatments each received a little over 80% affirmative responses while the static graphic organizer treatment group received exactly 60% affirmative responses. These results are depicted in figure 10.

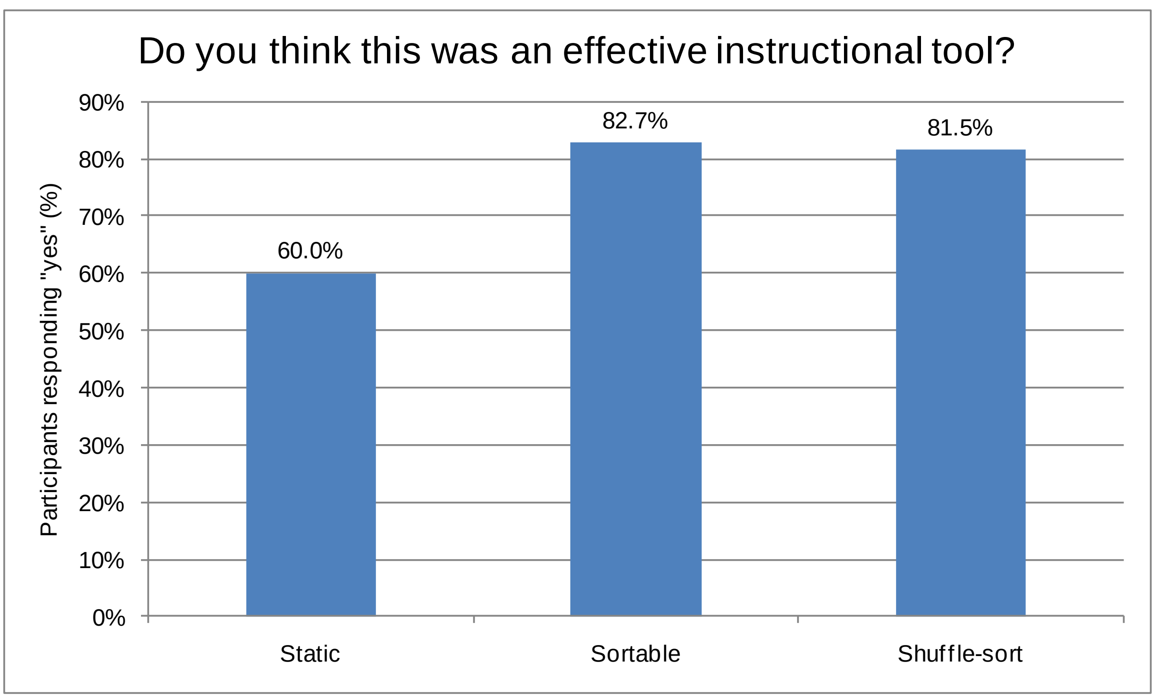


*Figure 10. Participant-reported effectiveness rating*

# Chapter Five: Discussion

This study's primary goal was to investigate the effects of two instances of a new type of graphic organizer (the dynamic graphic organizer) on learners' ability to recall information, identify trends, and make comparative/inferential judgments after studying a particular graphic organizer and accompanying informational text passage. Response latency, that is the difference between the time a question was displayed and the time the participant responded, was also recorded and analyzed as part of this study.

The two types of dynamic graphic organizer were designed to give learners increasingly complex levels of available interactivity. The first dynamic graphic organizer type, the sortable graphic organizer, allowed participants to sort rows, in ascending or descending order, by the values of elements in any column contained within the graphic organizer. The second dynamic graphic organizer type, the shuffle-sort graphic organizer, provided the same capability and additionally provided a feature such that learners could "shuffle" the contents of the graphic organizer in a column-wise fashion. These two types of dynamic graphic organizers, plus a traditional static (non-sortable) graphic organizer, were investigated by means of an experiment in which participants were randomly assigned to graphic organizer treatment groups.

A multivariate analysis of variance was employed to investigate the relationship between the independent variable (graphic organizer type) and the dependent variables (accuracy and latency for factual, comparative, and inferential judgments). A second multivariate analysis of variance was used to analyze the latency characteristics of both the question types as well as the graphic organizer types. Ancillary questions related to trends and mental strategies were also administered, recorded, and considered as part of this study.

A total of 161 participants completed this research study. Sixty-eight percent of the participants were female while the remaining 32% were male. Participants were recruited using various means (extra course credit, small cash payment, token compensation such as snacks) from various undergraduate classes and the general student population at one two-year community college and one four-year research university located in a mid-sized urban center in the southeast United States. Most participants (59%) reported a major in education or related discipline; overall, 38 unique majors were reported by participants.

This chapter summarizes the research questions and results, followed by recommendations for learners, educators and instructional designers, and finally educational researchers with respect to how this study's findings might be best applied in each context. Suggestions for future research directions by educational researchers are also given in light of the present study.

*Summary of Research Questions and Results*

By augmenting an existing static medium (a graphic organizer) with attributes such that learners can sort or rearrange information in multiple ways, two new types of dynamic graphic organizers were created to enable the present study. An experiment to investigate the effectiveness of these dynamic graphic organizers as instructional tools was undertaken. Several predictions were made before this experiment took place, as described in the following paragraphs.

Because of the increasing intellectual complexity of the three mental tasks (factual, comparative, inferential) accuracy was expected to decrease across those measures for each of the three graphic organizer treatments. However, the decrease was not expected to be equal across the three treatments. That is, an ordinal interaction between graphic organizer treatment and mental task was expected. Specifically, accuracy for factual judgments was predicted to be similar for each of the three treatments. Accuracy for comparative judgments was predicted to be similar for both dynamic graphic organizer treatments, with both treatments being significantly better than the static graphic organizer treatment. It was also expected that dynamic graphic organizers would be useful for making trends in presented information more apparent, thereby providing a device where learners are able to more accurately make comparative and inferential judgments than would be possible with a static graphic organizer. Furthermore, it was expected that a dynamic graphic organizer providing learners with a “shuffle-sort” capability would permit learners to more accurately make inferential judgments than a dynamic graphic organizer with a simple sort capability, with both types allowing more accurate inferential judgments than would be possible with a static graphic organizer.

Response latency, that is, the difference between the time a question was displayed and the time a participant responded to that question, was expected to vary with the complexity of mental tasks. That is, response latency for inferential judgments was expected to be greater than response latency for comparative judgments which was expected to be greater than response latency for factual judgments

*Discussion of Results*

*Research questions*

*Question one*: Is there a significant difference in accuracy for factual judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer?

A multivariate analysis of variance revealed a significant difference between graphic organizer types on the combined dependent variables: $F(6, 312)=2.378$, $p=.029$; Wilks' Lambda=0.914; partial eta squared=.044. However, when the dependent variable results were considered separately, none of the differences reached statistical significance using a Bonferroni-adjusted alpha level of 0.017. Because factual judgment accuracy is one of the constituent variables in the MANOVA, one cannot conclude that a significant difference in accuracy for factual judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer exists.

The factual accuracy means (with standard deviations in parentheses) for the graphic organizer types static, sortable, and shuffle-sortable were 10.42 (3.33), 9.69 (2.27), and 10.52 (3.23), respectively.

*Question two*: Is there a significant difference in accuracy for comparative judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer?

A multivariate analysis of variance revealed a significant difference between graphic organizer types on the combined dependent variables: $F(6, 312)=2.378$, $p=.029$; Wilks' Lambda=0.914; partial eta squared=.044. However, when the dependent variable results were considered separately, none of the differences reached statistical significance using a Bonferroni-adjusted alpha level of 0.017. Because comparative judgment accuracy is one of the constituent variables in the MANOVA, one cannot conclude that a significant difference in accuracy for comparative judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer exists.

The comparative accuracy means (with standard deviations in parentheses) for the graphic organizer types static, sortable, and shuffle-sortable were 10.29 (2.78), 9.50 (3.15), and 9.80 (2.93), respectively.

*Question three*: Is there a significant difference in accuracy for inferential judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer?

A multivariate analysis of variance revealed a significant difference between graphic organizer types on the combined dependent variables: $F(6, 312)=2.378$, $p=.029$; Wilks' Lambda=0.914; partial eta squared=.044. However, when the dependent variable results were considered separately, none of the differences reached statistical significance using a Bonferroni-adjusted alpha level of 0.017. Because inferential judgment accuracy is one of the constituent variables in the MANOVA, one cannot conclude that a significant difference in accuracy for inferential judgments among learners presented with a static graphic organizer versus a dynamic sortable graphic organizer versus a dynamic shuffle-sort graphic organizer exists.

The inferential accuracy means (with standard deviations in parentheses) for the graphic organizer types static, sortable, and shuffle-sortable were 10.24 (3.03), 9.54 (3.07), and 8.70 (3.10), respectively.

*Accuracy*

Because of the increasing intellectual complexity of the three mental tasks (factual, comparative, inferential) accuracy was expected to decrease across those measures for each of the three graphic organizer treatments. To test this prediction, within-group analyses of variance were performed across the three measures for each of the three graphic organizer treatments, with the following results:

A one-way analysis of variance comparing factual, comparative, and inferential accuracy for the Static graphic organizer revealed no statistical difference between the measures, with $F(2, 162) = 0.05, p=.950$.

A one-way analysis of variance comparing factual, comparative, and inferential accuracy for the Sortable graphic organizer revealed no statistical difference between the measures, with $F(2, 153) = 0.06, p=.941$.

A one-way analysis of variance comparing factual, comparative, and inferential accuracy for the Shuffle-sortable graphic organizer revealed a statistical difference between the measures, with $F(2, 159) = 4.723, p=.01$. Once this difference was noted, a Tukey HSD follow-up procedure was performed to investigate the pair-wise comparisons among the accuracy results for this (the shuffle-sort) graphic organizer type. The results showed that inferential accuracy was significantly lower than factual accuracy (*mean difference* = -1.81, $p$=.007).

From the above findings that it may be noted that, of the three graphic organizer types, only the shuffle-sort treatment exhibited the predicted downward trend in accuracy as mental task complexity increased. Figure 5 (p. 47) graphically represents this observation: the slope of the static and sortable accuracy graphs is relatively flat, while the slope of the shuffle-sort accuracy graph has an obvious downward trend. In fact, the mean difference between factual accuracy and inferential accuracy for the shuffle-sort graphic organizer is nearly two accuracy points (-1.81) on a scale having a range of 0-15 inclusive.

*Latency*

Response latency, that is, the difference between the time a question was displayed and the time a participant responded to that question, was expected to vary with the complexity of mental tasks for each graphic organizer type. That is, response latency for inferential judgments was expected to be greater than response latency for comparative judgments which was expected to be greater than response latency for factual judgments.

Before investigating the above-stated prediction, a one-way between-groups multivariate analysis of variance was performed to determine if latency differences existed between graphic organizer types. For this analysis, the dependent variables were Factual Latency, Comparative Latency, and Inferential Latency. The independent variable was graphic organizer type.

The multivariate analysis of variance showed no significant difference between graphic organizer types on the combined dependent variables, $F(6, 312)=1.31$, $p=.25$; Wilks' Lambda=0.951; partial eta squared=.025. Therefore, the null hypothesis that latency did not differ for the graphic organizer types was not rejected.

To examine the expectation that response latency would increase within each graphic organizer type as the complexity of mental tasks increased, within-groups analyses of variance were performed. Dependent variables were Factual Latency, Comparative Latency, and Inferential Latency. The independent variable was judgment type.

A one-way analysis of variance comparing factual, comparative, and inferential latency for the Static graphic organizer revealed no significant difference between the measures, with *F(2, 162) = 2.56, p=.08*.

A one-way analysis of variance comparing factual, comparative, and inferential latency for the Sortable graphic organizer revealed a significant difference between the measures, with *F(2, 153) = 8.79, p=.00*. Once this difference was noted, a Tukey HSD follow-up procedure was performed to investigate the pair-wise comparisons among the latency results for this (the sortable) graphic organizer type. The results showed that inferential latency was significantly higher than comparative latency (*mean difference* = 24.71, *p*=.00). The results also showed that inferential latency was significantly higher than factual latency (*mean difference* = 20.65, *p*=.004).

A one-way analysis of variance comparing factual, comparative, and inferential latency for the Shuffle-sort graphic organizer revealed a significant difference between the measures, with *F(2, 159) = 6.448, p=.002*. Once this difference was noted, a Tukey HSD follow-up procedure was performed to investigate the pair-wise comparisons among the latency results for this (the sortable) graphic organizer type. The results showed that inferential latency was significantly higher than comparative latency (*mean difference* = 19.08, *p*=.006). The results also showed that inferential latency was significantly higher than factual latency (*mean difference* = 18.96, *p*=.006).

From the above findings it may be noted that, of the three graphic organizer types, the predicted increase in latency associated with increased complexity of mental tasks was only partially observed. For both dynamic graphic organizer types (sortable and shuffle-sortable), latency for inferential judgments was greatest. However, factual and comparative latencies were relatively similar for both of these graphic organizer types (for the sortable treatment, mean comparative latency was actually about four seconds less, although this difference was not significant). The static treatment, although appearing to graph in a fashion similar to the two dynamic treatments, showed no statistical differences between latency for each mental task. Figure 6 (p. 51) graphically represents the measured response latencies for each mental task and each graphic organizer. This figure, in concert with the MANOVA results, show the fairly dramatic increase in response latency for the inferential judgment types. The greatest deltas observed were for the sortable treatment, with mean latency differences of 24.71 seconds (inferential versus comparative) and 20.65 seconds (inferential versus factual).

*Interactivity*

Participants seemed willing to exercise the interactive capabilities inherent to the two dynamic graphic organizer treatments.

For the Sortable treatment group, participants sorted their graphic organizers about 12 times (M = 12.15, SD = 11.79) with a max of 45 and a min of 0. Six participants (11.5%) did no sorting. The remaining 46 participants (88.5%) sorted from 2 to 45 times each.

For the Shuffle-sort treatment group, participants sorted their graphic organizers about 8 times (M = 7.85, SD = 10.08) with a max of 45 and a min of 0. Thirteen participants (24.1%) did no sorting. The remaining 41 participants (75.9%) sorted from 1 to 45 times each. (One might speculate that the shuffle-sort treatment’s apparently lower number of mean sort events was influenced by the fact that the shuffle-sort treatment offered two controls for rearranging the graphic organizer content while the sortable treatment had but one.) The Shuffle-sort treatment also afforded participants with the capability of "shuffling" columns in a horizontal direction. Participants shuffled their graphic organizers about 10 times (M= 10.13, SD = 8.02) with a min of 0 and a max of 34. Six participants (11.1%) did no shuffling. The remaining 48 participants (88.9%) shuffled from 2 to 34 times each.

The above findings suggest that learners, by overtly manipulating graphic organizer elements in the two dynamic treatments, were taking mindful, effortful actions expected to contribute to learning and transfer (Salomon & Globerson, 1987). Learners took such mindful, effortful actions more than 88% of the time for the Sortable treatment and more than 75% of the time for the Shuffle-sort treatment.

One treatment-independent user interface control available to participants was the *View Text* button, displayed for each treatment during its five-minute graphic organizer study period. One-hundred-forty-six participants (91%) used the *View Text* button to, at least briefly, view the text passage that accompanied each graphic organizer. Because some of these non-zero *View Text* values may represent participants who simply had a brief investigatory look at the accompanying text passage (without any meaningful study of the text passage) a metric characterizing a longer text study time might be more valuable than a simple "clicks > 0". A more meaningful text viewing time might be one minute. When considering this criterion (that is, participants who viewed the text for at least one minute) the number becomes 76 participants, or 47%. It should be noted that the default study condition for each treatment was "study graphic organizer." In other words, participants who took no overt action to click/hold the *View Text* button saw only their treatment-dependent graphic organizer. This was by design, as the primary focus of this study was dynamic graphic organizers, not text passages. This characteristic of the study's design is not viewed as a limitation, as the researcher believes that this study's results would not have been materially different had the text passage been omitted completely

*Summary of Findings*

This study's primary goal was to investigate the effects of two instances of a new type of graphic organizer (the dynamic graphic organizer) on learners' ability to recall information, identify trends, and make comparative/inferential judgments after studying a particular informational passage. Response latency was also recorded and analyzed as part of this study.

Graphic organizers arrange information in a manner that facilitates side-by-side comparison, exhibiting a "visual argument" whereby interrelationships between presented elements are readily perceivable (Robinson, Robinson, & Katayama, 1999). In this study, the supposition was tested that providing learners with a mechanism that might allow them to overtly influence the degree of visual argument (by reorienting display elements nearer to each other) would increase learner accuracy, especially with respect to more complex mental tasks such as comparative and inferential judgments. Similarly, exploiting generative learning (Wittrock, 1991) while adding an interactive dimension to a formerly static medium (Kozma, 1991) were projected to yield benefits for the two dynamic graphic organizer treatments. Contrary to expectations, the graphic organizers that gave learners this interactive capability seemingly performed no better than a traditional, static graphic organizer. In fact, mean accuracy for inferential judgments (the most complex type) actually decreased (although not to a statistically significant degree) as the level of available graphic organizer interactivity increased.

One possible explanation for this observed phenomenon might be that the inherent overhead associated with sorting (or shuffle-sorting) was not compensated by any potential accuracy improvements gained by the newly arranged elements in the graphic organizer. This overhead involved the opportunity cost associated with manipulation of the user interface controls (i.e., a participant rearranging the items in the graphic organizer was not studying the graphic organizer). Similarly, mindful processing associated with rearranging the elements may not have benefited schema development associated with the material under study, but instead benefited only knowledge associated with learning the user interface controls themselves.

Rather than an overhead-based explanation for the dynamic graphic organizers' performance, one could also describe it in terms of cognitive load (defined by Sweller [1988] as the demand on mental resources imposed by both the number of elements and the interrelatedness of these elements). The dynamic graphic organizers' inherent cognitive load could have conceivably been increased (unlike the static graphic organizer) thus exhausting available mental resources in the learners, with relatively few resources remaining for the actual learning.

Another factor to consider is the possible influence of text viewing time. Text viewing time, or simply text time, is the cumulative time that a participant spent with the *View Text* user interface button pressed. When this button was pressed, the on-screen graphic organizer was replaced by the accompanying 204-word text passage. This passage comprised the text-only version of instructional material, informationally equivalent to the graphic organizers. Participants were required to keep constant pressure on this button in order to keep the text displayed. Similarly, displaying the text required overt action on the participant's part. Taken together, these premises might suggest that text time was more mindful study time. In contrast, during the non-text-time portion of the five-minute study period participants might have been looking somewhere other than the graphic organizer, randomly manipulating the dynamic graphic organizers' controls, or simply daydreaming.

A very promising finding is the fact that participants in both dynamic treatments reported much greater percentages of affirmative responses to the question, "Did you think your graphic organizer was an effective instructional tool?" with 82.7% and 81.5% responding "yes" for the Sortable and Shuffle-sort groups, respectively, and only 60.0% responding "yes" for the Static group. These findings are important, as it is conceivable that learners with such positive perceptions might be more likely to use dynamic graphic organizers. Similarly, metacomprehension (that is, a person's ability to judge his or her own learning and/or comprehension of text materials) research has shown that adult learners often tend to make efficacious study choices (Metcalfe, 2009). It might follow, therefore, that learners who perceived that a dynamic graphic organizer was more effective than a static one might be more likely to study the former. Similarly, these learners might have more confidence in their ability to learn from such devices.

### *Recommendations to Stakeholders*

By drawing from both the review of the relevant literature as well as the findings of the current study, this section puts forth recommendations for learners, instructors and instructional designers, and finally for the design of future studies.

#### *Learners*

The ultimate goal of this study has been to benefit learners. Without individual participants taking on the role of learners, this study would not have been possible. This study's results suggest that a dynamic graphic organizer may be no more effective than a traditional static graphic organizer for making trends and relationships apparent to learners. However, the subject material of the current study was of a fairly narrow scope and size (a 204-word passage comprising declarative text related to several fictitious species of fish and their characteristics). It is conceivable that a dynamic graphic organizer might perform better when used with other educational content. Learners encountering graphic organizers of any type may wish to be attentive to cues in the instructional material related to trends or relationships, as matrix-like graphic organizers are frequently used to convey information of this type.

*Instructors and Instructional Designers*

With respect to the unique perspective and requirements of instructional designers and educators, this study's findings may give pause to those considering the implementation of a dynamic graphic organizer. For the type of comparative prose studied in this research, a traditional static graphic organizer may serve the educational requirements just as well as a dynamic graphic organizer. It should be noted that scope and content of the present study's instructional material represent a small subset of instructional material types—this specific instructional material (a 204-word passage comprising declarative text related to several fictitious species of fish and their interrelationships) cannot begin to represent all types of instructional material. It is plausible that a dynamic graphic organizer might perform better when used with other educational content. Educators and instructional designers should also keep in mind the increased learner engagement benefits potentially derivable from interactive entities such as the dynamic graphic organizer.

*Educational Researchers*

The experiment conducted as part of this study used a relatively limited, somewhat artificial subject material of a relatively small size (a 204-word passage comprising declarative text related to several fictitious species of fish and their interrelationships). Educational researchers may wish to retest this study's baseline hypothesis by using other types of instructional materials (e.g., more elements, increased complexity). Similarly, educational researchers may wish to revisit the study's hypothesis using a different approach to study time. In this research, study time was fixed at five minutes. An alternative approach might involve graphic organizer study time under the control of the learner rather than the experimental program. It is possible that a dynamic graphic organizer might perform better than static graphic organizers under one or both conditions just noted, although the present study does not provide evidence for this.

*Final Summary*

This study was undertaken to determine what effects on learner recall might exist when two instances of a new type of graphic organizer (the dynamic graphic organizer) were used to convey information taken from a particular comparative text passage. Learner responses were measured for both recall accuracy and latency when making factual, comparative, and inferential judgments related to the information contained in the graphic organizer and text.

The two dynamic graphic organizer treatments were designed to give learners two distinct levels of interactive capability. The first dynamic treatment (sortable graphic organizer) allowed participants to sort rows, in ascending or descending order, by the content of a particular column within the graphic organizer. The second treatment (shuffle-sort graphic organizer) added a feature such that learners could “shuffle” (that is, reorient columns in a left-to-right or right-to-left fashion) the contents of the graphic organizer in a column-wise fashion. These two dynamic graphic organizer treatments, plus a traditional static (non-sortable) graphic organizer, were the basis of the subject experiment.

A total of 161 volunteer participants completed this research study. Sixty-eight percent of the participants were female; the remaining 32% were male. Participants were recruited using various means (extra course credit, small cash payment, or with compensation other than small snacks) from various undergraduate classes and the general student population at one two-year community college and one four-year research university located in a mid-sized urban center in the southeast United States.

Two multivariate analyses of variance were used to examine the relationships between the independent variable (graphic organizer type) and the dependent variables (accuracy and latency for factual, comparative, and inferential judgments). These analyses showed no significant differences between the three graphic organizer types for response accuracy or response latency, suggesting that a dynamic graphic organizer may be equivalent to a static graphic organizer for the type of comparative material represented in the graphic organizers. A within-groups analysis of variance showed no significant differences in response accuracy or latency between mental tasks within the static or sortable tasks. However, analysis of variance did indicate that accuracy for inferential judgments was less than that for factual judgments in the shuffle-sortable group, suggesting that the shuffle-sortable type of dynamic organizer may not be as robust with respect to mental task type as the other two types of graphic organizers evaluated.

Response latency within groups was also considered. A within-groups analysis of variance showed significant differences in response latency between factual and inferential judgment-making for both the sortable and shuffle-sort treatments; no significant differences in response latency were observed within the static treatment.

Other findings revealed that participants in the shuffle-sort group spent significantly less time viewing the accompanying text than participants in the static group, suggesting that perhaps learners in the static group had more time available to do so, in contrast to the shuffle-sort participants, who may have been occupied with the unique controls provided in that treatment. This finding was consistent even when outliers and extreme values were removed from the shuffle-sort group's data.

Analysis also revealed a significant, although weak, negative correlation between text viewing time and accuracy across all three mental task types, suggesting that learners who spent more time viewing the text (and therefore less time viewing the graphic organizer) did slightly worse than learners who did the opposite. This reinforces findings from earlier studies that showed the overall effectiveness of graphic organizers as adjunct displays to text.

This study investigated the effect of dynamic graphic organizers on learner recall accuracy and response latency for various types of mental tasks associated with a particular instance of instructional material. The results suggest that dynamic graphic organizers may be equivalent to static graphic organizers, at least under the conditions of the present study. However, a much higher proportion of dynamic treatment learners (versus the static treatment learners) perceived that their respective graphic organizers were effective instructional tools. Opportunities for future research exist to perhaps reinforce or refute these findings, while simultaneously augmenting the instructional technology research literature.

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Appendices

Appendix A. The original informational text passage

Fish fall into one of three social groupings: solitary, small, or school. Solitary fish do not socialize with other fish. Examples of solitary fish are the Hat and the Arch. Although the Hat and Arch are both solitary fish, they differ in several ways. The Hat swims at depths of 200 feet, whereas the Arch swims 400 feet below the surface. The Arch is 45 cm in length; the Hat is 30 cm. The Hat is a black color and eats shrimp. The Arch is blue and eats krill.

Fish in small groups also vary. They swim at depths of 200 feet like the Lup or at 600 feet like the Tin. The Lup is 30 cm, eats shrimp, and is brown. The Tin is 70 cm, eats prawn, and is yellow.

Fish in schools vary along different dimensions. The Bone, for example, is 45 cm and swims at 400 feet. In contrast, the Scale is 70 cm and can be found at 600 feet. The Bone is orange and eats krill, whereas the Scale is white and eats prawn.

Thus, it can be seen that fish which belong to various social groups are quite diverse with respect to size, color, depth and diet.

*Figure 11. Robinson and Schraw informational text passage*

The text shown above is the original 204-word passage from Robinson & Schraw (1994). It contains various facts (and implicit relationships) related to six fictitious species of fish.

Appendix B. Informational text passage for the current study

Fish fall into one of three social groupings: solitary, small, or school. Solitary fish do not socialize with other fish. Examples of solitary fish are the Latuk and the Taroz. Although the Latuk and Taroz are both solitary fish, they differ in several ways. The Latuk swims at depths of 200 feet, whereas the Taroz swims 400 feet below the surface. The Taroz is 60 inches in length; the Latuk is 40 inches. The Latuk is a black color and eats algae. The Taroz is blue and eats shrimp.

Fish in small groups also vary. They swim at depths of 200 feet like the Goken or at 600 feet like the Ponef. The Goken is 40 inches, eats algae, and is brown. The Ponef is 90 inches, eats flounder, and is yellow.

Fish in schools vary along different dimensions. The Kupod, for example, is 60 inches and swims at 400 feet. In contrast, the Somet is 90 inches and can be found at 600 feet. The Kupod is orange and eats shrimp, whereas the Somet is white and eats flounder.

Thus, it can be seen that fish which belong to various social groups are quite diverse with respect to size, color, depth and diet.

*Figure 12. Current informational text passage*

The text passage shown above was used in the study. It is based on Robinson & Schraw (1994) with the following changes:

- The fictitious fish names used by Robinson and Schraw have been replaced. Although the fish species used by Robinson and Schraw were intended to be fictitious, some of the selected names are similar to genuine species of fish (e.g., bonefish and archer fish). To help prevent prior fish species knowledge activation within the participants, the fictitious fish species from the original passage were replaced with two-syllable non-words having relatively low scores on Noble’s (1952) “index of meaning” rating; these two-syllable non-words were originally used in Spears, Motes, & Kealy (2005).
- The units of measure for fish length were converted from centimeters to inches. This was done to make the text passage more suited for participants in the United States, the location of the proposed study. The fish sizes were also increased (but proportions maintained) to make them more authentic as prawn- and shrimp-eating marine fishes.
- Finally, the diet species were changed to match Kiewra et al. (1999). This was done for two reasons: (1) to use species that would be more familiar to participants (e.g.,

"krill" and "prawn" are likely not as familiar to participants as "algae" and "shrimp"); and (2) to use species whose relative sizes would be more apparent to learners, thus providing an opportunity to include another trend in the data.

The differences between the Robinson & Schraw and the current study informational text passages are summarized below.

Table 12.
*Differences between Robinson & Schraw and this study*

| **Robinson & Schraw (1994)** | **Proposed Study** |
|---|---|
| Lup | Goken |
| Hat | Latuk |
| Bone | Kupod |
| Arch | Taroz |
| Tin | Ponef |
| Scale | Somet |
| 30 cm | 40 inches |
| 45 cm | 60 inches |
| 70 cm | 90 inches |
| Shrimp | Algae |
| Krill | Shrimp |
| Prawn | Flounder |

Appendix C. Criterion items used in the study

Table 13.
*Factual judgment-making criterion questions*

| No. | Criterion Question | Choices | Category | Rand. |
|---|---|---|---|---|
| 1 | What color is Latuk? | **Black**/Blue | F1 | 50342 |
| 2 | What color is Taroz? | Yellow/**Blue** | F2 | 68168 |
| 3 | What color is Ponef? | Orange/**Yellow** | F3 | 25126 |
| 4 | At what depth does Goken swim? | **200 ft.** / 400 ft. | F4 | 55104 |
| 5 | At what depth does Kupod swim? | **400 ft.** / 600 ft. | F5 | 39832 |
| 6 | At what depth does Somet swim? | 400 ft. / **600 ft.** | F6 | 15292 |
| 7 | What does Goken eat? | **Algae**/Shrimp | F7 | 40531 |
| 8 | What does Kupod eat? | **Shrimp**/Flounder | F8 | 75265 |
| 9 | What does Somet eat? | Shrimp/**Flounder** | F9 | 58012 |
| 10 | What is Latuk's social grouping? | **Solitary**/Small | F10 | 96817 |
| 11 | What is Goken's social grouping? | **Small**/School | F11 | 2456 |
| 12 | What is Taroz's social grouping? | **Solitary**/Small | F12 | 37706 |
| 13 | What size is Kupod? | **60 in.** / 90 in. | F13 | 41477 |
| 14 | What size is Ponef? | 60 in. / **90 in.** | F14 | 99589 |
| 15 | What size is Somet? | 60 in. / **90 in.** | F15 | 40643 |

(Correct answers shown in **bold** typeface.)

Table 14.
*Comparative judgment-making criterion questions*

| No. | Criterion Question | Choices | Category | Rand. |
|---|---|---|---|---|
| 16 | Which is darker in color? | **Goken**/Kupod | C1 | 83151 |
| 17 | Which is darker in color? | **Latuk**/Ponef | C2 | 58130 |
| 18 | Which is lighter in color? | Kupod/**Somet** | C3 | 98289 |
| 19 | Which swims at a lesser depth? | **Goken**/Somet | C4 | 54411 |
| 20 | Which swims at a greater depth? | Goken/**Taroz** | C5 | 84632 |
| 21 | Which swims at a greater depth? | Latuk/**Ponef** | C6 | 43946 |
| 22 | Which feeds more on shrimp? | Kupod/**Latuk** | C7 | 90245 |
| 23 | Which feeds more on algae? | **Goken/**Ponef | C8 | 13472 |
| 24 | Which feeds more on flounder? | Taroz/**Somet** | C9 | 77150 |
| 25 | Which forms into smaller groups? | **Latuk**/Somet | C10 | 78137 |
| 26 | Which forms into larger groups? | Ponef/**Kupod** | C11 | 20603 |
| 27 | Which forms into larger groups? | **Somet**/Goken | C12 | 96843 |
| 28 | Which is smaller in size? | Taroz/**Goken** | C13 | 37616 |
| 29 | Which is smaller in size? | Ponef/**Latuk** | C14 | 54016 |
| 30 | Which is larger in size? | **Somet**/Kupod | C15 | 82674 |

(Correct answers shown in **bold** typeface.)

Table 15.
*Inferential judgment-making criterion questions*

| No. | Criterion Question | Choices | Category | Rand. |
|---|---|---|---|---|
| 31 | Lighter-colored fish tend to swim at a _____ depth. | lesser/**greater** | I1 | 97755 |
| 32 | Darker-colored fish tend to be _____ in size. | **smaller**/larger | I2 | 6676 |
| 33 | Darker-colored fish tend to form _____ groups. | **smaller**/larger | I3 | 85457 |
| 34 | Lesser-depth fish tend to form _____ groups. | **smaller**/larger | I4 | 88738 |
| 35 | Greater-depth fish tend to be _____ colored. | **lighter**/darker | I5 | 77191 |
| 36 | Lesser-depth fish tend to be _____ in size. | **smaller**/larger | I6 | 97780 |
| 37 | Algae-eating fish tend to swim at a _____ depth. | **lesser**/greater | I7 | 11846 |
| 38 | Algae-eating fish tend to be _____ colored. | lighter/**darker** | I8 | 75910 |
| 39 | Flounder-eating fish tend to swim at a _____ depth. | lesser/**greater** | I9 | 87073 |
| 40 | Smaller groupings of fish tend to be _____ colored. | lighter/**darker** | I10 | 81172 |
| 41 | Smaller groupings of fish tend to be _____ in size. | **smaller**/larger | I11 | 10014 |
| 42 | Larger groupings of fish tend to be _____ colored. | **lighter**/darker | I12 | 17081 |
| 43 | Smaller-sized fish tend to be _____ colored. | lighter/**darker** | I13 | 38192 |
| 44 | Smaller-sized fish tend to form _____ groups. | **smaller**/larger | I14 | 33438 |
| 45 | Larger-sized fish tend to be _____ colored. | **lighter**/darker | I15 | 75589 |

Correct answers shown in **bold** typeface.)

Table 16.
*Aggregate criterion questions after having random sequence applied*

| No. | Criterion Question | Choices | Category | Rand. |
|---|---|---|---|---|
| 11 | What is Goken's social grouping? | **Small**/School | F11 | 2456 |
| 32 | Darker-colored fish tend to be _____ in size. | **smaller**/larger | I2 | 6676 |
| 41 | Smaller groupings of fish tend to be _____ in size. | **smaller**/larger | I11 | 10014 |
| 37 | Algae-eating fish tend to swim at a _____ depth. | **lesser**/greater | I7 | 11846 |
| 23 | Which feeds more on algae? | **Goken/**Ponef | C8 | 13472 |
| 6 | At what depth does Somet swim? | 400 ft. / **600 ft.** | F6 | 15292 |
| 42 | Larger groupings of fish tend to be _____ colored. | **lighter**/darker | I12 | 17081 |
| 26 | Which forms into larger groups? | Ponef/**Kupod** | C11 | 20603 |
| 3 | What color is Ponef? | Orange/**Yellow** | F3 | 25126 |
| 44 | Smaller-sized fish tend to form _____ groups. | **smaller**/larger | I14 | 33438 |
| 28 | Which is smaller in size? | Taroz/**Goken** | C13 | 37616 |
| 12 | What is Taroz's social grouping? | **Solitary**/Small | F12 | 37706 |
| 43 | Smaller-sized fish tend to be _____ colored. | lighter/**darker** | I13 | 38192 |
| 5 | At what depth does Kupod swim? | **400 ft.** / 600 ft. | F5 | 39832 |
| 7 | What does Goken eat? | **Algae**/Shrimp | F7 | 40531 |
| 15 | What size is Somet? | 60 in. / **90 in.** | F15 | 40643 |
| 13 | What size is Kupod? | **60 in.** / 90 in. | F13 | 41477 |
| 21 | Which swims at a greater depth? | Latuk/**Ponef** | C6 | 43946 |
| 1 | What color is Latuk? | **Black**/Blue | F1 | 50342 |
| 29 | Which is smaller in size? | Ponef/**Latuk** | C14 | 54016 |
| 19 | Which swims at a lesser depth? | **Goken**/Somet | C4 | 54411 |
| 4 | At what depth does Goken swim? | **200 ft.** / 400 ft. | F4 | 55104 |
| 9 | What does Somet eat? | Shrimp/**Flounder** | F9 | 58012 |
| 17 | Which is darker in color? | **Latuk**/Ponef | C2 | 58130 |
| 2 | What color is Taroz? | Yellow/**Blue** | F2 | 68168 |
| 8 | What does Kupod eat? | **Shrimp**/Flounder | F8 | 75265 |
| 45 | Larger-sized fish tend to be _____ colored. | **lighter**/darker | I15 | 75589 |
| 38 | Algae-eating fish tend to be _____ colored. | lighter/**darker** | I8 | 75910 |
| 24 | Which feeds more on flounder? | Taroz/**Somet** | C9 | 77150 |
| 35 | Greater-depth fish tend to be _____ colored. | **lighter**/darker | I5 | 77191 |
| 25 | Which forms into smaller groups? | **Latuk**/Somet | C10 | 78137 |
| 40 | Smaller groupings of fish tend to be _____ colored. | lighter/**darker** | I10 | 81172 |
| 30 | Which is larger in size? | **Somet**/Kupod | C15 | 82674 |
| 16 | Which is darker in color? | **Goken**/Kupod | C1 | 83151 |
| 20 | Which swims at a greater depth? | Goken/**Taroz** | C5 | 84632 |
| 33 | Darker-colored fish tend to form _____ groups. | **smaller**/larger | I3 | 85457 |
| 39 | Flounder-eating fish tend to swim at a _____ depth. | lesser/**greater** | I9 | 87073 |
| 34 | Lesser-depth fish tend to form _____ groups. | **smaller**/larger | I4 | 88738 |
| 22 | Which feeds more on shrimp? | Kupod/**Latuk** | C7 | 90245 |
| 10 | What is Latuk's social grouping? | **Solitary**/Small | F10 | 96817 |
| 27 | Which forms into larger groups? | **Somet**/Goken | C12 | 96843 |
| 31 | Lighter-colored fish tend to swim at a _____ depth. | lesser/**greater** | I1 | 97755 |
| 36 | Lesser-depth fish tend to be _____ in size. | **smaller**/larger | I6 | 97780 |
| 18 | Which is lighter in color? | Kupod/**Somet** | C3 | 98289 |
| 14 | What size is Ponef? | 60 in. / **90 in.** | F14 | 99589 |

Correct answers shown in **bold** typeface.)

Appendix D.  Research instrument screen capture images

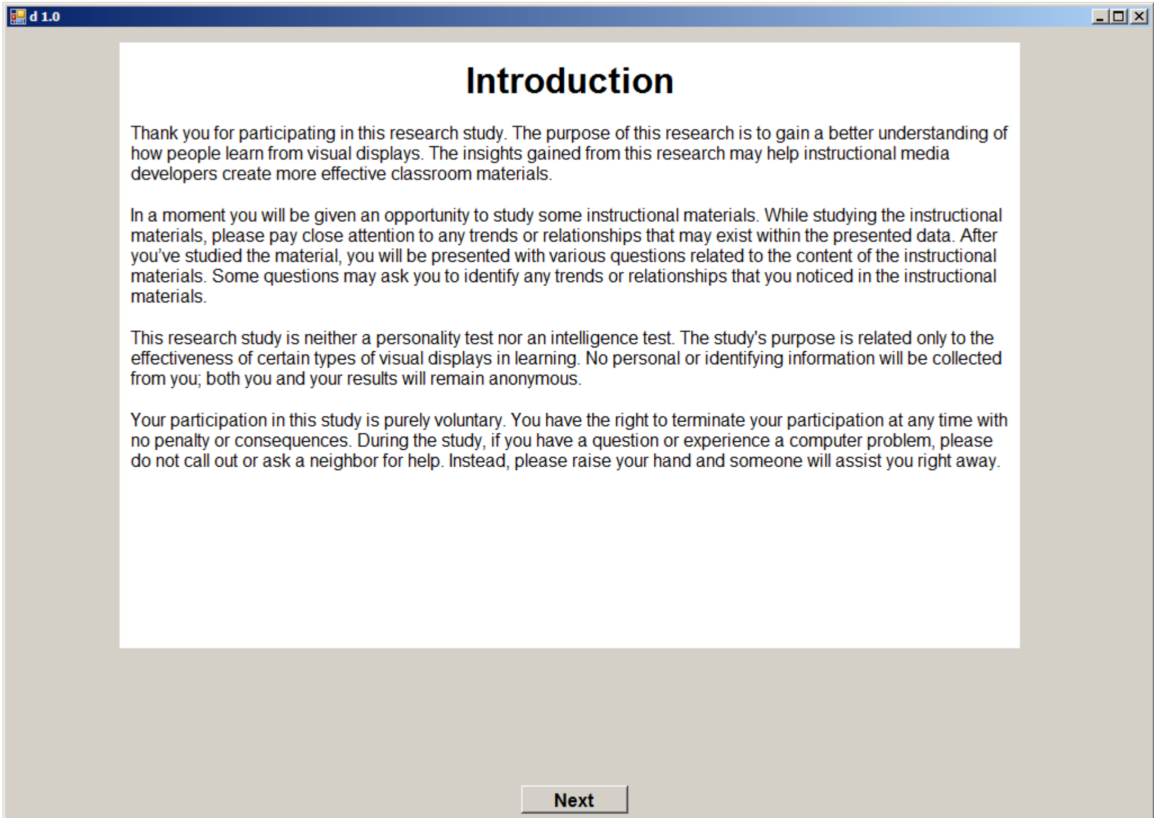



*Figure 13. Opening screen*

This screen welcomes the participant to the study, provides a preview of the task (looking for trends in instructional materials), and finally reminds each participant of his or her rights as a volunteer research participant.

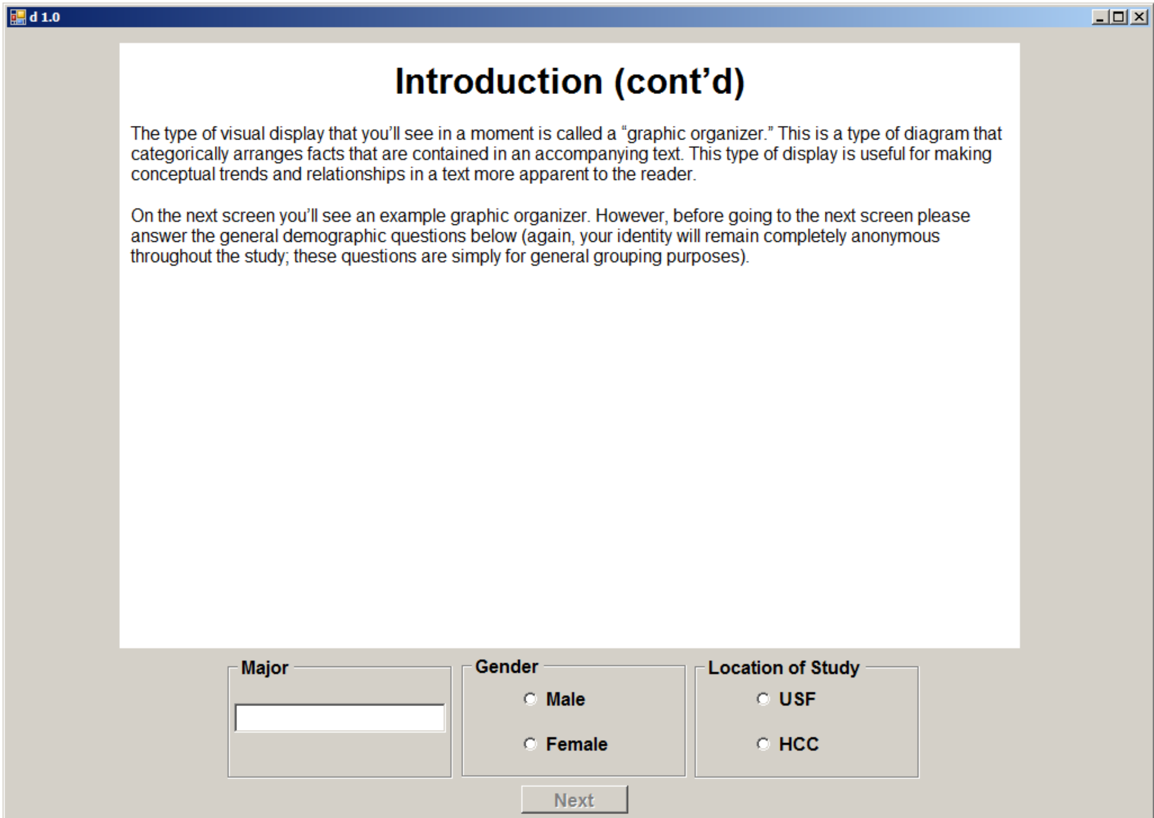



*Figure 14. Second introduction screen*

This screen introduces the concept of a graphic organizer. It also collects some basic demographic information (major, gender, institution) from each participant.

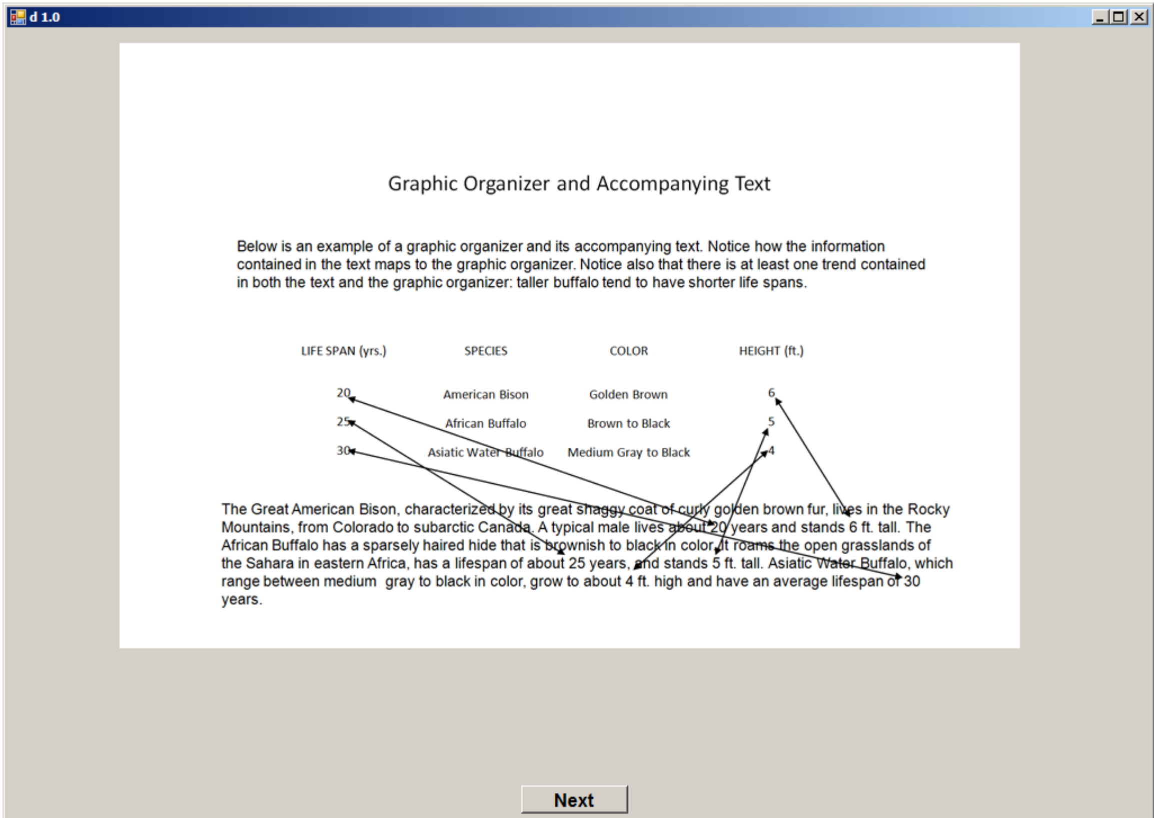



*Figure 15. Third introduction screen*

This screen provides an overview of graphic organizers and shows how a linkage often exists between a graphic organizer and the text it accompanies.

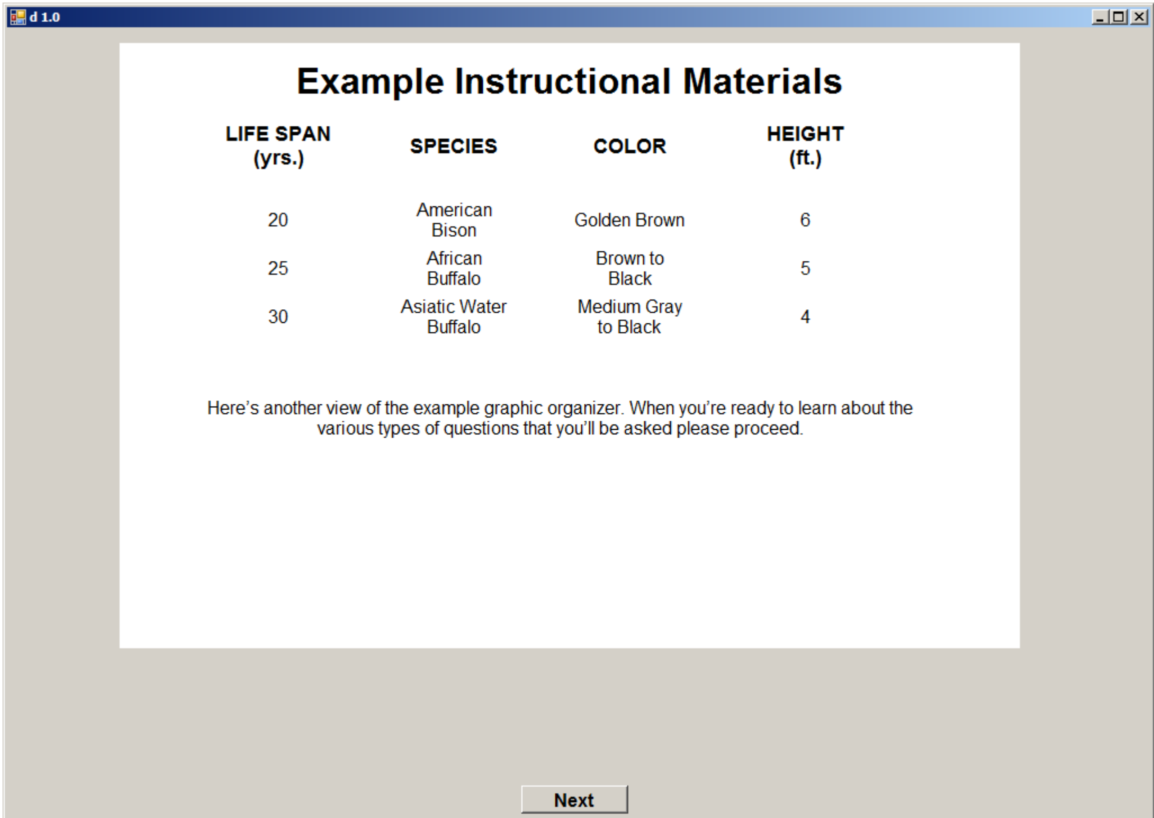



*Figure 16. Example static graphic organizer*

This screen lets the participant see an example graphic organizer. It is a treatment-specific screen, i.e., the type of example graphic organizer displayed matches the type that will be presented later in the study. In the image above, an example static graphic organizer is shown.

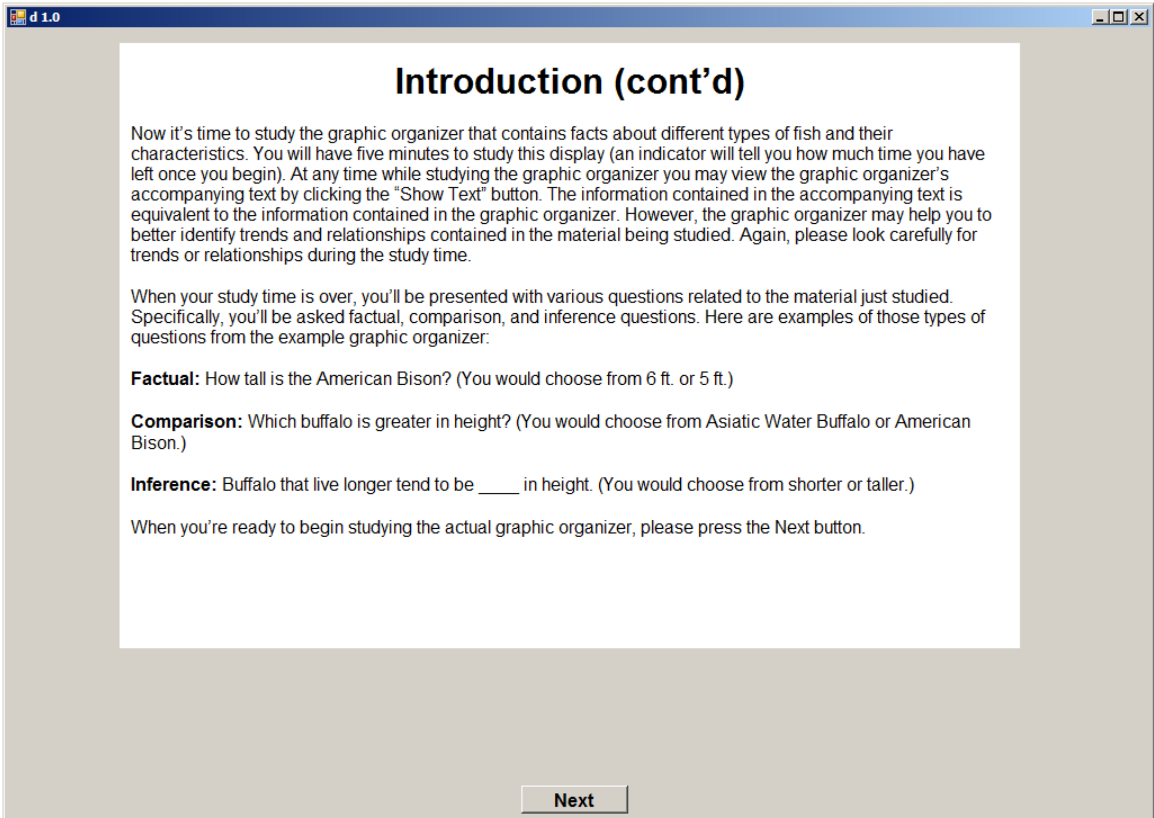
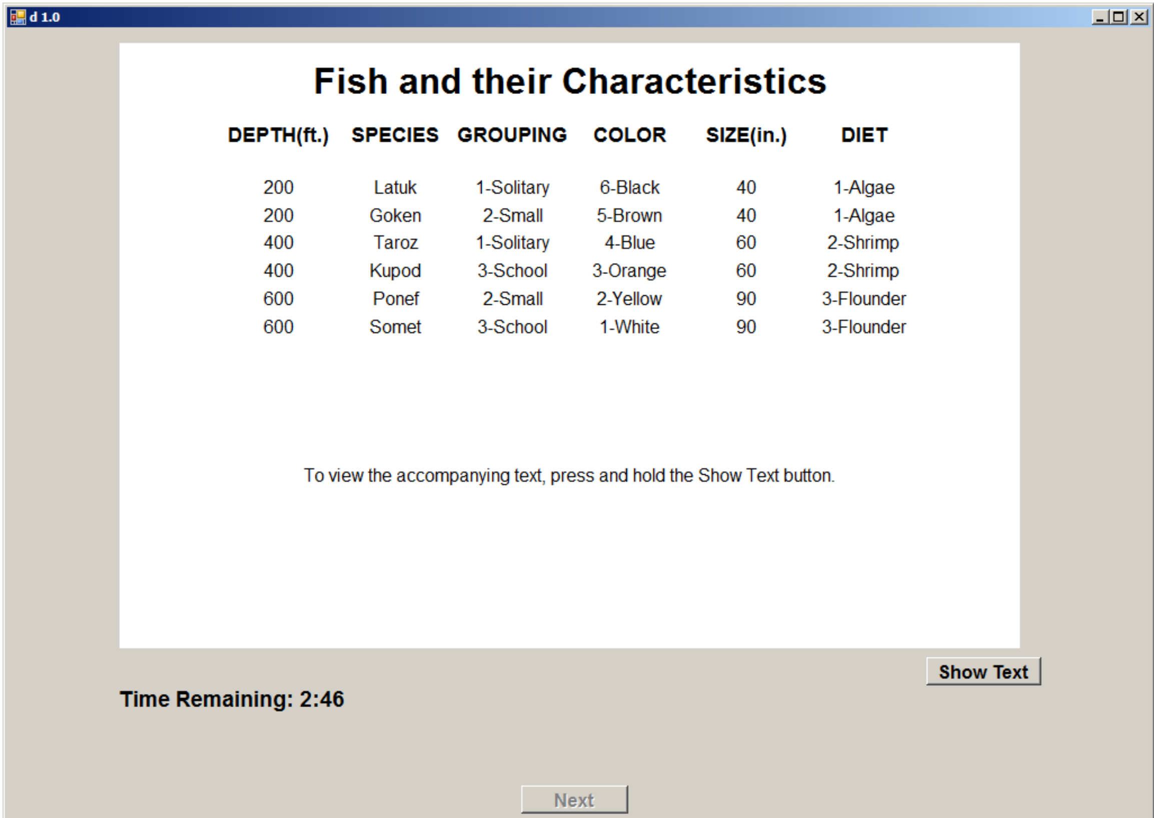



*Figure 17. Example questions*

This screen introduces the participant to the three types of questions that he or she will be asked to answer.




| DEPTH(ft.) | SPECIES | GROUPING | COLOR | SIZE(in.) | DIET |
|---|---|---|---|---|---|
| 200 | Latuk | 1-Solitary | 6-Black | 40 | 1-Algae |
| 200 | Goken | 2-Small | 5-Brown | 40 | 1-Algae |
| 400 | Taroz | 1-Solitary | 4-Blue | 60 | 2-Shrimp |
| 400 | Kupod | 3-School | 3-Orange | 60 | 2-Shrimp |
| 600 | Ponef | 2-Small | 2-Yellow | 90 | 3-Flounder |
| 600 | Somet | 3-School | 1-White | 90 | 3-Flounder |

*Figure 18. Static treatment graphic organizer*

This is the static graphic organizer presented to participants in that treatment group. Note the countdown timer that lets participants know how much time remains of the five-minute study period. Also note the "Show Text" button—this button, when clicked with the mouse, displays the text passage that accompanies the graphic organizer. The text passage remains displayed as long as the participant keeps the mouse button pressed.

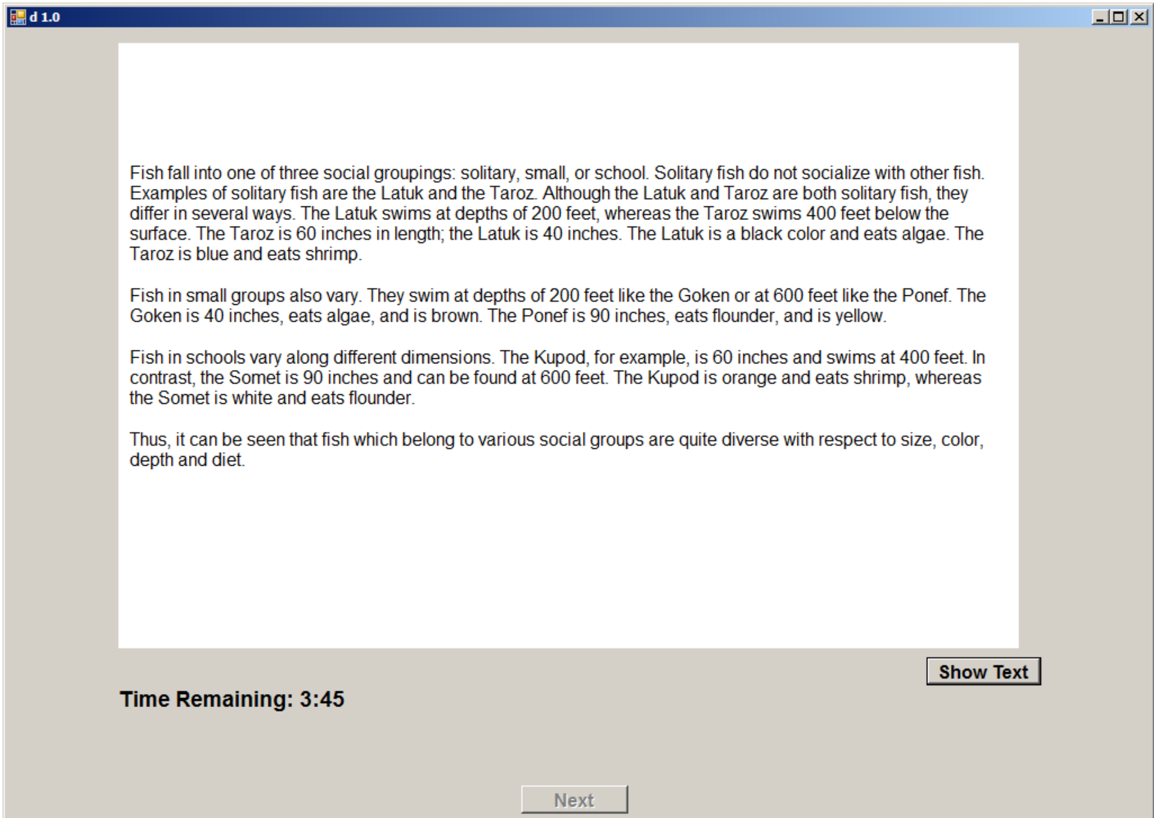



*Figure 19. Accompanying text passage*

This is the text passage that accompanies the graphic organizer. The text passage above is displayed only when a participant clicks (and holds) the “Show Text” button. The text passage is not treatment-specific, i.e., each group’s participants will see the screen above when the “Show Text” button is clicked and held. Participants who choose not to click the “Show Text” button will not see the above text passage.

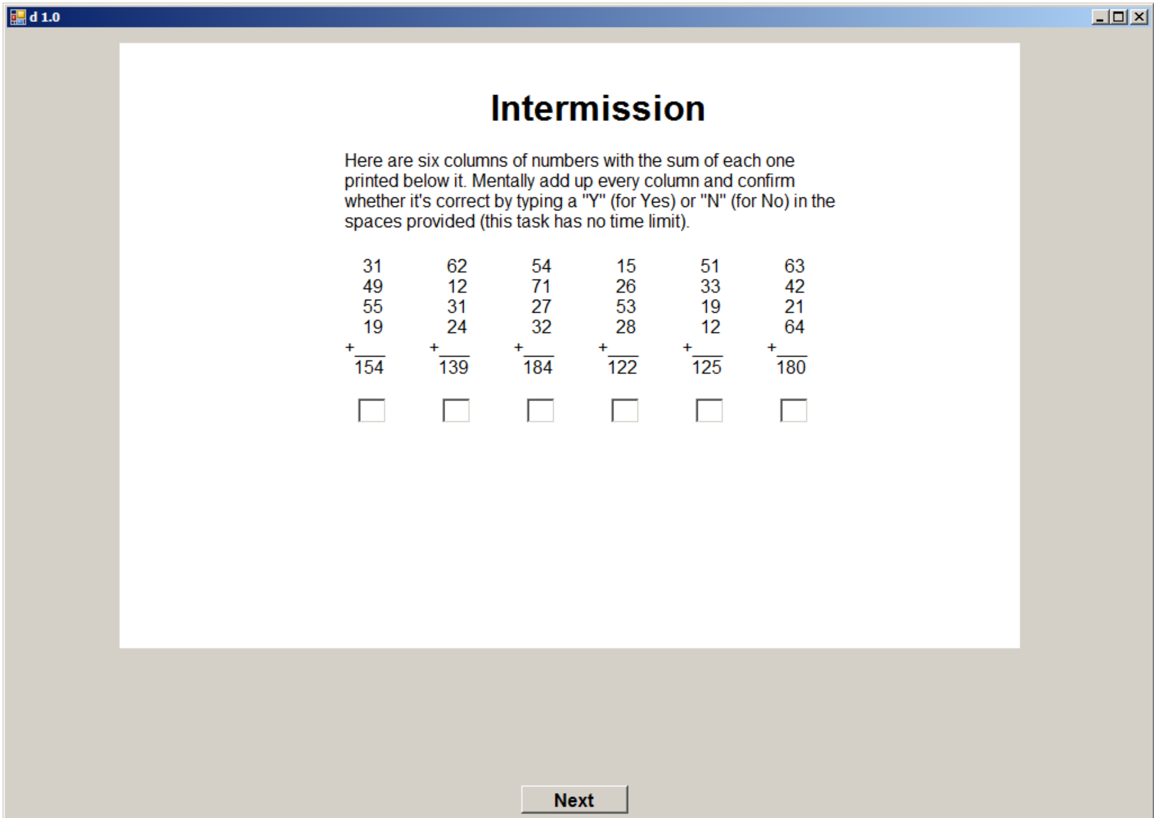



*Figure 20. Interpolated memory task screen*

Participants perform the above arithmetic task to accomplish the experiment's goal of preventing rehearsal of the previously studied graphic organizer information, thus clearing short-term memory.

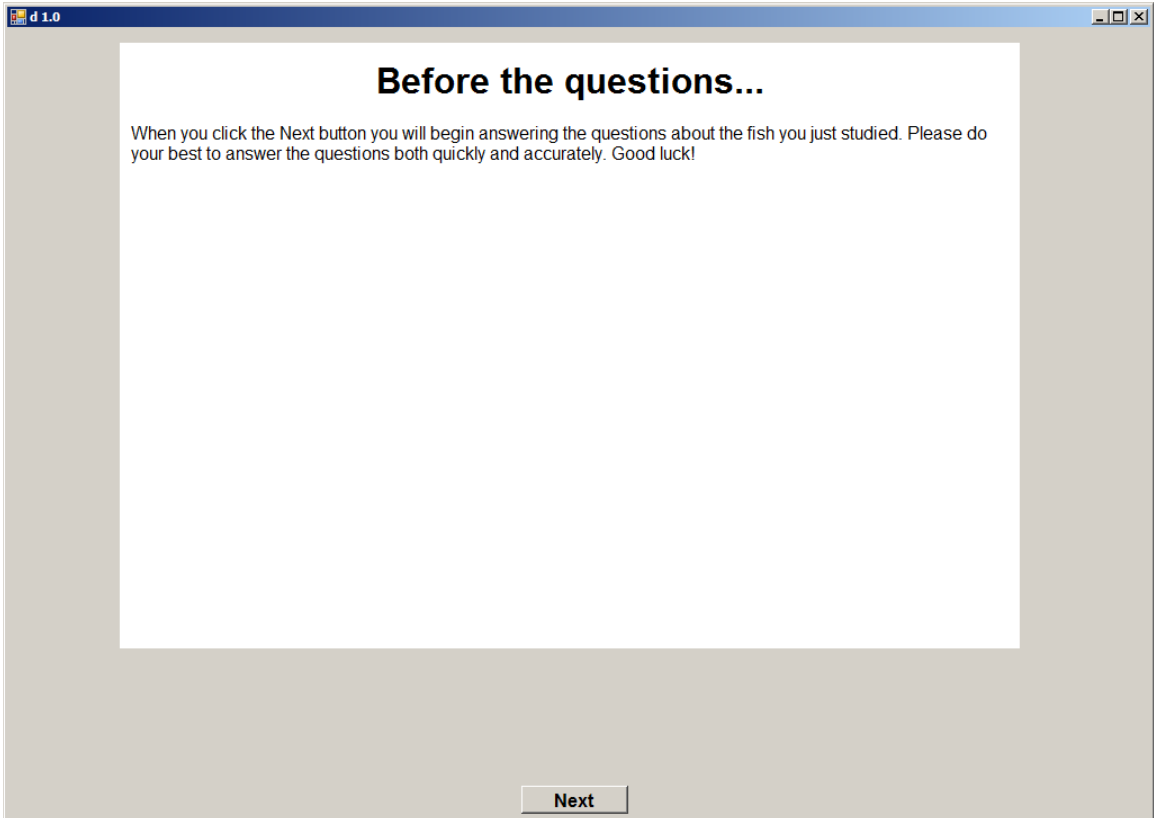



*Figure 21.* *Separator screen before criterion questions*

The above screen serves as a separator between the study portion of the study and the criterion question portion of the study. It also provides participants with task expectancy information by telling them what is about to occur. Finally, it asks participants to answer the upcoming questions both quickly and accurately.

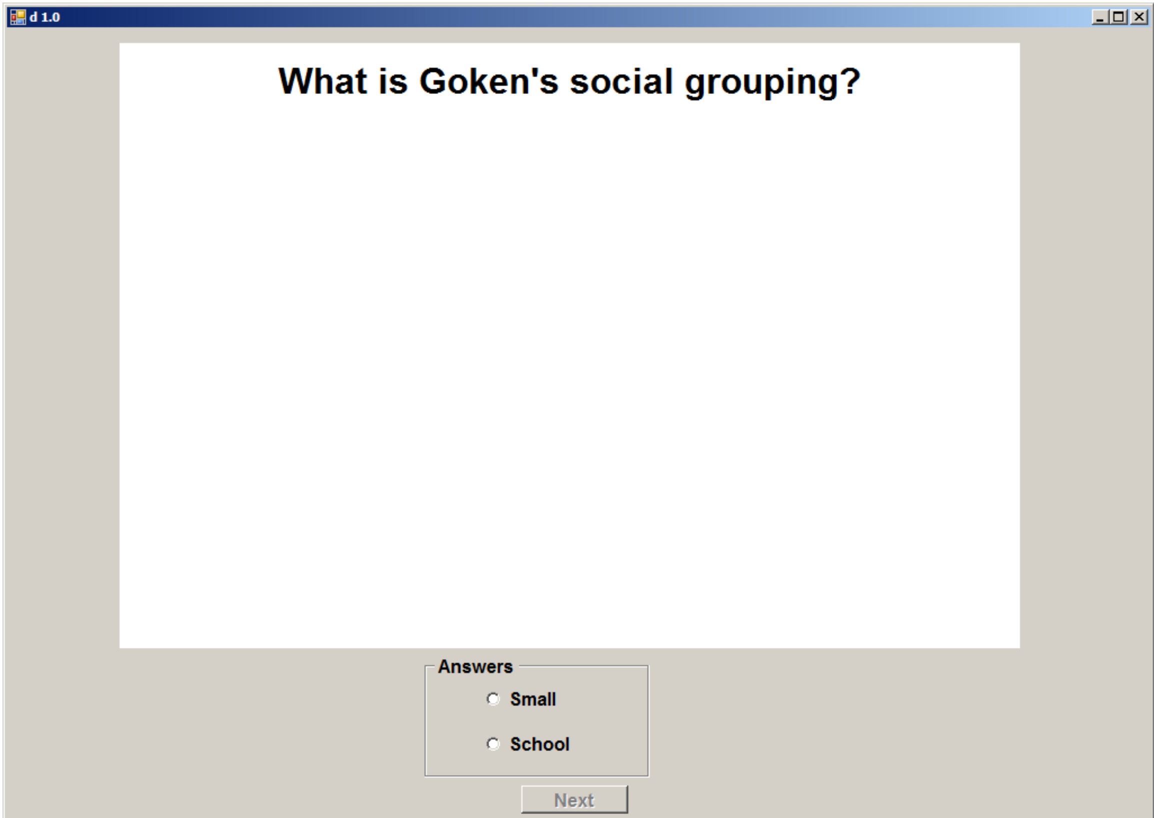



*Figure 22. Example factual criterion question*

This image shows one of the fifteen factual criterion questions. A total of 45 criterion questions (3 factual, 3 comparative, and 3 inferential) were presented to each participant using one predefined random sequence.

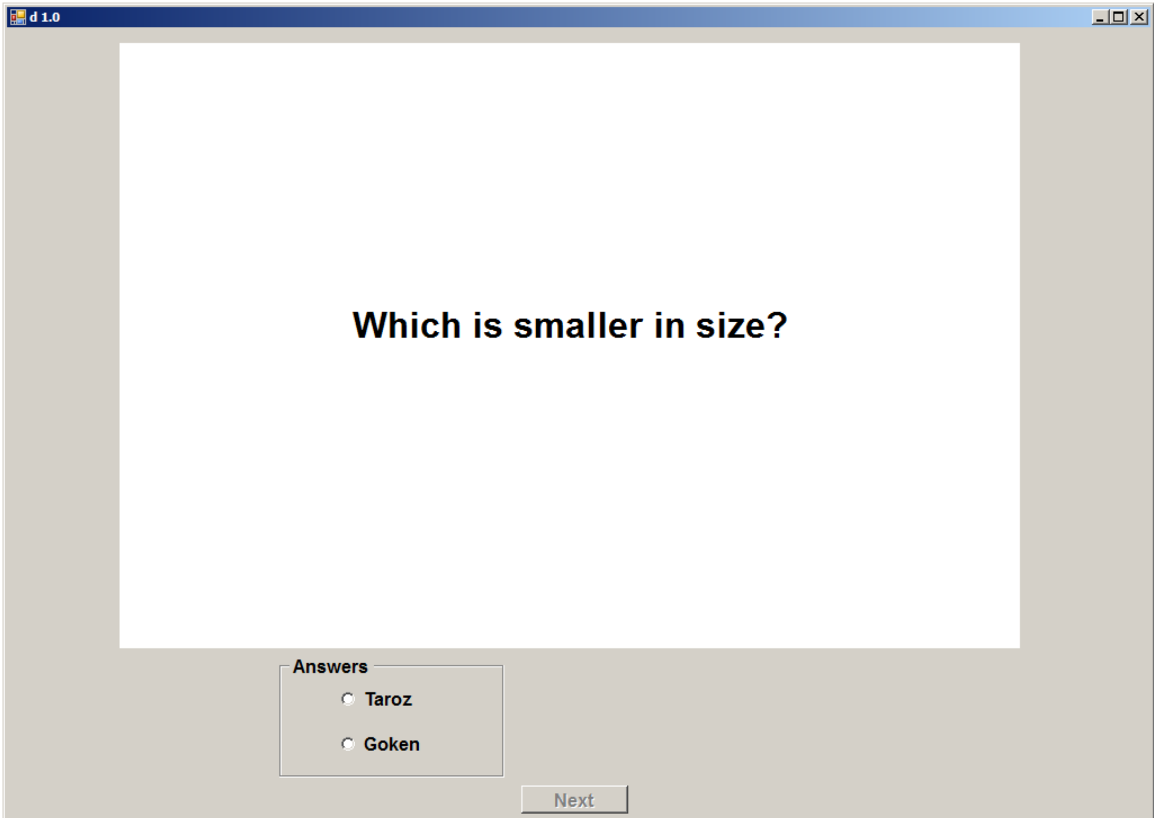



*Figure 23. Example comparative criterion question*

This image shows one of the fifteen comparative criterion questions. A total of 45 criterion questions (3 factual, 3 comparative, and 3 inferential) were presented to each participant using one predefined random sequence.

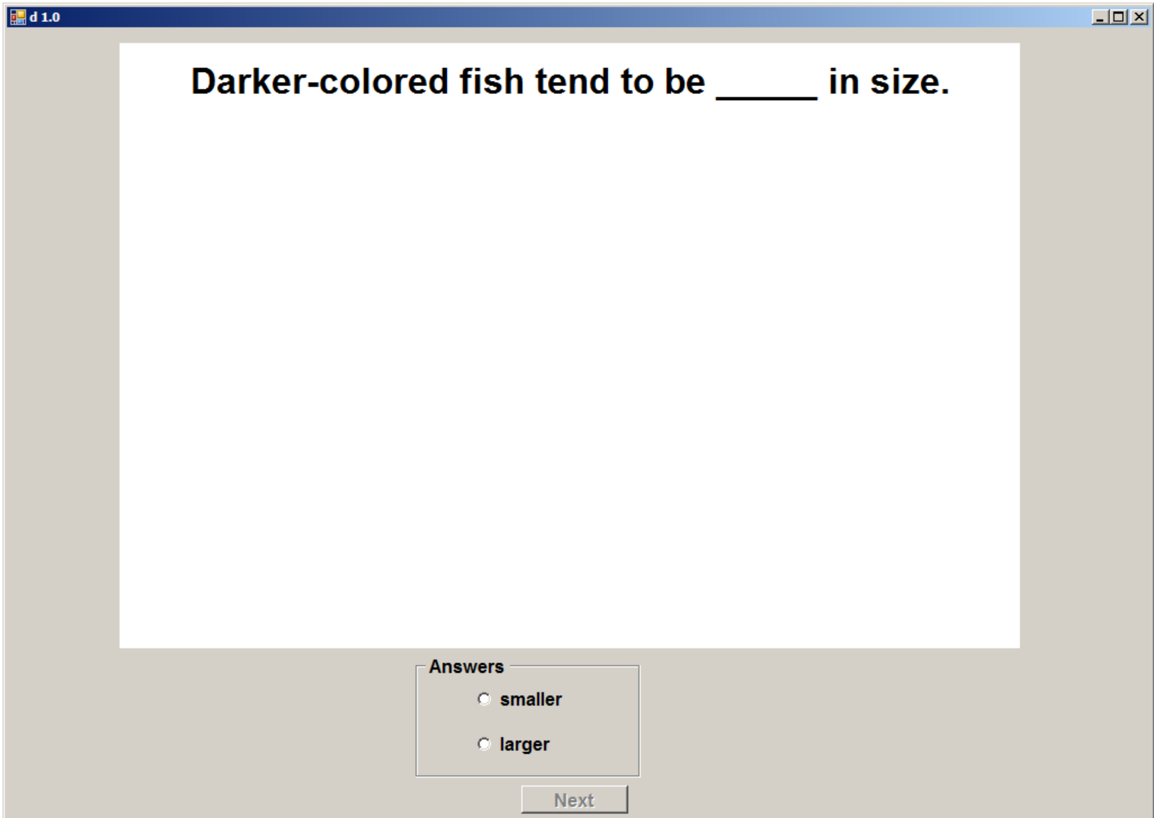



*Figure 24. Example inferential criterion question*

This image shows one of the fifteen inferential criterion questions. A total of 45 criterion questions (3 factual, 3 comparative, and 3 inferential) were presented to each participant using one predefined random sequence.

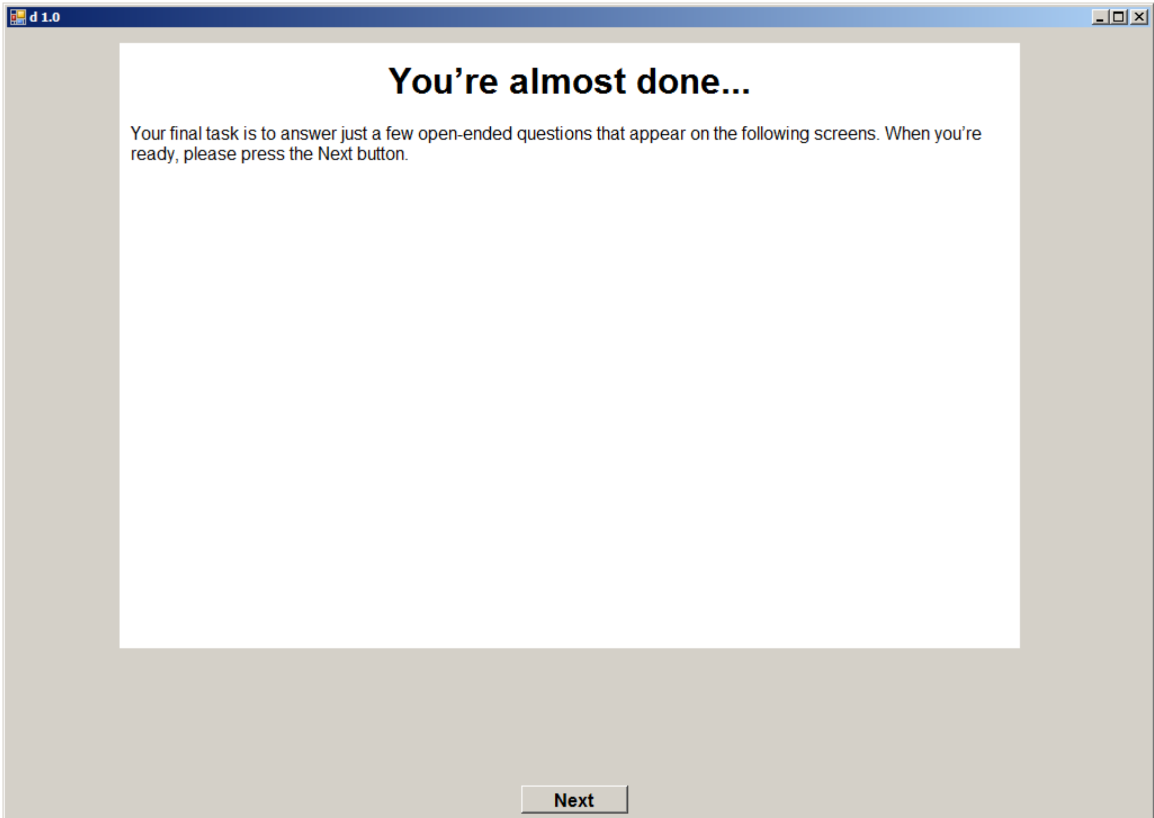



*Figure 25. Separator screen before follow-up questions*

The above screen serves as a separator between the criterion question portion of the study and the ancillary question portion of the study. It also provides participants with task expectancy information by telling them what is about to occur.

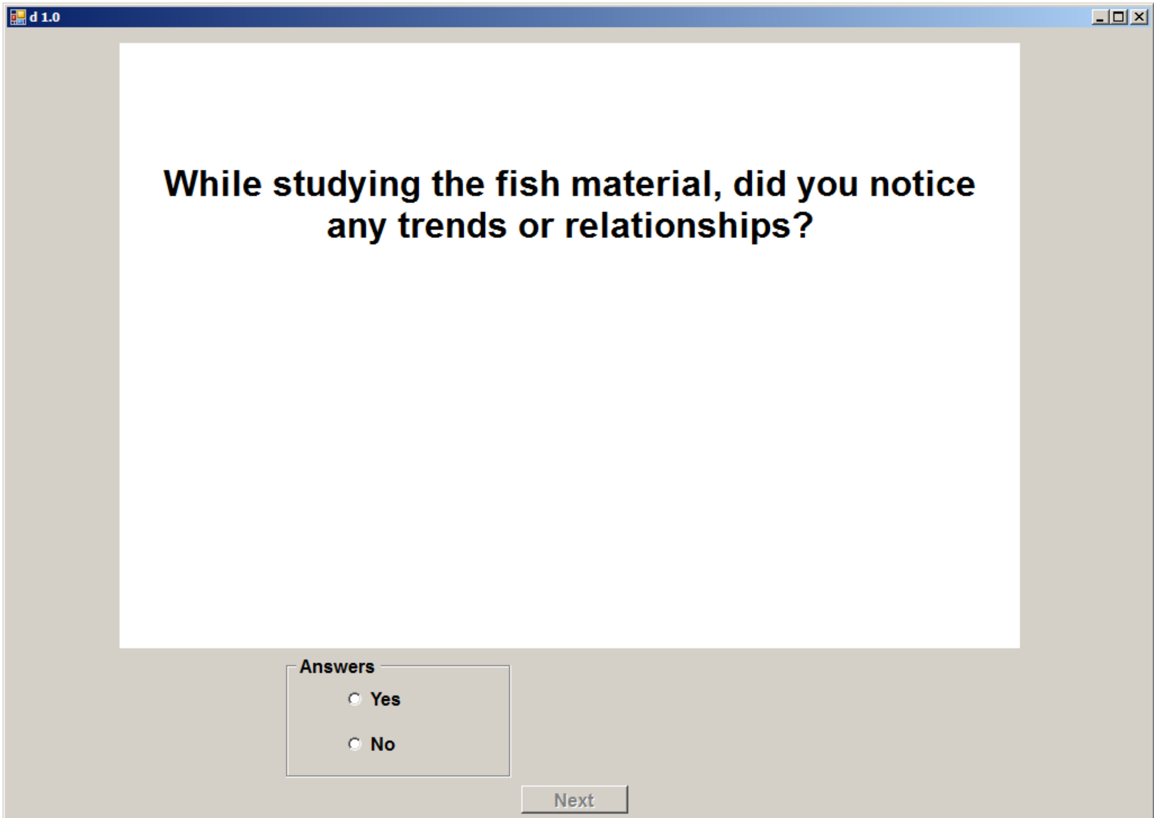



*Figure 26. Trends or relationships question*

This screen allowed the participant to self-report his or her perception of whether any trends or relationships had been noticed during the study.

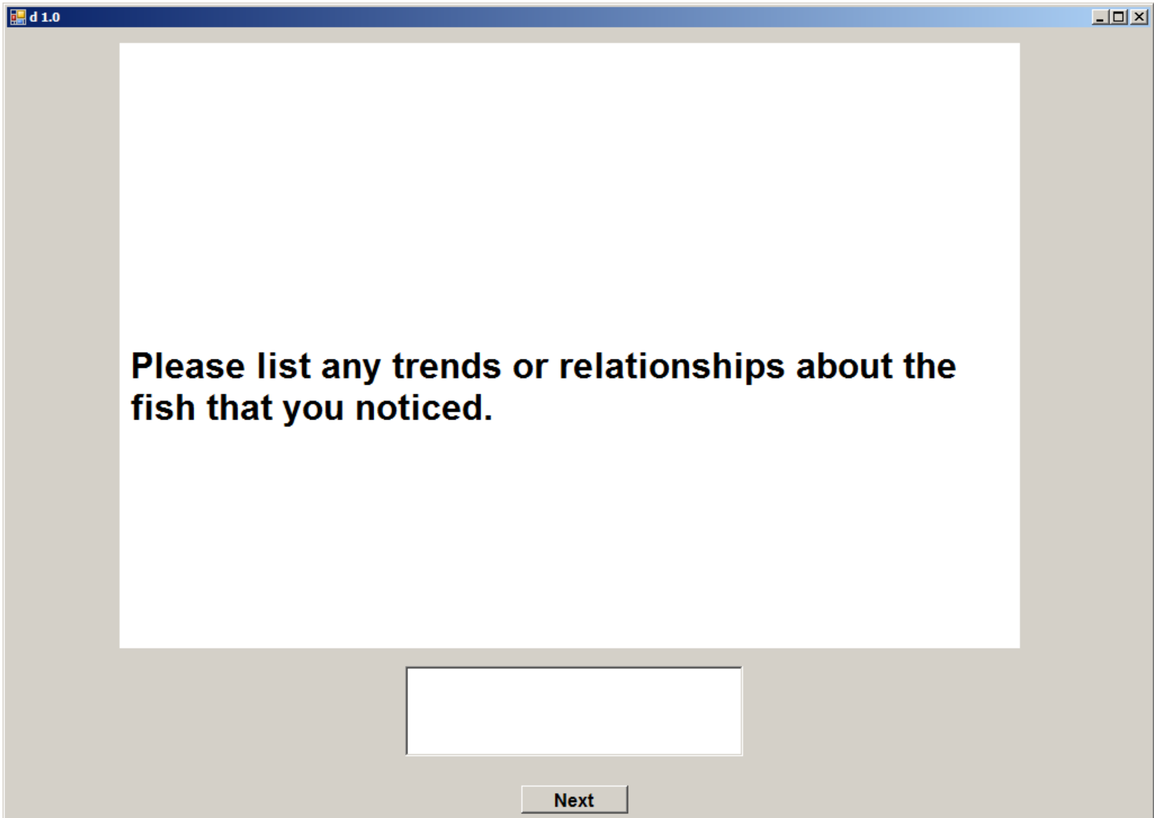



*Figure 27. Trends or relationships list*

This screen allowed the participant to list any trends or relationships noticed during the study.

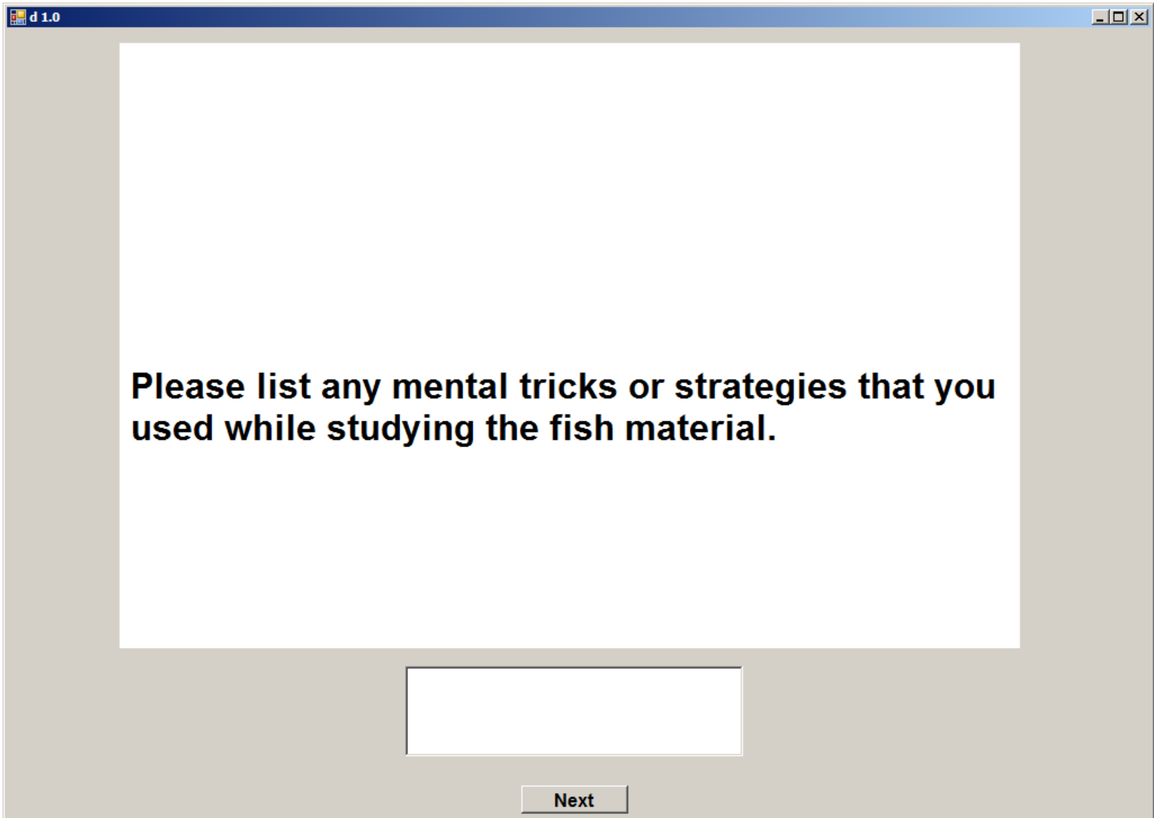



*Figure 28. Mental tricks question*

This screen allowed the participant to list any mental tricks or strategies used during the study.

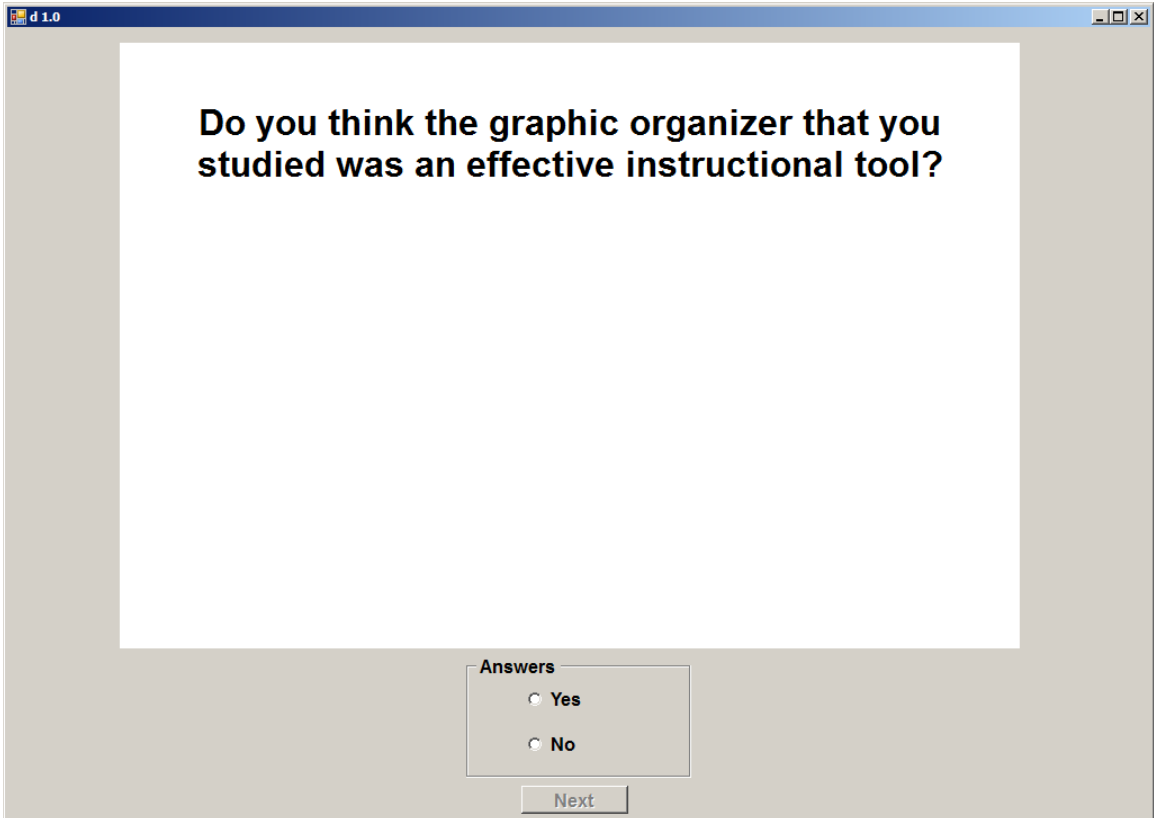



*Figure 29. Usefulness of graphic organizer question*

This screen allowed the participant to provide his or her opinion on the usefulness of the graphic organizer as an instructional tool.

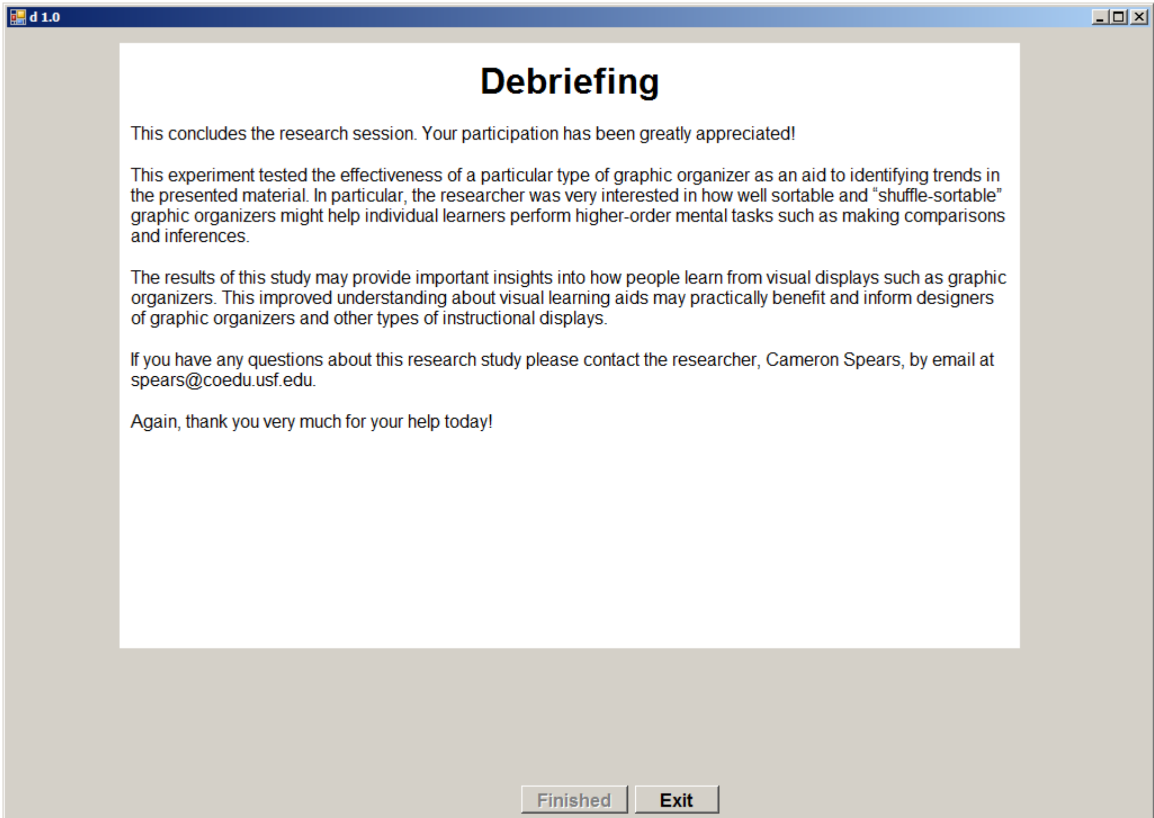



*Figure 30. Debriefing*

This screen provided the participant with overview information related to the purpose of the study (information that could not be disclosed at the beginning of the study). It also thanks the participant and provides the researcher's contact information.

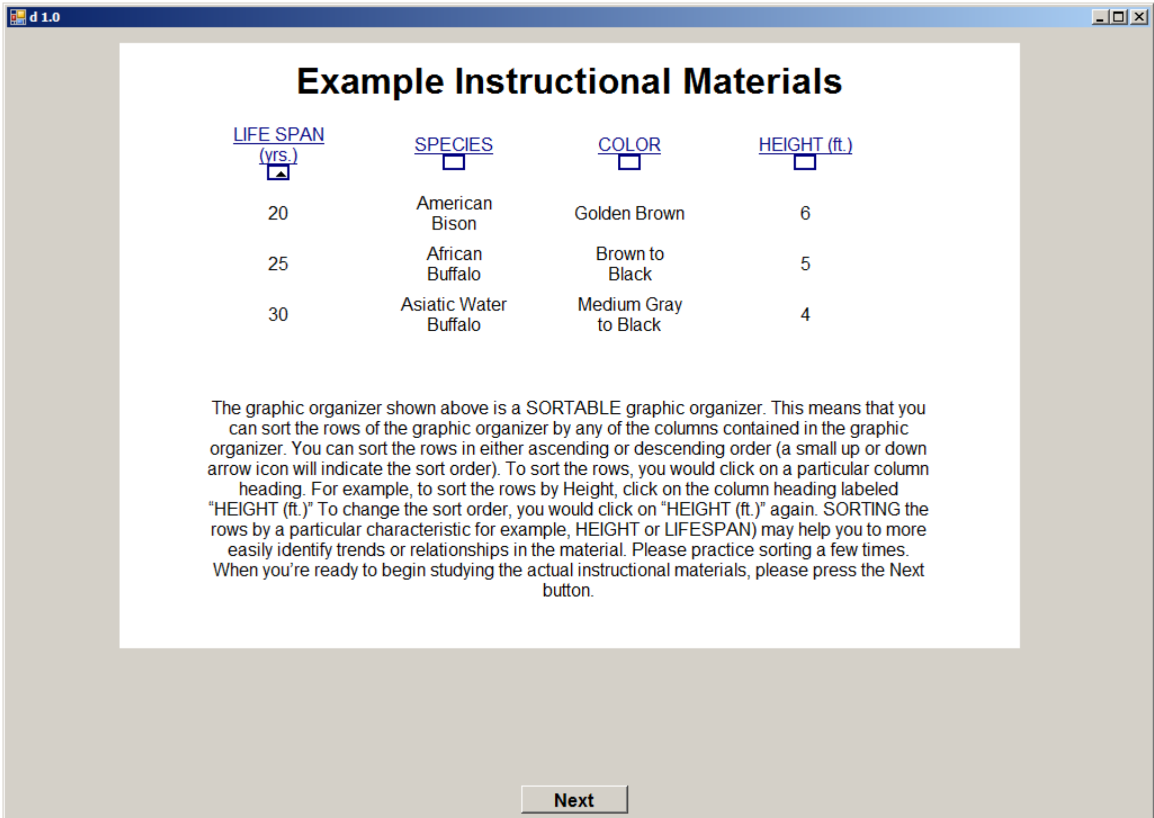



*Figure 31. Example sortable graphic organizer*

This is an example sortable graphic organizer presented to participants in that treatment group. This graphic organizer contains controls for sorting rows in the graphic organizer. Each of the small rectangles can contain an arrow symbol (as shown above) to indicate the most recently sorted column. Participants were given instructions on the use of these controls as part of the onscreen text. Participants were also encouraged to practice the use of these controls.

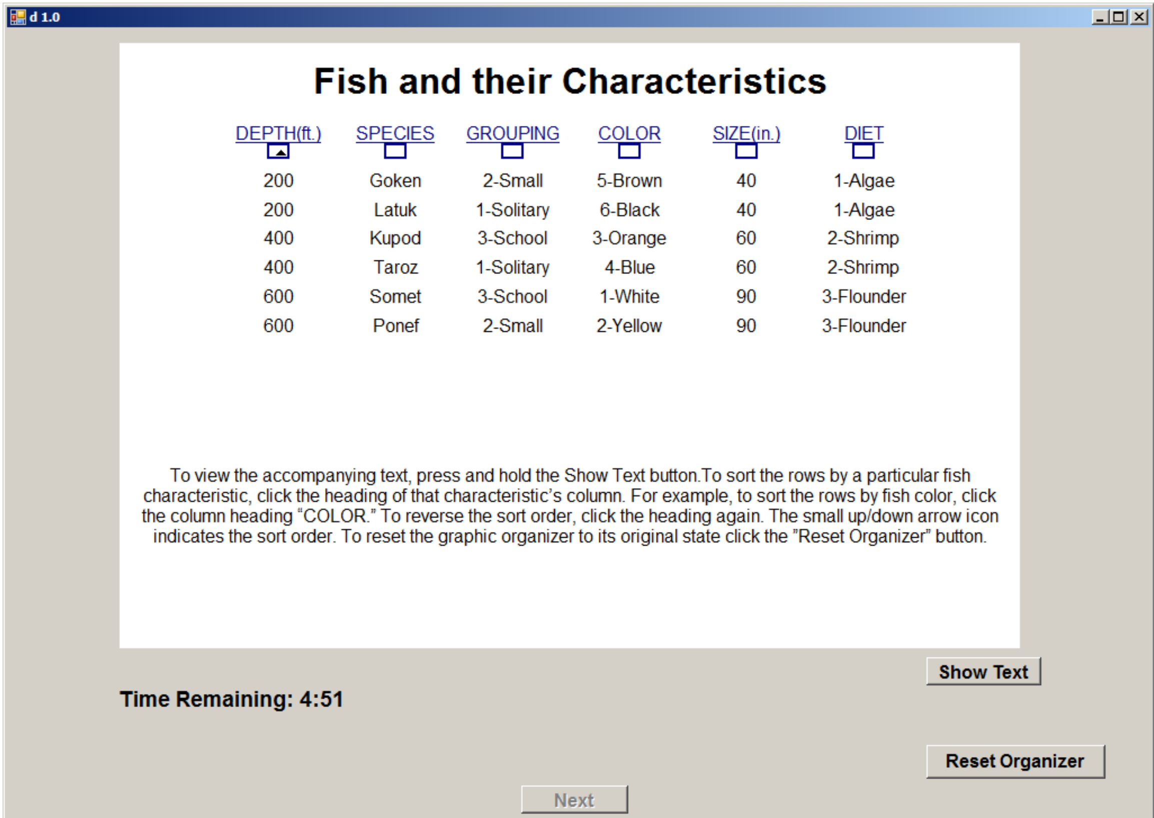



*Figure 32. Sortable graphic organizer*

This is the sortable graphic organizer presented to participants in that treatment group. Note the countdown timer that lets participants know how much time remains of the five-minute study period. Also note the “Show Text” button—this button, when clicked, displays the text passage that accompanies the graphic organizer. The text passage remains displayed as long as the participant keeps the mouse button pressed. A “Reset Organizer” button was also provided, such that a participant could restore the graphic organizer to its original state if desired.

This graphic organizer also contains controls for sorting graphic organizer. Each of the small rectangles can contain an arrow symbol (as shown above) to indicate the most recently sorted column. Participants were given instructions on the use of these controls. Participants were also encouraged to practice the use of these controls.

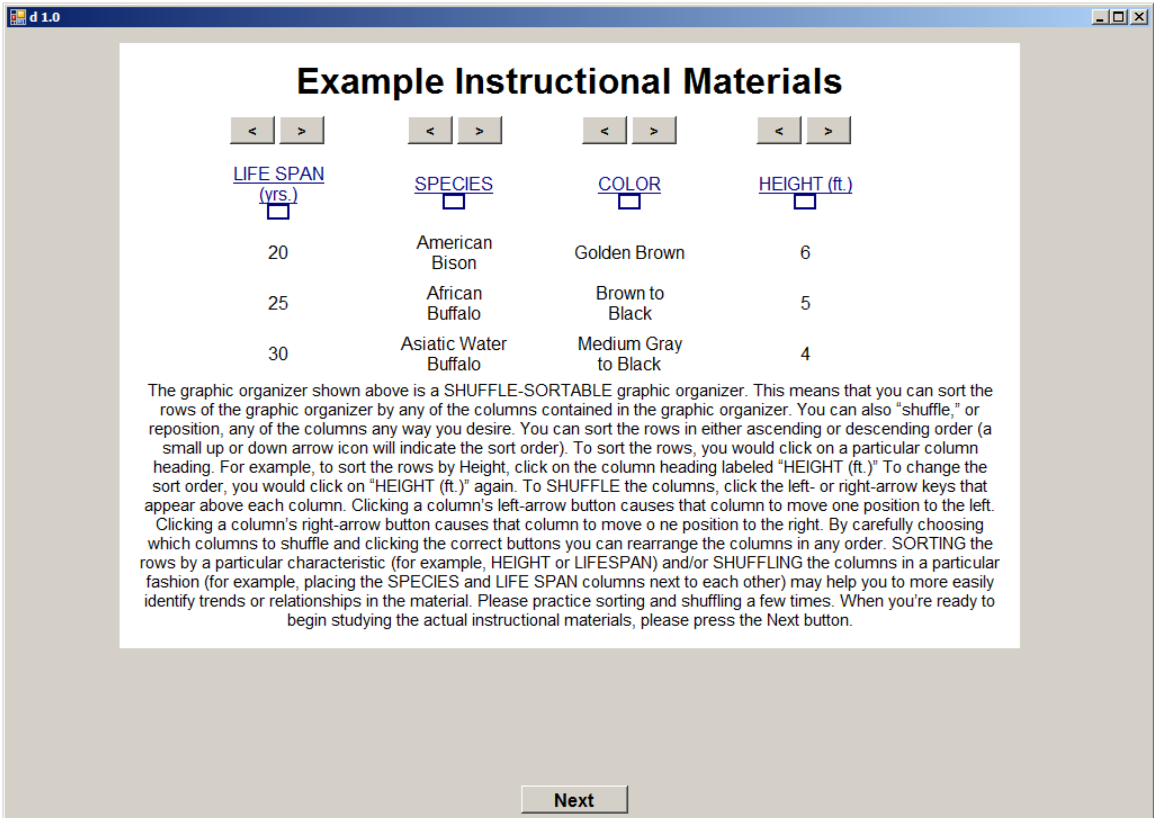



*Figure 33. Example shuffle-sortable graphic organizer*

This is an example shuffle-sortable graphic organizer presented to participants in that treatment group. This graphic organizer contains controls for sorting or "shuffling" rows and columns respectively in the graphic organizer. Participants were given instructions on the use of these controls as part of the onscreen text. Participants were also encouraged to practice the use of these controls.

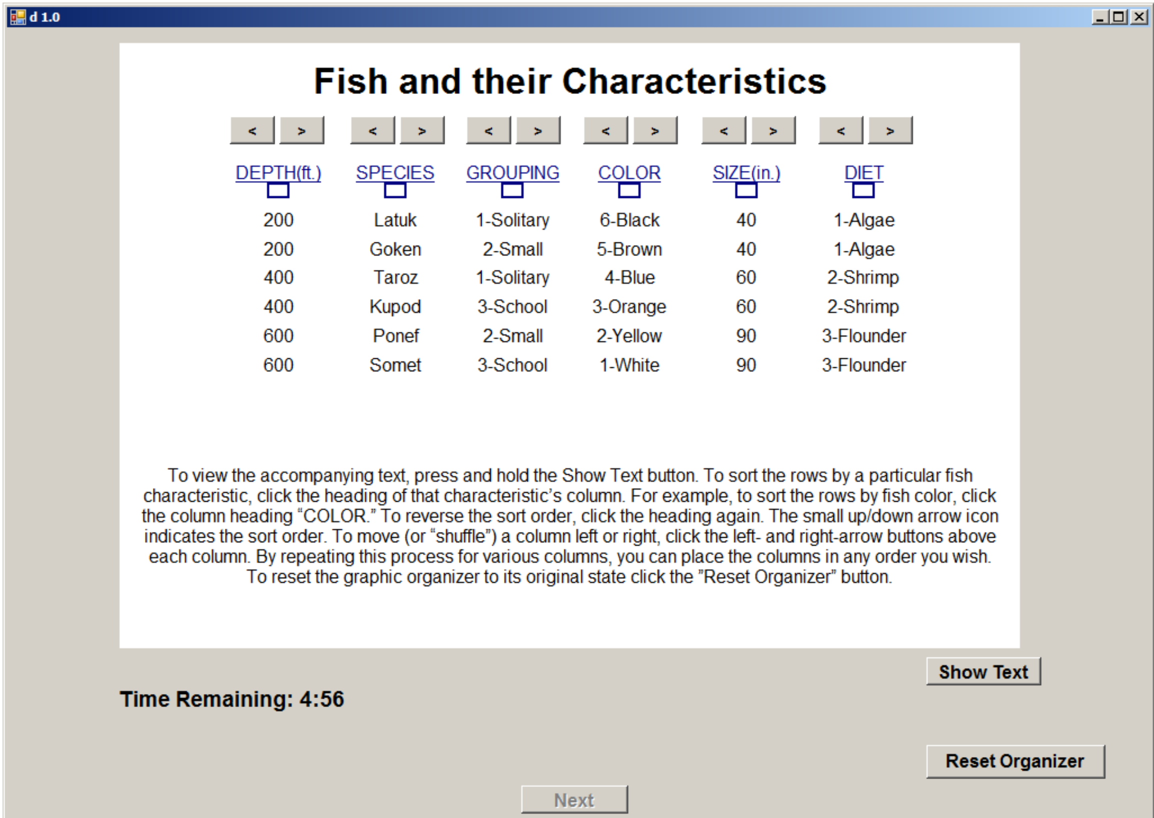



*Figure 34. Shuffle-sortable graphic organizer*

This is the shuffle-sortable graphic organizer presented to participants in that treatment group. Note the countdown timer that lets participants know how much time remains of the five-minute study period. Also note "Show Text" button—this button, when clicked, displays the text passage that accompanies the graphic organizer. The text passage remains displayed as long as the participant keeps the mouse button pressed. A "Reset Organizer" button was also provided, such that a participant could restore the graphic organizer to its original state if desired.

This graphic organizer also contains controls for sorting or "shuffling" graphic organizer rows and columns, respectively. Participants were given instructions on the use of these controls. Participants were also encouraged to practice the use of these controls.

Appendix E. Pilot study screen capture images

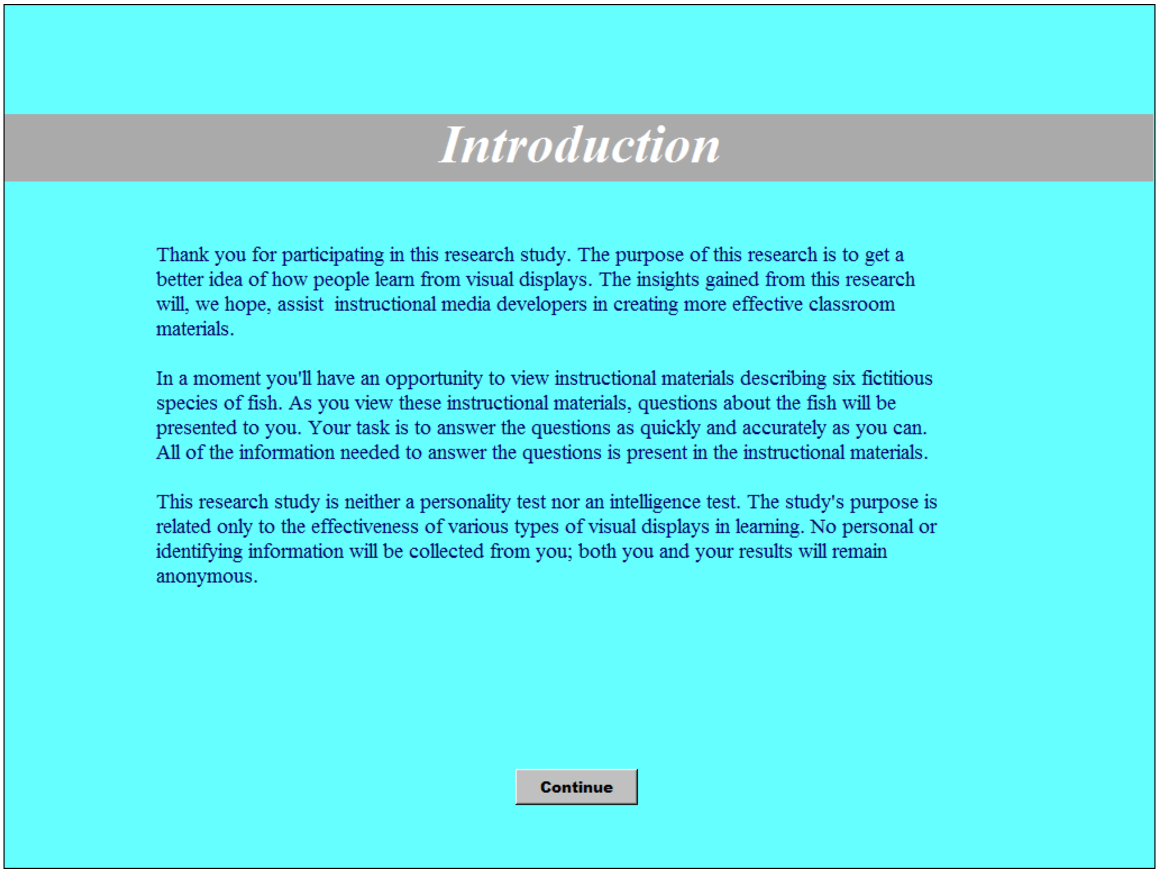



*Figure 35. Introductory screen from pilot study*

Above is a depiction of the introductory screen from the pilot study. This study investigated the effects of a sortable graphic organizer on learners’ ability to make comparative and inferential mental judgments.

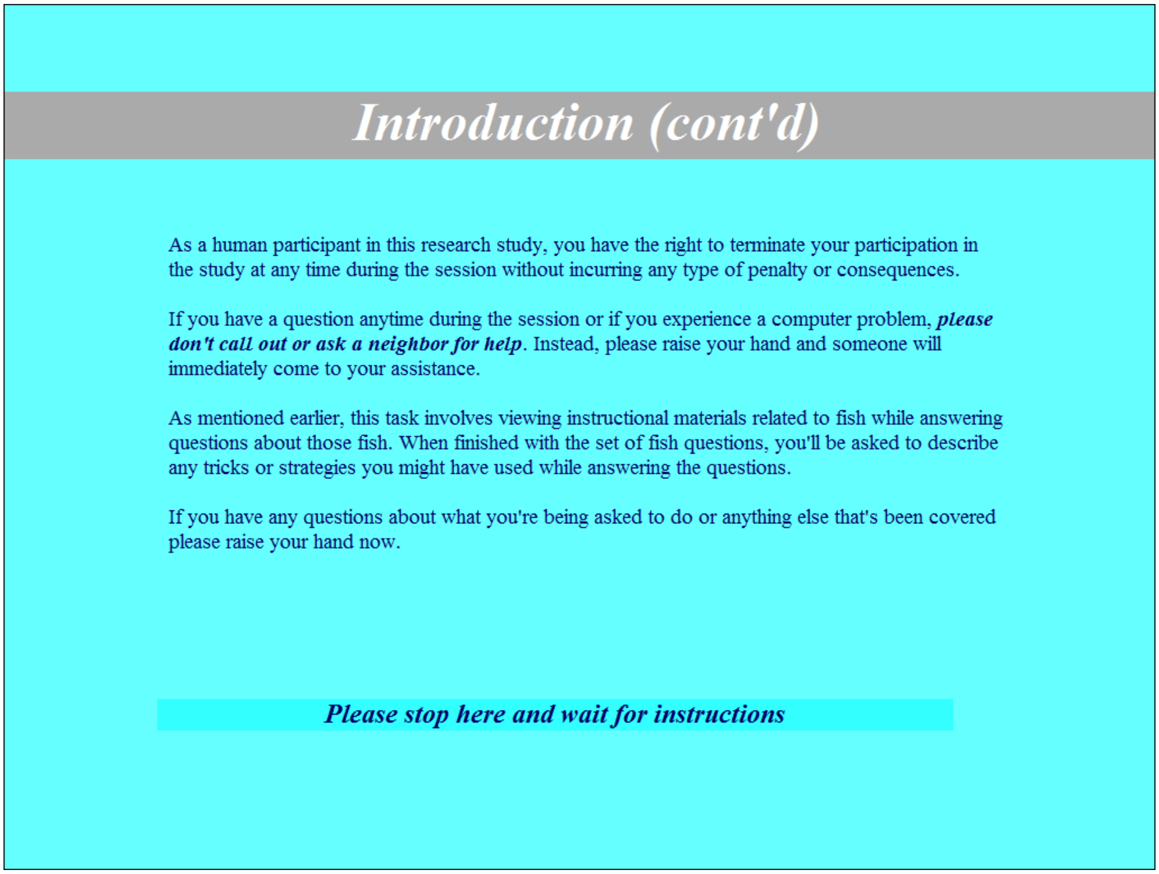



*Figure 36.* *Introductory screen from pilot study, cont'd*

Above is a depiction of the second introductory screen from the pilot study. On this screen, participants were reminded of their rights as human subjects, and given an overview of the task about to be completed.

| LIFE SPAN | SPECIES | COLOR | HEIGHT |
|---|---|---|---|
| 20 years | American Bison | Golden Brown | 6 feet |
| 25 years | African Buffalo | Brown to Black | 5 feet |
| 30 years | Asiatic Water Buffalo | Medium Brown to Grey | 4 feet |

Before you begin, it will be helpful to learn a bit about the type of instructional material that you'll be viewing. The type of instructional material that you'll be viewing is called a graphic organizer (or GO for short). Above is an example of a GO that contains information about various species of buffalo. As you can see in this example, a GO is a matrix or table that arranges categorical information, such as "height" or "life span" by rows and columns.

Besides conveying information about a particular species of buffalo (for example, that the American Bison lives 20 years). GOs are also useful for conveying trends or relationships; one trend shown above is that longer-living buffalo species tend to be shorter in height (you can see in the GO that as the life span numbers increase, the height numbers decrease).

Continue

*Figure 37. Example static graphic organizer from pilot study*

This screen provided participants with an exemplar of a static graphic organizer.

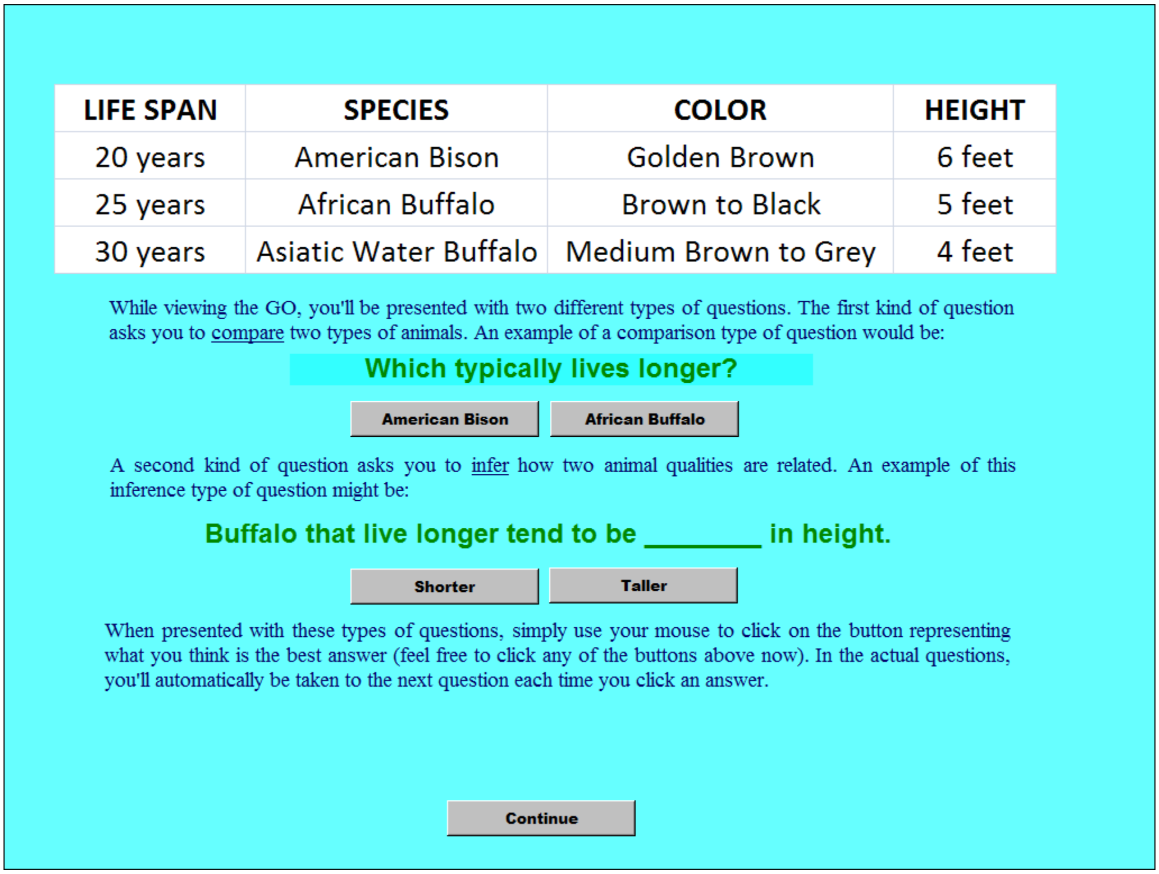



*Figure 38. Sample questions from pilot study*

This screen introduced participants to the two types of criterion questions (comparative and inferential) used by the pilot study.


*Figure 39. Introductory sortable graphic organizer screen from pilot study*

This screen introduced participants to the capabilities of the sortable graphic organizer.


| DEPTH | SPECIES | GROUPING | COLOR | SIZE | DIET |
|---|---|---|---|---|---|
| 200 | Goken | Small group | Brown | 12 inches | Baby shrimp |
| 200 | Latuk | Solitary | Black | 12 inches | Baby shrimp |
| 400 | Kupod | School | Orange | 18 inches | Krill |
| 400 | Taroz | Solitary | Blue | 18 inches | Krill |
| 600 | Ponef | Small group | Yellow | 24 inches | Prawns |
| 600 | Somet | School | White | 24 inches | Prawns |



*Figure 40.* *Sortable graphic organizer from pilot study*

This screen shows the sortable graphic organizer. By clicking any of the Sort buttons, participants caused the rows of the graphic organizer to be sorted by the contents of the column of interest. Clicking an already sorted column would toggle the sort order (e.g., from ascending to descending).

Also shown on this screen is an example of a criterion question requiring the participant to perform an inferential judgment to derive his or her response.

| DEPTH | SPECIES | GROUPING | COLOR | SIZE | DIET |
|---|---|---|---|---|---|
| 200 | Goken | Small group | Brown | 12 inches | Baby shrimp |
| 200 | Latuk | Solitary | Black | 12 inches | Baby shrimp |
| 400 | Kupod | School | Orange | 18 inches | Krill |
| 400 | Taroz | Solitary | Blue | 18 inches | Krill |
| 600 | Ponef | Small group | Yellow | 24 inches | Prawns |
| 600 | Somet | School | White | 24 inches | Prawns |



*Figure 41*. *Static graphic organizer from pilot study*

This screen shows the static, or non-sortable graphic organizer. Other than the absence of sort controls, its design and layout are the same as the sortable graphic organizer

Also shown on this screen is an example of a criterion question requiring the participant to perform a comparative judgment to derive his or her response.

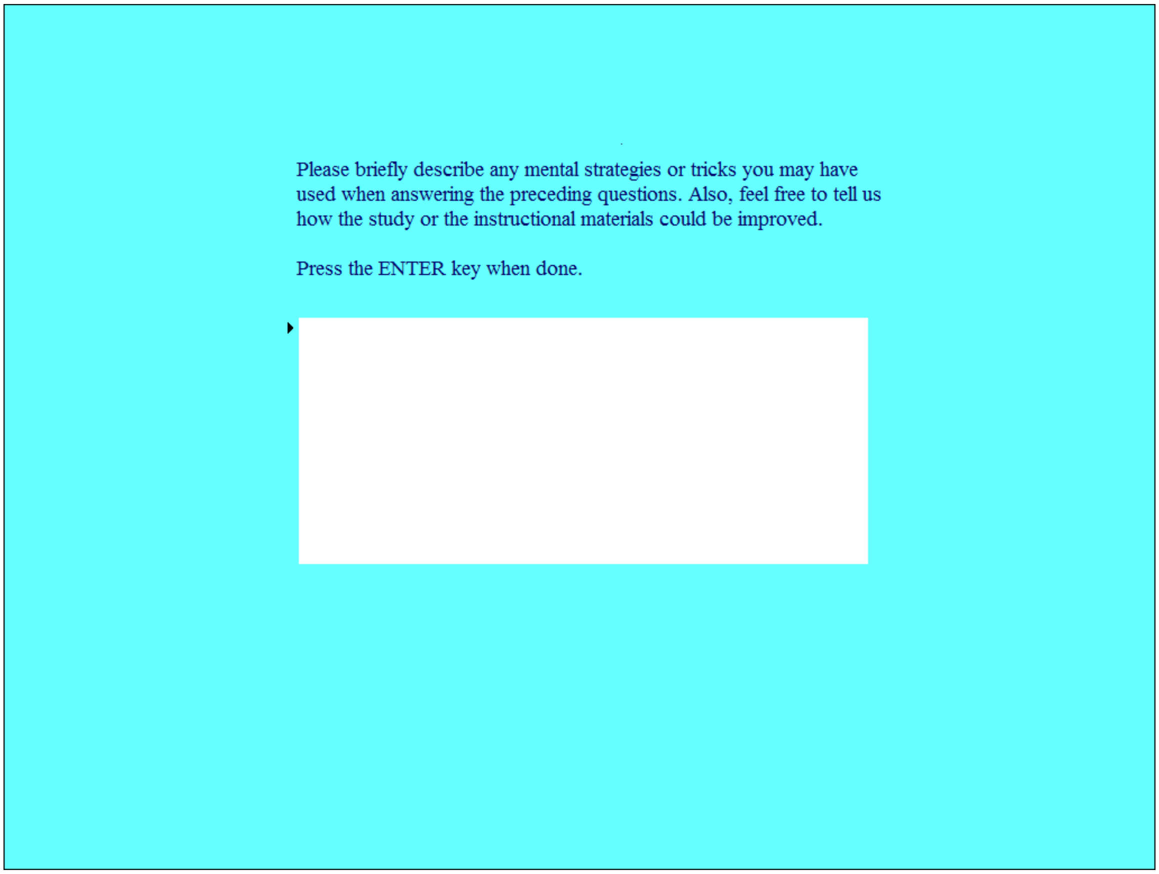



*Figure 42. Metacognitive strategies screen from pilot study*

This screen prompted participants to describe any mental tricks or strategies used during the graphic organizer study session.


*Figure 43.* *Debriefing screen from pilot study*

This screen thanked participants, provided some general information related to the study's goals, and provided the researcher's contact information.

Appendix F. Proposal defense outcomes and results

At the proposal defense held in mid-2009, the members of the doctoral committee documented several outcomes that were to be addressed by the candidate before data collection could commence. This appendix details those outcomes and their corresponding resolutions on the following pages.

I. Issues to be resolved before data collection
   a. The candidate should re-analyze past studies and existing pilot data or gather new data via appropriate means to refine his procedures and instrumentation regarding the following issues:
      i. Potential for gender-based performance differences and means for controlling such
      ii. Potential for problematic test items of the inference class – some inferences may be obvious without reference to the treatment data
      iii. Ensure that interpolated activity is of sufficient duration
      iv. Potential for floor effect deriving from change in procedure to avoid ceiling effect by removing access to GO during outcome measure
   b. Devise means of asking participants to identify other study strategies used
   c. Consider use of multiple random question order indices to minimize possible item order effects
II. Issues to be addressed in final document
   a. Clarify that multiple "in vivo" performance measures were recorded and analyzed – durations, choices, etc.
   b. Clarify that multiple latencies/sub-latencies were observed for analysis
   c. Address reading comprehension theory and research in literature synthesis. (Possibly characterize it and GO as different dimensions of a larger "digital literacy"

*Figure 44. Outcomes from the proposal defense*

**“Potential for gender-based performance differences and means for controlling such”**

Background: At the proposal defense a committee member asked whether a participant’s gender might affect his or her performance in the study (the committee member mentioned male participants’ prior experience with texting and gaming as possible contributors to gender-based performance differences in the planned study). The committee member also suggested controlling the assignment of participants to groups such that male participants were more or less equally distributed among the three treatment groups.

Investigative Actions Taken: (1) Multiple searches of the literature were performed in an attempt to identify evidence of gender differences relevant to the types of tasks performed in the proposed study; (2) data from two graphic organizer studies that used similar instructional materials and criterion questions to the planned study were examined in an attempt to identify gender differences in participant performance; (3) several influential graphic organizer experiments from the last 20 years were reviewed in an attempt to determine if/how gender was managed in those studies; and (4) numerous texts dealing with experimental design were consulted to gain further insight into random assignment and its application in experiments.

Results from Investigative Actions:

(1) Literature: Even a cursory literature search quickly reveals evidence of gender-based differences among college students in attributes such as self-efficacy and attitudes about computers, e.g., Busch (1995). Similarly, it is not difficult to find evidence of gender-based differences related to computer experience (e.g.,

Terlecki & Newcombe, 2005) and computer confidence (e.g., Comber, et al., 1997). Finding clear evidence of gender differences related to computer aptitude or performance, however, is less straightforward, as explicated by Kay (1993) who said, "out of 32 occasions of aptitude measurement, males outperformed females 15 times, females outperformed males 5 times, and males and females performed equally well on 12 occasions" (p. 81). One can also find evidence of gender equality (or at least no significant difference) as noted in the following studies: Kay (2003) indicates, "Our results from the computer confidence, career understanding, and social-bias questions in our survey do not provide evidence of strong gender differences as indicated in past research" (p. 57); North (2002) states, "…the impact of psychological gender (sex and sex-role) was assessed and found, in general, not to significantly influence attitudes or cognitions towards computers" (p. 1); and finally Hyde (2005) noted, "extensive evidence from meta-analyses of research on gender differences supports the gender similarities hypothesis. A few notable exceptions are some motor behaviors [e.g., throwing distance] and some aspects of sexuality, which show large gender differences" (p. 590).

(2) Past studies by the candidate: Participant gender was recorded in two of three previous studies undertaken by the candidate that used criterion questions and instructional materials similar to the planned study. These studies collected comparison-making and inference-making accuracy from participants who had studied one of three types of graphic organizers. The results, broken down by gender, are presented in tables 1 and 2 below. Although the samples were not of

sufficient size to perform statistical comparisons of means, one can still see from the reported means that males could not have outperformed females overall, as the female means were numerically greater than (but not necessarily significantly different from) male means in nine of the 12 sets of means reported.

(3) Past studies by others: Several influential visual learning experiments were examined to determine whether gender was considered in these studies. Gender was not mentioned in most studies. In the studies where gender was reported, it was neither controlled nor analyzed separately. Table 3 depicts representative quotes from several of the examined studies.

(4) The importance of random assignment: The planned study is an experiment. The importance of random assignment in an experiment cannot be overstated, as exemplified by the quotes shown in table 4, e.g., "In a study with a between-groups design, it is *essential* that we allocate participants randomly to our experimental conditions" (authors' emphasis) (Field & Hole, 2003, p. 71).

Conclusion: In light of the above investigation and analysis, the candidate has elected to retain the assignment strategy as documented in the original dissertation proposal. That is, participants will be assigned to treatment groups in a purely random fashion, without consideration for gender. However, each participant's gender will be recorded during the data collection procedure. This gender information will be available for gender-based data analysis should a need for same arise later.

**“Potential for problematic test items of the inference class – some inferences may be obvious without reference to the treatment data”**

Background: An issue was raised at the proposal defense that some inference questions may be discernible by participants without reference to the treatment data. That is, might participants be able to glean correct responses to some inference questions based solely on prior knowledge and/or deductive reasoning?

Analysis: It is true that in fish biology many trends and relationships exist (for example, schools of fish tend to comprise small fish, while solitary fish tend to be medium or large in size). However, for many “rules of thumb” exceptions typically exist—for example, bluefin tuna can weigh over 1000 lbs yet are schooling fish. The treatment data in the planned study is based on fictitious fish species. The species names were selected from lists of two-syllable non-words with very low familiarity scores, thus preventing any participant prior knowledge about the fish species *per se*. For each of the trends “hidden” in the experimental data, examples can be found from the real world that both conform to the trend as well as contradict the trend (for example, one trend in the experimental data is that deeper swimming fish tend to be larger – in the real world, one can find both large and small species at both shallow and deep depths). Although participants may attempt to use prior knowledge, as well as making “educated guesses” when answering questions the candidate feels this is not a significant risk (participants should be expected to attempt to use prior knowledge and/or deductive reasoning when attempting to answer criterion questions, regardless of the study or its subject matter).

Conclusion: The candidate plans to use the inference questions as presented in the original proposal. Any attempted use of prior knowledge by the participants is mitigated because: (1) the trends in the experimental treatments may or may not be present in nature, (2) there are fifteen inference questions based on five attributes, thus increasing fidelity of this experimental measure and finally, (3) the instructions given to the participants will include explicit directions to avoid using prior knowledge when answering the questions.

**“Ensure that interpolated activity is of sufficient duration”**

Background: The original dissertation proposal’s plan described “a brief interpolated arithmetic task to ensure that short-term memory has been cleared” (p. 35). The committee directed the candidate to ensure that this interpolated memory task was of sufficient duration to accomplish its desired purpose.

Analysis: The interpolated arithmetic task is an example of a distractor task. Distractor tasks are often used in experiments related to memory and learning. The primary purpose of a distractor task is to prevent rehearsal (Greene, 1992). Inserting a distractor task between the learning and recall tasks ensures that participants’ short-term memory is cleared (by preventing rehearsal), thus helping to measure what has been encoded in long-term memory during the recall portion of the study.

One frequently cited distractor task is the Brown-Peterson paradigm (so named because it was independently introduced by Brown in 1958 then Peterson and Peterson in 1959 (Tulving & Craik, 2000). Using this method, participants performed a task (typically counting backwards by threes from a certain number) for time intervals ranging from 3 to 18 seconds. Participants were then asked to recall consonants (learned immediately before the distractor task) and were able to recall fewer than 10% of them after a filled retention interval of 18 seconds (Greene, 1992).

Other researchers use similar distractor tasks to prevent rehearsal. For example, Schwartz, Ellsworth, Graham, & Knight (1998) wrote, “When the story was over, learners were given 1 minute to complete the math task” (p. 78). Similarly, Spears & Kealy (2005, March) presented three two-column simple addition problems to participants; participants were prompted to confirm the accuracy of each sum presented by pressing "Y" if correct or "N" if incorrect.

Conclusion: The candidate will ensure that the interpolated memory task has a duration of at least 18 seconds (to satisfy the common findings of the Brown-Peterson paradigm). The candidate will further ensure that the interpolated memory task takes roughly one minute to thoroughly ensure that participant short term memory has been cleared.

**“Potential for floor effect deriving from change in procedure to avoid ceiling effect by removing access to GO during outcome measure”**

Background: One observation from the pilot study was a severe ceiling effect (nearly every participant scored 13, 14, or 15 out of 15 possible points on accuracy for both comparative and inferential judgments). On post-study analysis, it became quite clear that this was a result of the simultaneous presentation of the graphic organizer and criterion questions (typically, the graphic organizer and/or text would be presented to participants prior to the presentation of the criterion questions).

Analysis: The planned study uses the more traditional “study then answer” strategy. Results from previous similar studies (see for example, tables 1 and 2) show that with this scheme participant scores exhibit neither a ceiling nor a floor effect. In the data in tables 1 and 2, random participant guessing would have yielded, on average, scores around 0.5. Inspection of that data shows that typical scores were in a range around 0.6 to 0.8, or exactly where the candidate would like them to be (high enough to demonstrate that participants were performing better than random guessing, yet low enough to still show variability between participants).

Conclusion: Past studies using the “study then answer” strategy with similar instructional materials and criterion questions resulted in responses that tended neither toward ceiling nor floor effects—the results instead tended toward the desired “sweet spot” of response ranges. The candidate therefore plans to maintain the procedure documented in the original dissertation proposal in the planned study.

**“Devise means of asking participants to identify other study strategies used”**

Background: The committee pointed out that making inferences about participant performance based solely on accuracy and latency of responses might paint an incomplete picture with respect to the effects of the various treatments. The committee further recommended that participants be queried about any methods/strategies they might have used while studying the treatment materials.

Analysis: Precedent exists from similar studies for doing this. For example, in Spears & Kealy (2005, March), participants were asked to, “Please briefly describe any mental tricks or strategies used” (p. 6). In Kealy, Bakriwala, & Sheridan (2003), participants were asked to describe any “mental trick or strategy used to recall details of the story” (p. 34). The candidate agrees that asking open-ended, self-reporting questions related to study strategies is an excellent recommendation from the committee.

Conclusion: Participants will be asked, at minimum, to “Please briefly describe any mental tricks or strategies that you used while studying the graphic organizer.” Participant responses will be recorded and analyzed.

**”Use of multiple random question order indices to minimize possible item order effects”**

Background: At the proposal defense, a committee member inquired about the possibility that sequence effects might influence the results. In the original proposal, the 45 total criterion questions (3 sets of 15) were to be presented to the participants in random order. That is, a single random sequence would be generated before data collection commenced such that every participant received the questions in the same random sequence. Because the three sets of criterion questions (factual, comparative, and inferential) were to be combined then randomized, participants would see a mix of questions (for example, they might see one inferential question, then two factual questions, then a comparison question, followed by another inference question, and so on).

Investigative Actions Taken: (1) Literate was examined to learn about question order effects, and the related topics of item randomization and counterbalancing; (2) past influential studies were examined to determine if/how other researchers had addressed issues of sequence effects in criterion questions; (3) the criterion questions for the planned study were carefully inspected in an attempt to identify any potential order effects; and (4) a measurement and research professor was consulted for guidance on this issue.

Results from Investigative Actions:

1. Literature: Abundant literature exists related to the ordering of *responses* for a question (e.g., Schwarz, Hippler, & Noelle-Neumann, 1992). Much of this literature seems concerned with surveys, especially opinion polls, psychological

surveys, and the like. The primacy effect and recency effect are just two of many possible concerns that researchers should consider when designing a survey of this type. Literature related to the ordering of *questions* is less easy to find. Some heuristics related to the sequence of questions can be derived with just a little careful thought (for example, open-ended questions should be asked before closed-ended questions on similar topics [Weisberg, Krosnick, & Bowen, 1996]). Similarly, surveys related to political candidates, new products, and similar typically obscure the subject of the survey until toward the end of the survey to avoid influencing participants' answers during the earlier stages of the survey. Literature related to question sequence for less survey-like studies (such as the planned study) was not readily obtainable by the candidate. By contrast, one can easily find techniques and guidance related to counterbalancing (e.g., Field & Hole, 2003; Christensen, 1977). However, counterbalancing is not feasible when more than a handful of questions are present and thus cannot be used in the planned study. Therefore, the candidate considers the following advice from Boroditsky & Griffiths (n.d.) to be both practical and valid: "How do you know when to randomize and when to counterbalance? If you have lots of subjects or lots of items, just randomize."

2. <u>Past studies:</u> Several well-cited, similar studies from the past two decades were examined in an attempt to determine if or how other researchers had managed the sequencing of criterion questions. Some researchers presented different question types in blocks of questions, with open-ended questions being presented prior to closed-ended questions (for example, in Kiewra, et. al. (1999) the global relations

test was presented first followed by the local relations test). This makes sense, as presenting the questions in the reverse order might taint participants' responses for the global relations test by exposing them to details that would later be recalled. Other than this, however, information was typically absent with respect to randomization or lack thereof. In fact, question sequence information was typically just not present—a report might simply say, "Each quiz contained 30 multiple-choice items" (Robinson, et al. 2006, p. 105). Based on the candidate's examination of these studies, it seems that the order of individual questions was not of great concern to these researchers.

3. Inspection of criterion questions for the planned study: The candidate carefully examined the 45 criterion questions in the planned study in an attempt to identify any obvious sequence effects that might be of concern. No obvious "bad" sequences of questions were identified. With some effort, one might be able to manually assemble an undesirable sequence of instructions such that participants with excellent recall and deductive reasoning abilities might be able to better answer certain questions solely because of question order. However, the probability of this occurring in a random sequence seems inconsequential to the candidate.

4. Consultation: Finally, the candidate consulted a full professor in measurement and research after performing the above-noted procedures (this individual is not being identified because the professor's response was in a private email message). An excerpt from the message follows, "We use tests (and surveys) all the time, where each participant encounters the questions in the same order. Why for this set of

questions should we worry?" It is the candidate's belief that no specific sequence effect risk was identified for the planned study's questions (in other words, the concern was more of a "what if" scenario).

Conclusion: In light of the above investigation and analysis, the candidate has elected to maintain the question sequencing strategy as documented in the original dissertation proposal. The absence of evidence showing that any strategy other than randomization should be used, plus the mitigating factor that even if a sequence effect existed that all participants would experience it equally, has convinced the candidate that a single randomized sequence, delivered to all participants, is a sound research strategy.

Table 1. Mean response accuracy (SD) from Spears & Kealy (2005, March).

| **Treatment** | **Gender** | **Comparison Accuracy (SD)** | **Inference Accuracy (SD)** |
|---|---|---|---|
| **Colors** | Female (n=8) | 0.75 (0.23) | 0.68 (0.36) |
| | Male (n=1) | 0.60 (0) | 0.47 (0) |
| **Labels** | Female (n=6) | 0.78 (0.24) | 0.86 (0.23) |
| | Male (n=7) | 0.60 (0.32) | 0.72 (0.26) |
| **Size** | Female (n=5) | 0.76 (0.26) | 0.71 (0.33) |
| | Male (n=2) | 0.77 (0.28) | 0.57 (0.39) |

Table 2. Mean response accuracy (SD) from Spears & Kealy (2005, October).

| **Treatment** | **Gender** | **Comparison Accuracy (SD)** | **Inference Accuracy (SD)** |
|---|---|---|---|
| **Color** | Female (n=14) | 0.77 (0.15) | 0.76 (0.20) |
| | Male (n=3) | 0.58 (0.32) | 0.58 (0.17) |
| **Labels** | Female (n=14) | 0.69 (0.19) | 0.72 (0.24) |
| | Male (n=1) | 0.87 (0) | 1.00 (0) |
| **Size** | Female (n=14) | 0.75 (0.14) | 0.81 (0.21) |
| | Male (n=2) | 0.74 (0.09) | 0.80 (0.09) |

*Table 3. Representative gender-related quotes from past studies*

| |
|---|
| “Students were randomly assigned to one of the four between-subjects conditions” (Bera & Robinson 2004, p. 382). Gender was not mentioned. |
| “Each student was randomly assigned to one of four experimental conditions” (Crooks, White, & Barnard, 2007, p. 375). Gender of participants was noted but neither controlled nor analyzed. |
| “Students were randomly assigned to one of the four conditions“ (Griffin & Robinson, 2005, p. 32). Gender was not mentioned. |
| “Each student was randomly assigned to one of three experimental conditions” (Robinson, Corliss, Bush, Bera, & Tomberlin, 2003, p. 35). Gender of participants was noted (interestingly, with a ratio similar to USF’s College of Education: F=61, M=12) but it was neither controlled nor analyzed. |

*Table 4. Representative quotes related to the importance of random assignment*

| |
|---|
| “Statistical reasoning is dependent on the randomization process, so we emphasize again: Randomize whenever and wherever possible” (authors’ emphasis) (Johnson & Christensen, 2004, p. 280). |
| “In a study with a between-groups design, it is essential that we allocate participants randomly to our experimental conditions” (authors’ emphasis) (Field & Hole, 2003, p. 71). |
| “The word random should not be passed over lightly. The use of randomization is the keystone of the application of statistical theory to the design of experiments, and the validity of our deductions rests upon the principle of randomization” (John, 1971, p. 4). |
| “Randomization is the cornerstone underlying the use of statistical methods in experimental design” (Montgomery, 1997, p. 13). |

*Table 5. Representative quotes related to question order*

| |
|---|
| “Students were then given eight practice items with corrective feedback that were randomly chosen from the 72 total items. All students received the same practice items. Then the 64 test items appeared” (Robinson & Schraw, 1994, p. 406). |
| “Each quiz contained 30 multiple-choice items” (Robinson, et al. 2006, p. 105). There was no apparent mention of sequence of quiz items. |
| “Participants then took the global relations test and the local relations test in that order without reference to their study materials (Kiewra, et. al., 1999, p. 383). No apparent mention of sequence of quiz items. |
| “They were instructed on the first screen of the experiment that they would view 20 text screens and 7 GO screens, and complete two tests. They proceeded from 1 screen to the next by pressing the space bar, and were instructed not to go back to previous screens. Students wrote their answers to the free recall test and indicated their choice on the multiple choice relations test by circling the corresponding letter (a, b, c, d)” (Robinson, et al., 2003, p. 31). There was no apparent mention of item sequence. |
| “Participants then completed the local relationship, global relationship, and fact tests in that order” (Kauffman, 2009-in-press, p. 30). There was no apparent mention of item sequence. |

Appendix G. Final defense outcomes and results

At the final defense held in mid-2010, the members of the doctoral committee documented several outcomes that were to be addressed by the candidate in order to complete this dissertation. This appendix details those outcomes and their corresponding resolutions.

The candidate's defense was evaluated successful and his document approved by all committee members pending revision to address the following issues/recommendations. Each of these matters should be given consideration for discussion in Chapter Five as alternate interpretations of outcomes, limitations, or bases for further research.

| | **Outcome** | **Resolution** |
|---|---|---|
| 1. | Discuss 6th grade reading level as a potential limitation. Even though there was no ceiling effect (in fact, the means were closer to the 50% "floor"), could the low reading level, in comparison to the norm for college-level readers, have failed to catalyze the hypothetical affordances to higher-level cognition offered by dynamic GOs? | COMPLETED (pp. 27-28) |
| 2. | Discuss the potential limitations of the "press to hold text onscreen, with default back to GO upon release" functionality of the experimental software. | COMPLETED (pp. 74-75) |

| | Outcome | Resolution |
|---|---|---|
| 3. | Discuss the potential limitations of the relatively “weak” practical utility of the “shuffle” feature in comparison to the sort feature. | NOT DONE -- Although it’s certainly possible that the shuffle feature is weak when compared to the sort feature, I can’t find evidence to support this. The shuffle feature *should* permit a learner to decrease the semantic distance between elements, thus making trends in the displayed information more apparent, while also improving a learner’s ability to make inferential judgments (Winn & Holliday, 1982). Similarly, juxtaposition of elements (made possible by shuffling) is one of the ways that spatial displays effectively communicate concepts and their relationships (MacDonald-Ross, 1979). |
| 4. | Incorporate the results of your post-hoc correlation of text-reading-time to performance. Consider the implications of the weakness of this correlation for your methods and outcomes. | COMPLETED (p. 56; p. 81) |
| 5. | Interpret the outcomes of the experiment more optimistically, with better overall balance. Although the “objective” observed outcomes were not significant, the significance of participant-reported preferences is important. Although it may have been the case that participants deluded themselves, it is also quite likely that the “objective” materials, measures and procedures weren’t potent/sensitive enough to reveal an effect. | COMPLETED (Abstract; pp. 77) |

| | Outcome | Resolution |
|---|---|---|
| 6. | Interpret the outcomes of the experiment from the perspective of "metamemory" theory. | COMPLETED (p. 77) But framed as metacomprehension, rather than metamemory) -- Metamemory refers to knowledge about memory, which doesn't seem appropriate to describe the participants' higher "effective instructional tool" ratings for the dynamic graphic organizers. Metacomprehension, in contrast, refers to "a person's ability to judge his or her own learning and/or comprehension of text materials." |
| 7. | Report the observation that no participants wrote down any notes and consider the implications of that. | COMPLETED (p. 38) |
| 8. | Report the statistics on the degree to which participants who were afforded the opportunity to sort or shuffle actually did so (some didn't at all) and consider the implications of that. | COMPLETED (Abstract; p. 56; p.72) |
| 9. | Discuss the degree to which learner performances were "mindful and effortful." | COMPLETED (pp. 57-58; p. 74) |
| 10. | Reconsider/reduce the use of acronyms throughout the document in favor of using the complete terms more frequently. | COMPLETED (throughout manuscript, but mostly in the tables) |
| 11. | Discuss possible limitations owing to initial method of random assignment and later restrictions. Consider post-hoc analysis of only the non-restricted data set as a means of assessing the potential threat to validity. | COMPLETED (p. 48) |
| 12. | Consider changing tables to report percentage scores as opposed to raw scores. | COMPLETED (pp. 46-47) |

| | Outcome | Resolution |
|---|---|---|
| 13. | Consider adding post-hoc analyses by “unit of effort” to develop the possible assertion that use of GOs alone can serve as an equivalent replacement, possibly a faster one, for the reading of text. E.g. “reading text is the current ‘gold’ standard, but GOs are just as good and may be faster.” | PARTIALLY DONE—The only reasonable “unit of effort” I can think of that could be extracted from the current study is *time*. The post-hoc analysis in item 4 above did show that learners who spent more time on the graphic organizer (at the expense of time spent on the text) performed slightly better in recall accuracy.<br><br>The recommendation about “GOs are just as good and may be faster than text” has been done in past studies (and it was not even a peripheral goal of this one). Robinson (1998) showed that, “the facilitative advantage of graphic organizers in locating information is attributable to computationally efficient indexing rather than fewer words.” This premise was part of my theoretical framework and I believe was covered in my lit review. With respect to “GOs alone can serve as a replacement for text”: the GO heuristics I’ve seen recommend against making GOs so detailed that they replace text—they are considered adjunct (or pre- or post-) displays to accompany text. |
| 14. | Add the chance line to the charts to show the floor. | COMPLETED (p. 47) |

## Appendix H. IRB exempt certifications

This study met two conditions that made it eligible for exemption from Institutional Review Board oversight: (1) participants in this study remained anonymous, and (2) the materials, methods, and procedures used in the study were materially similar to everyday classroom materials, methods, and procedures. Exempt status was requested by the researcher and granted by the Institutional Review Board before data collection commenced. Soon thereafter, a modification to the study's protocol was requested and received. This modification gave the researcher more flexibility in participant recruitment procedures; it also added a second research site. The relevant Institutional Review Board documents are reproduced on the following pages.

UNIVERSITY OF SOUTH FLORIDA

DIVISION OF RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-5618

October 26, 2009

Cameron Spears
Secondary Education
12115 Marblehead Drive
Tampa, FL 33626

RE: **Exempt Certification** for IRB#: 108517 G
Title: *The Dynamic Graphic Organizer and its Influence on Making Factual, Comparative and Inferential Determinations within Comparative Content*

Dear Mr. Spears:

On October 22, 2009, the Institutional Review Board (IRB) determined that your research **meets USF requirements and Federal Exemption criteria one (1).** It is your responsibility to ensure that this research is conducted in a manner reported in your application and consistent with the ethical principles outlined in the Belmont Report and with USF IRB policies and procedures.

**If the you decide to offer compensation to participants so as to improve participation in the study, please submit a modification request with revised questionnaire reflecting compensation information.**

Please note that changes to this protocol may disqualify it from exempt status. It is your responsibility to notify the IRB prior to implementing any changes.

The Division of Research Integrity and Compliance will hold your exemption application for a period of five years from the date of this letter or for three years after a Final Progress Report is received. If you wish to continue this protocol beyond those periods, you will need to submit an Exemption Certification Request form at least 30 days before this exempt certification ends. If a Final Progress Report has not been received, the IRB will send you a reminder notice prior to end of the five year period; therefore, it is important that you keep your contact information current with the IRB Office. Should you complete this study prior to the end of the five-year period, you must submit a Final IRB Progress Report for review.

**Please reference the above IRB protocol number in all correspondence** regarding this protocol with the IRB or the Division of Research Integrity and Compliance. In addition, you can find the Institutional Review Board (IRB) Quick Reference Guide providing guidelines and resources to assist you in meeting your responsibilities in the conduction of human participant research on our website. Please read this guide carefully. It is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-2036.

Sincerely,

Krista Kutash, Ph.D., Chairperson
USF Institutional Review Board

Cc: Anna Davis/cd, USF IRB Professional Staff
James White, PhD

USF
UNIVERSITY OF SOUTH FLORIDA

DIVISION OF RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-5618

November 17, 2009

Cameron Spears
Secondary Education
12115 Marblehead Drive
Tampa, FL 33626

RE: **Exempt Certification** Modification Request
IRB#: 108517 G
Title: *The Dynamic Graphic Organizer and its Influence on Making Factual, Comparative and Inferential Determinations within Comparative Content*

Dear Cameron Spears:

On October 23, 2009, it was determined that your project referenced above meets the federal criteria, which exempts it from further IRB oversight.

You have requested the following changes to your research:

**1. Change in research sites: Addition of Hillsborough Community College, Dale Mabry Campus.**
**2. Change in subject recruitment: Participants will be recruited by means of posters, flyers, and messages on electronic bulletin boards or listservs in areas frequented by college students. There will be 3 types of recruitment flyers:**
**-Flyers offering token compensation such as soft drinks, brownies, and similar treats.**
**-Flyers offering extra credit points in a specific college course. These flyers will only be used in cases where an instructor has given prior approval that s/he will award extra credit points for participation.**
**-Flyers offering cash compensation of $5 for participation.**

On **November 13, 2009**, the IRB Chairperson reviewed your request and determined this change does not impact the study's eligibility for exemption. The study continues to meet Exempt Criteria. Any grants supporting this project must be submitted to the Institutional Review Board for review.

Please note that future changes to this protocol may disqualify it from its current exempt status. It is your responsibility to notify the IRB prior to implementing any changes.

**Please reference the above IRB protocol number in all correspondence** to the IRB c/o the Division of Research Integrity and Compliance. It is your responsibility to ensure that this research is conducted in a manner consistent with the ethical principles outlined in the Belmont Report and with USF IRB policies and procedures.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-2036.

Sincerely,

Krista Kutash, Ph.D., Chairperson
USF Institutional Review Board

Cc: Anna Davis/cd, USF IRB Professional Staff
James White PhD

## About the Author

Cameron Spears earned a BS in Computer Science from the University of South Alabama followed by an MS in Computer Science from California State University, Fullerton. He spent several years in the technology industry as a member of the technical staff, group head, and senior manager in charge of various commercial and defense-related computing products, including multiprocessor servers, advanced disk storage devices, shipboard display systems, and server fault-tolerance solutions.

While working in product development at a well-known computer manufacturer in Southern California, he took a part-time position as an adjunct faculty member at a local university—this was when he discovered a passion for teaching. This breakthrough, coupled with a life-long desire to conduct formal research, motivated Cameron to pursue his Ph.D. in instructional technology at the University of South Florida. During this phase of his career, Cameron taught from three to eight distance and face-to-face courses every term, at up to three institutions of higher learning per term. After graduation, Cameron looks forward to continuing his teaching, research, and writing as a full-time university professor.