A DESIGN-BASED RESEARCH INVESTIGATION OF A WEB-BASED LEARNING ENVIRONMENT DESIGNED TO SUPPORT THE READING PROCESS

A Dissertation in

Instructional Systems

by

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ABSTRACT

This research study had two purposes, (a) to design and develop a Web-based learning environment that supports the use of a set of reading strategies, and (b) to investigate the impact of this Web-based learning environment on readers’ memory and understanding of an instructional unit on the human heart (Dwyer & Lamberski, 1977). These purposes led to four major research goals:

1. Guide the design of a Web-based learning environment that supports the use of a set of five reading strategies: (a) Text-macrostructure or chunking strategy: Readers can chunk the instructional unit on the human heart into smaller sections by moving elements (one or more paragraphs of text and an image) that make up the instructional unit into tabs that they create in the Web-based learning environment. (b) Summarization strategy: Readers can write a summary for each section that they create. (c) Imagery strategy: Readers can select an image from a library of images that is most representative of the contents of a given section. (d) Reading self-assessment or comfort-meter strategy: Readers can mark on a scale of 1-5 how comfortable they feel with their understanding of each section of the instructional unit. (e) Note-taking strategy: Readers can take notes on an element-by-element basis—these notes are attached to the elements that make up the instructional unit.

2. Establish validity and reliability of Web-based measurement instruments that were designed to measure memory and understanding of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model and macro-situation model.
3. On the basis of these measurement instruments, determine whether participants who read the instructional unit on the human heart in the Web-based learning environment developed better memory and understanding of the instructional unit when compared with participants who read the same text on a regular Web page.

4. Develop an understanding of participants’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.

A design-based research framework guided a series of studies that addressed these research goals. These studies were conducted in four phases. Findings from each of the first three phases of the investigation were used to inform and update the design of the Web-based learning environment, the Web-based measurement instruments, and the research design of the subsequent phase. The investigation culminated in a large-scale quasi-experimental study.

**Summary of Findings**

In the Phase I study, participants’ use of the text-macrostructure or chunking strategy was investigated with the help of an early-stage paper prototype of the Web-based learning environment. Participants’ organization of the individual elements that made up the instructional unit on the human heart into sections, and the labels that participants gave these sections were markedly different across the six participants who completed this study. This evidence indicated that participants in the study made use of the text-macrostructure strategy to develop unique macro-level representations of the instructional unit on the human heart. Findings from this study provided support for incorporating the text-macrostructure strategy in the Web-based
learning environment. This strategy played a key role in the overall design of the Web-based learning environment.

In the Phase II study, Web-based measurement instruments that measured participants’ knowledge of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model, and macro-situation model—were designed and validated. Cronbach’s alpha for scores on the multiple-choice items on all four Web-based human heart tests was greater than .75. Knowledge of human anatomy and spatial ability were treated as possible covariates. The Cronbach’s alpha for scores on the knowledge of human anatomy test was .713. On the basis of item-total statistics and the discrimination index data, two items were identified as being most problematic; one item was updated, the other item was replaced. Reliability for scores on the spatial ability tests could not be calculated because of insufficient data. An implementation of the Damerau-Levenshtein distance (DLD) algorithm was found to be suitable for scoring the “rearranging-type” questions in the macro-textbase and macro-situation model tests. Given the high correlations between scores on the Web-based human heart tests, the knowledge of the human anatomy test, and the paper-folding test, it was determined that there would be an advantage to using scores on the knowledge of human anatomy and paper-folding tests as covariates in studies in the subsequent phases. Technology used to develop the measurement instruments (implementation of the autocomplete design-pattern, drag-and-drop, and AJAX) and online delivery of measurement instruments was tested; bugs that were identified were fixed. The Web-based measurement instruments developed in this study were used in the subsequent phases of the investigation.

Participants in the Phase III study read the instructional unit on the human heart in the Web-based learning environment. Participants engaged deeply with the reading task in the Web-
based learning environment spending nearly twice as much time reading when compared with participants in the Phase II study who read the instructional unit on the human heart on a regular Web page. An animated demonstration that provided participants an overview of the user interface of the Web-based learning environment was prepared and tested. Feedback questions related to participants’ experience in the Web-based learning environment and the Web-based measurement instruments were prepared and tested. On the basis of data collected from interviews with participants, responses to the feedback survey, think-aloud and video data, numerous updates were made to the user interface and the design of the reading strategies in the Web-based learning environment.

On the basis of observations in the Phase III studies, a decision was made to develop two variants of the animated demonstration for the Web-based learning environment. The first demonstration was similar to the demonstration used in the Phase III studies. The objective of this demonstration was to provide participants an orientation of the user interface of the Web-based learning environment. In addition to providing participants an orientation of the user interface of the Web-based learning environment, the second demonstration provided explicit instruction on the five reading strategies.

The Phase IV study investigated the impact of the Web-based learning environment on readers’ memory and understanding of an instructional unit on the human heart. Two levels of the independent variable—the Web-based learning environment—were set up: (a) Web-based learning environment with demonstration that did not include explicit instruction on the reading strategies (T1); and (b) Web-based learning environment with demonstration that included explicit instruction on the reading strategies (T2). In the control condition participants read the instructional unit on the human heart on a regular Web page. The six dependent variables in the
study included scores on four tests that measured participants’ memory and understanding of the instructional unit on the human heart (micro-textbase, macro-textbase, micro-situation model, and macro-situation model), time spent reading the instructional unit on the human heart, and the time spent responding to test questions. Six research questions were pursued: (a) Did the Web-based learning environment help participants develop better memory (micro-textbase and macro-textbase) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies? (b) Did the Web-based learning environment help participants develop better understanding (micro-situation model and macro-situation model) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies? (c) Did participants in the three experimental conditions spend equal amount of time reading the instructional unit on the human heart? (d) Did participants in the three experimental conditions spend equal amount of time responding to Web-based human heart tests? (e) How did participants use the five reading strategies in the Web-based learning environment and what was their experience in the Web-based learning environment? (f) What was participants’ experience with the Web-based human heart tests?

Participants in the Web-based learning environment group with demonstration that included explicit instructions on the reading strategies (T2) performed significantly better ($p < .10$) than participants in the control group on the macro-textbase, micro-situation model, and macro-situation model tests ($p = .076$, $p = .079$, and $p = .012$ respectively). There was no difference in performance on the micro-textbase test ($p = .274$). Performance of participants in the Web-based learning environment group with demonstration that did not include explicit instructions on the reading strategies (T1) was unexpected; they scored lower than participants in the control group on all four tests.
Participants in the two Web-based learning environment conditions (T1 and T2) spent nearly twice as much time reading the instructional unit on the human heart when compared with participants in the control group who read the instructional unit on the human heart on a regular Web page ($p = .000$ and $p = .000$ respectively).

Participants in the Web-based learning environment group with demonstration that did not include explicit instructions on the reading strategies (T1) spent significantly less time responding to questions on the Web-based human heart tests when compared with participants in the control group and the Web-based learning environment group with demonstration that included explicit instructions on the reading strategies (T2) ($p = .001$ and $p = .001$ respectively).

Feedback from participants in the Web-based learning environment groups indicated that they engaged deeply with the instructional text in the Web-based learning environment; many of the participants were able to use the five reading strategies effectively, several participants thought that they benefited from using these reading strategies. Overall, 87% of the participants noted that they had a favorable experience in the Web-based learning environment. There was a significant difference between the Web-based learning environment group with demonstration that did not include explicit instructions on the reading strategies (T1) and the Web-based learning environment group with demonstration that included explicit instructions on the reading strategies (T2) [$\chi^2 (1, N = 353) = 8.10, p = .004$]; 93% of the participants in Treatment 2 (T2) voted favorably, as compared to 83% of the participants in Treatment 1 (T1). Furthermore, 89% of the participants in Treatment 2 (T2) noted that they would have liked to use the Web-based learning environment in the following semester. In comparison, this percentage was only 75% for participants in Treatment 1 (T1). This difference was statistically significant [$\chi^2 (1, N = 351) = 13.88, p = .000$].
Overall, 82% of the participants found the experience of responding to questions on the Web-based human heart tests to be favorable. There was a significant difference between the three experimental groups \(\chi^2 (2, N = 545) = 16.62, p = .000\). Participants in the control group and the Web-based learning environment group with demonstration that included explicit instructions on the reading strategies (T2) rated their experience to be more positive (89%, 84% respectively) than participants in the Web-based learning environment group with demonstration that did not include explicit instructions on the reading strategies (T1) (73%).

Reading comprehension is contingent upon the successful execution of a series of cognitive and metacognitive processes. The reading strategies in the Web-based learning environment support a subset of these comprehension processes. Findings from this research stand to inform our understanding of these comprehension processes, and ways in which affordances of current Web technologies can be used to design compelling reading environments and assessments that measure learning that occurs in these environments. The Web-based learning environment also has potential for impacting the practice of reading strategies instruction.
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CHAPTER 01
INTRODUCTION

Why are some people able to read better, and learn more from what they read, than others?

Given the fact that text, printed or online, has become the primary means of sharing information and ideas, it is easy to see why finding answers to questions like the one posed above is crucial to the success of a society in a global knowledge-based economy (Reigeluth, 1999).

Reading researchers such as Stanovich (1986) have argued that a deficit in the development of reading ability has far reaching consequences on the overall intellectual development of an individual. To make his point he shares a poignant remark from a nine-year old student who finds himself far behind his peers in reading proficiency. With tears in his eyes this student remarked, “Reading affects everything you do” (p. 390)—even a nine year old realizes the ramifications of not being able to read effectively. Stanovich has described this as a “rich-get-richer and poor-get-poorer” pattern of reading achievement (p. 360).

The question posed at the beginning of this chapter has been the subject of vigorous investigation spanning many years. In fact, one could reasonably claim that the field of reading research is one of the most actively pursued research areas in the educational and behavioral sciences. Over the years, many dimensions of the “reading problem” have come to be better understood—many questions have been answered and many new, unexplored facets of the problem have been exposed. Quite like settlers in a new land, literacy researchers have tirelessly
explored newly discovered facets of the reading problem, making attempts at finding answers to known questions, and in the process framing new questions.

Consider a particular finding from reading research: *Reading is largely an acquired skill—we are not born with the skill, rather we develop it through practice* (Gambrell, Morrow, & Pressley, 2007; Pressley, 2006). Clearly this finding is of a fundamental nature, one with many implications. For example one can make the following assertion: *It cannot be taken for granted that the current generation of students will be adept online readers only by virtue of the being born in the digital age.* In fact, this assertion is somewhat counterintuitive to Prensky’s (2001) argument that in online environments “digital natives” have a natural advantage over the “digital immigrants.” Prensky argues that since digital natives grew up with information technology, they are more likely to be successful in online environments than digital immigrants.

Reading research, on the other hand, tells us that learning from text, even in online environments, depends to a much greater extent on variables such as prior-knowledge, knowledge of reading strategies, metacognitive skills, and motivation, than it does on the level of comfort with technology (Afflerbach, 2002; Baker, 2002; Bransford & Johnson, 1972; Mannes & Kintsch, 1987; McNamara & Kintsch, 1996; Trabasso & Bouchard, 2002). In fact, DiBiase and Kidwai (2009) found stark differences in the performance and attitudes of older and younger students in an online environment—while older students (working professionals; median age 34) thrived in the online class on introductory geographical information systems (GIS), several students in the younger (undergraduates; median age 21) population struggled to meet course deadlines. The level of engagement of the two groups, as demonstrated by participation in online discussion boards, email activity and time-on-task, was remarkably different—the older students
engaged much more deeply in class activities, and they spent more time discussing questions and sharing information and ideas with their classmates.

The determination that reading is an acquired skill has inspired a program of research that investigates the impact that use of reading strategies and instruction on these strategies can have on the reading abilities, processes, and performance of readers (National Institute of Child Health and Human Development, 2000; Palincsar & Brown, 1984; Pressley, 2000; Pressley & Harris, 2006). The current research study belongs to such a program of research. It attempts to respond to the rhetorical question posed at the beginning of this chapter: Why are some people able to read better, and learn more from what they read, than others?

The study had two purposes, (a) to design and develop a Web-based learning environment that supports the use of a set of reading strategies, and (b) to investigate the impact of this Web-based learning environment on readers’ memory and understanding of an instructional unit on the human heart (Dwyer & Lamberski, 1977). The design of the Web-based learning environment was motivated by the researcher’s belief that, (a) reading strategies can indeed be acquired through practice, and (b) affordances of new Web technologies can be used to design learning environments that support readers’ use of these reading strategies.

Web-Based Learning Environment

Theoretical Foundations

The design of the Web-based learning environment was informed by Kintsch’s Construction-Integration (CI) model (Kintsch, 1988; van Dijk & Kintsch, 1983); Paivio’s dual coding theory (Sadoski & Paivio, 2004; see also Ainsworth, 1999); research on the role of
metacognitive processes such as comprehension monitoring (Palincsar & Brown, 1984; Pressley & Ghatala, 1990; Pressley & Harris, 2006), note-taking (Kiewra, DuBois, Christian, McShane, Meyerhoffer, & Roskelley, 1991) and summarization strategies (Armbruster, Anderson, & Ostertag, 1987; Pressley, Johnson, Symons, McGoldrick, & Kurita, 1989). Theories in human-computer interaction (Carroll, 2003) informed the design of the Web-based learning environment, in particular its user interface. In order to constrain the research problem, the current investigation was focused on the learning aspects of the Web-based learning environment. Investigation of the human-computer interaction (HCI) aspects of the Web-based learning environment merits a separate study (Soloway, Guzdial, & Hay, 1994).

*Design of the Web-Based Learning Environment*

The quality of the reader’s memory and understanding of a text is a function of the quality of the mental knowledge representations that are generated upon reading the text (Kintsch, 1988; van Oostendorp & Goldman, 1999). Higher quality knowledge representations directly impact an individual’s ability to apply knowledge in novel situations. For example, the quality of knowledge representations is a known indicator of the probability of success in problem-solving situations (McNamara, E. Kintsch, Songer, & W. Kintsch, 1996). It was expected that by using the reading strategies in the Web-based learning environment, readers would be able to create higher-quality knowledge representations of instructional texts that they read in the learning environment. Although not investigated in this study, it was also expected that after multiple use of the reading strategies in the Web-based learning environment, readers would internalize the reading strategies and be able to use them outside of the Web-based learning environment (Elshout-Mohr & van Daalen-Kapteijns, 2002).
Over the course of this research, the design of the Web-based learning environment evolved over multiple iterations. What follows is a description of the final iteration of the user interface of the Web-based learning environment; screenshots from an animated demonstration of the Web-based learning environment used in the Phase IV study are used in the description. The instructional text used in the demonstration was titled “How Airplanes Work.”

Documents in the Web-based learning environment are composed of elements. Each element consists of one or more paragraphs of text. Some elements also contain an image (see Figure 1).

![Figure 1. First two elements of the “How Airplanes Work” instructional text.](image)

Readers could use five reading strategies in the Web-based learning environment. Each of these strategies is described below.

1. **Text-macrostructure (chunking) strategy**: A reader can chunk the instructional unit on the human heart into smaller sections by moving elements that make up the instructional unit
into tabs that they create on the interface of the Web-based learning environment. A reader can also label these tabs. In this way each tab on the user interface corresponds to a reader-generated section of instructional unit. An example of a sequence of steps that a reader would take in executing this strategy is provided below (see Figure 2, Figure 3, Figure 4, Figure 5). It is expected that in the process of reorganizing the instructional unit at the macro-level, the reader would begin to develop a macro-level understanding of the text—the “big picture.” Being able to customize the instructional unit in this way should also motivate the reader to engage with it deeply.

Figure 2. Text-macrostructure strategy: Creating a new section (tab on the interface).
**Figure 3.** Text-macrostructure strategy: Two new sections are created (top-left hand corner).

**Figure 4.** Text-macrostructure strategy: An element is moved to a section (tab).
Figure 5. Text-macrostructure strategy: The “aerodynamic force” tab with element 2 and element 3 in it.
2. Summarization strategy: A reader can write summaries for each section (tab) that she creates (see Figure 6). It is expected that in the process of writing summaries the reader would access her *macro-level understanding* of the instructional unit. In the process of writing summaries, gaps in macro-level understanding, if any, would be exposed. In the event the reader found gaps in understanding, she could take action—for example, rereading a particular section of the instructional unit (Armbruster, Anderson, & Ostertag, 1987).

*Figure 6. Summarization strategy.*
3. Imagery strategy: A reader can select an image from a library of images that is most representative of the contents of a given section (see Figure 7). This strategy is expected to encourage readers to integrate knowledge across modalities, which in turn should lead to creation of well integrated and robust knowledge representations (Sadoski & Paivio, 2004; see also Ainsworth, 1999).

![Image of imagery strategy](image)

*Figure 7. Imagery strategy.*
4. Reading self-assessment (comfort-meter) strategy: A reader can mark on a scale of 1-5 how comfortable she feels with her understanding of each section of the instructional unit (see Figure 8). It is expected that a metacognitively aware reader would realize that not all sections of the instructional unit are equally challenging. On the basis of this knowledge, the reader could decide to allocate cognitive resources to the more difficult sections, for example by choosing to revisit and reread them (Pressley & Harris, 2006; Pressley & Ghatala, 1990).

Figure 8. Reading self-assessment (comfort-meter) strategy.
5. **Note-taking strategy**: A reader can take notes on an *element-by-element* basis—these notes are attached to the elements that make up the instructional text (see Figure 9). It is expected that note-taking will support comprehension by allowing the reader to externalize her understanding, maintain attention, and provide a summary of the main points for a given element in the instructional unit (DiVesta & Gray, 1972; Peper & Mayer, 1986; see also Kiewra et al., 1991).

![Figure 9. Note-taking strategy.](image)

**Construction of Knowledge Representations**

Reading involves the construction of mental knowledge representations. A hypothesis of the Construction-Integration (CI) model is that readers generate these representations at multiple levels. In the research literature, at least two dimensions of these mental representations are discussed—*micro-macro* (local-global) level structures and the *textbase-situation model* structures (Fletcher, 1994; Graesser & Clark, 1985; Graesser, Millis, & Zwaan, 1997; Kintsch,
1988; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). Micro representation pertains to comprehension at the local (word and clause) level, whereas macro representation relates to comprehension at the global level (section headings, gist inferring etc.). On the other dimension, the textbase is responsible for memory of facts in the text, whereas understanding of the text is a result of the construction of the situation model.

Four types of representation arise upon crossing the micro-macro and the textbase-situation model dimensions—micro-textbase, macro-textbase, micro-situation model, macro-situation model (see Figure 10 and Table 1). Although the micro-macro and textbase-situation models have been investigated separately, the researcher did not find evidence in research literature on the simultaneous use of the four types of representation mentioned above to describe the knowledge structures that readers create when they read text. A hypothesis of this research study is that readers generate knowledge representations at four levels when they read expository texts—micro-textbase, macro-textbase, micro-situation model, macro-situation model. Based on this hypothesis four sets of Web-based measurement instruments for the instructional unit on the human heart (Dwyer & Lamberski, 1977) were designed and validated.
Figure 10. Four levels of knowledge representation.

Table 1. Assessing Four Levels of Knowledge Representation

<table>
<thead>
<tr>
<th></th>
<th>Micro</th>
<th>Macro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textbase</td>
<td>Micro-textbase test</td>
<td>Macro-textbase test</td>
</tr>
<tr>
<td>Situation model</td>
<td>Micro-situation model test</td>
<td>Macro-situation model test</td>
</tr>
</tbody>
</table>

The measurement instruments (micro-textbase, macro-textbase, micro-situation model, macro-situation model) were designed to closely reflect the theoretical framework that forms the basis of the design of the Web-based learning environment. The Web-based learning environment and the Web-based measurement instruments informed the design of each other. Four out of the five strategies designed in the Web-based learning environment (text-macrostructure, summarization, imagery and reading self-assessment) were expected to affect the
construction of knowledge representations at the macro and situation model levels (macro-textbase, micro-situation model, macro-situation model). The note-taking strategy, on the other hand, was considered to be “representation neutral” in that it was expected to affect all four levels of knowledge representation (see Figure 11).

Figure 11. Web-based learning environment design and measurement instruments design.

Research Questions

This research study had two purposes, (a) to design and develop a Web-based learning environment that supports the use of a set of reading strategies, and (b) to investigate the impact of this Web-based learning environment on readers’ memory and understanding of an
instructional unit on the human heart (Dwyer & Lamberski, 1977). These purposes led to four major research goals:

1. Guide the design of a Web-based learning environment that supports the use of a set of five reading strategies: (a) Text-macrostructure or chunking strategy: Readers can chunk the instructional unit on the human heart into smaller sections by moving elements (one or more paragraphs of text and an image) that make up the instructional unit into tabs that they create in the Web-based learning environment. (b) Summarization strategy: Readers can write a summary for each section that they create. (c) Imagery strategy: Readers can select an image from a library of images that is most representative of the contents of a given section. (d) Reading self-assessment or comfort-meter strategy: Readers can mark on a scale of 1-5 how comfortable they feel with their understanding of each section of the instructional unit. (e) Note-taking strategy: Readers can take notes on an element-by-element basis—these notes are attached to the elements that make up the instructional unit.

2. Establish validity and reliability of Web-based instruments that are designed to measure memory and understanding of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model and macro-situation model.

3. On the basis of these measurement instruments, determine whether participants who read the instructional unit on the human heart in the Web-based learning environment developed better memory and understanding of the instructional unit on the human heart when compared with participants who read the same text on a regular Web page.

4. Develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.
Research Design

Design-based research (DBR) methodology (Barab, 2006; Barab & Squire, 2004; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Collins, Joseph, & Bielaczyc, 2004; Design-Based Research Collective, 2003; Fishman, Marx, Blumenfeld, Krajcik, & Soloway, 2004; Shavelson, Phillips, Towne, & Feuer, 2003) was ideally suited to investigate the design and learning impact of the Web-based learning environment and the design of items in the Web-based measurement instruments. A series of studies with a small number of participants was conducted to determine what “worked” and what did not work in the Web-based learning environment and the Web-based measurement instruments; these studies were followed by a large-scale quasi-experimental study. Specifically, the investigation was conducted over four phases, (a) Phase I: Exploratory study related to the design of the Web-based learning environment; (b) Phase II: Design, validate and revise the Web-based measurement instruments; (c) Phase III: Design, develop, and update the Web-based learning environment; develop a feedback survey to gauge readers’ use of the five reading strategies in the Web-based learning environment, their experience in the Web-based learning environment, and their experience with the Web-based human heart tests; and (d) Phase IV: Large-scale quasi-experimental study designed to estimate the learning benefits and to develop an understanding of readers’ experience in the Web-based learning environment.

Findings from each of the first three phases of the investigation were used to fine tune the design of the Web-based learning environment, the design of the Web-based measurement instruments, and research design of the subsequent phase of the study. The research goal(s) and the numbers of participants in each phase of the design-based research investigation are summarized in Table 2.
Table 2. Number of Participants and Research Goal(s) in Each Phase of the Design-Based Research Investigation

<table>
<thead>
<tr>
<th>Phase</th>
<th>Number of Participants</th>
<th>Research Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>10</td>
<td>Research Goal 1: Guide the design of a Web-based learning environment.</td>
</tr>
<tr>
<td>Phase II</td>
<td>55</td>
<td>Research Goal 2: Establish validity and reliability of Web-based instruments that are designed to measure memory and understanding of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model and macro-situation model.</td>
</tr>
<tr>
<td>Phase III</td>
<td>43</td>
<td>Research Goal 1: Guide the design of a Web-based learning environment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research Goal 4: Develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.</td>
</tr>
<tr>
<td>Phase IV</td>
<td>685</td>
<td>Research Goal 3: Determine the impact of reading in the Web-based learning environment on readers’ memory and understanding of the instructional text on the human heart.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Research Goal 4: Develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.</td>
</tr>
</tbody>
</table>

Significance of the Research

This research makes contributions to research on reading strategies, reading strategies instruction, the use of technology in designing Web-based learning environments and Web-based measurement instruments, and the use of a design-based research methodology to guide the design of technology-enhanced environments and investigation of learning that occurs in these environments.

Findings in this study can add to our understanding of the cognitive, metacognitive and motivational processes associated with the reading strategies that are designed in the Web-based
learning environment. Furthermore, the Web-based learning environment has a potential for impacting the practice of reading strategies instruction. More broadly, the researcher wants to make a case for the affordances of new Web technologies (for example, AJAX [Garrett, 2005]) and the potential that these technologies have for designing Web-based learning environments.

The Web-based measurement instruments developed in this study can serve as a representative example of measurement instruments that measure knowledge representations at multiple levels. More broadly, the researcher wants to make a case for the role that technology (for example AJAX, autocomplete design pattern, and drag-and-drop) can play in facilitating the measurement of learners’ knowledge representations.

This research also demonstrates the role that design-based research methodology can play in (a) guiding the design of technology-enhanced learning environments, (b) developing an understanding of how learners use these environments, (c) researching learning that occurs in these environments, and (d) guiding the design of technology-enhanced assessments.

Finally, the researcher strongly believes that learning research in general and reading research in particular can benefit from an interdisciplinary approach. The current investigation serves as an example of research that brings together knowledge and research from three major fields, viz. instructional design, educational psychology, human-computer interaction and computer science.

Definition of Terms

Textbase: The textbase is relatively faithful to the text being read in that it consists of explicit propositions from the text. The textbase has both a microstructure that represents the semantic details of the text and a macrostructure that represents the gist or the main ideas that tie
together larger sections of the text (Mannes & George, 1996). The textbase is developed in an iterative process when information reduction strategies apply on initial versions of the textbase to produce a final macro-propositional textbase, one that emphasizes the more important information from the text (Goldman, Varma, & Coté, 1996). In the development of a textbase, readers apply only a small number of inferences, and when they do so, it is to achieve local semantic coherence between propositions (Graesser & Britton, 1996).

Situation model: According to Mannes and George (1996) the situation model is “not solely textbased, but rather is a combination of prior-knowledge, including the goals and attitudes of the reader, and text information….This type of representation is useful in situations that require problem solving or divergent thinking; however, when a precise replication of the previously read text is required, the situation model may not be helpful.” (pp. 116). In developing the situation model readers generate inferences based on information provided in the text as well as their prior-knowledge. Situation model leads to coherence or understanding of the text (Graesser, Singer, & Trabasso, 1994; Magliano, Zwaan, & Graesser, 1999; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998).

Micro or local representation: Microstructure is defined as the local structure of the text, the sentence by sentence information represented via propositions (Kintsch, 1998).

Macro or global representation: Macro-structure, on the other hand is the hierarchically ordered set of propositions representing the global structure of the text. Macro-structure is derived from the micro-structure; it can include paragraph headings, as well as the gist or theme of the entire essay (Kintsch, 1998).

Micro-textbase: This representation is accessed by cognitive processes that are limited to searching information that is explicitly mentioned in sentences in the text. Students have to
consider only one or two sentences in the text to answer questions that test the micro-textbase (Magliano, Millis, Ozuru, & McNamara, 2007). The following question may be used to test a micro-textbase:

**Q. The heart muscle is called the _____**.

*Macro-textbase:* This representation differs from the micro-textbase with respect to the amount of text that the reader processes to develop the representation. With regard to questions that test the macro-textbase “potential answers provide paraphrases or summary statements of the theme that are reflected in multiple propositions in the textbase” (Magliano et al., 2007, pp. 117). The following question may be used to test a macro-textbase:

**Q. The following sentences belong to paragraphs in the human heart instruction that introduce “new” sections in the instruction. Your task is to arrange these sentences in the order in which they appear in the instruction.**

- Let us consider the flow of blood on the right side of the heart.
- Let us consider the two distinct phases of blood pressure caused by the contraction and relaxation of the heart.
- You should be able to identify the left and the right side of the heart.
- In reality several movements in the heart occur simultaneously and in parallel.
- Let us consider the flow of blood on the left side of the heart.
- To understand the functioning of the heart you will need to be able to identify the parts of the heart.
**Micro-situation model representation:** This representation is generated by inferential processes that integrate information provided in the text with the reader’s prior-knowledge. Questions that test the micro-situation model representation target understanding at the *local* level. The following question may be used to test a micro-situation model representation:

*Q. Which valve on the left side of the heart acts as the counterpart of the tricuspid valve?*

**Macro-situation model representation:** Like the micro-situation model representation, this representation is generated by inferential processes that integrate information provided in the text with the reader’s prior-knowledge. Questions that test the macro-situation model representation test a reader’s *global* understanding or the mental model for the entire text. The following question may be used to test a macro-situation model representation (see also Figure 12).

*Q. Below, on the left, you are provided a list of 20 parts of the human heart and on the right are 6 empty bins. In your mind organize the parts of the heart into groups and then drag and drop them from the list on the left into bins on the right. Move as many parts into bins as you like. You do not have to use all six bins but you MUST label the bins that you fill.*

*Example: Given the list {Red, Pennsylvania, New Jersey, Yellow, Tree, Blue} you might drag and drop {Red, Yellow, Blue} into a bin and name it “Color” and then drag and drop {Pennsylvania, New Jersey} into a bin and name that bin “States.” You might decide to leave Tree unmoved.*
Figure 12. Question from the macro-situation model test.
 CHAPTER 02
LITERATURE REVIEW

Introduction

Memory, both long-term and short term, forms the basis of reading comprehension processes. Baddeley’s (2006) adaptation of the Atkinson and Shiffrin memory model (1968) informs our understanding of reading comprehension processes. The Construction-Integration (CI) model (Kintsch, 1998; van Dijk & Kintsch, 1983) is regarded as being one of the most comprehensive models of text comprehension. Understanding of features of the CI model—the role of memory, construction and integration processes, the role of strategies in comprehension, and the postulate that readers construct knowledge representations at multiple levels—played a key role in the design of the Web-based learning environment and the measurement instruments that were developed to measure readers’ memory and understanding of the instructional unit on the human heart.

Research on reading strategies informed the design of the five reading strategies in the Web-based learning environment. The role of prior-knowledge in reading comprehension cannot be overlooked. Given that understanding of the instructional unit on the human heart required a capability to mentally animate the movement of blood through the parts of the heart, participants’ spatial ability was considered to be an important covariate. Participants’ knowledge of the human anatomy was also assessed.

Research on reading comprehension points to the importance of developing appropriate assessment (Afflerbach, 2007). The focus in this study was on assessment of multiple levels of knowledge representation and the role of that technology can play in designing assessments.
These concepts form the theoretical framework for this research study. Relationships among these concepts are depicted in Figure 13.

Figure 13. Schematic for the theoretical framework for the study.

Role of Memory in Reading Comprehension

Memory Models

A crucial component of the information processing (IP) framework on which this research is based is a model for memory. Atkinson and Shiffrin’s (1968) model of memory (see Figure 14) is the most prevalent in IP literature.
Atkinson and Shiffrin’s model and its successors, conceptualize memory in terms of the following sub-components:

1. Long-term memory (LTM): Our knowledge as well as memory of experiences is stored in the LTM. LTM does not have a capacity limit.

2. Short-term memory (STM): The STM is used as a temporary store for small pieces of information. The storage capacity and the duration for which information can be retained in the STM are extremely limited.

3. Working memory (WM): WM extends the concept of STM. Not only does WM allow for simple storage of information for short durations (this role of WM overlaps with the role of STM), it also allows for manipulation of information while it is being moved to and from WM. This function of WM is responsible for information reorganization as well as transfer of information into and retrieval from LTM.

As discussed above, STM and WM are overlapping concepts. The term STM is more commonly used in situations in which the intent is to describe the function of storage. On the other hand, for describing some form of active processing in addition to the storage of information, the term WM is preferred (Baddeley, 2006).
Memory plays a crucial role in the IP framework. Performance on complex tasks such as reading comprehension is accounted for, in large part, on the processing that occurs in the WM. The quality of processing in the WM, in turn, depends on factors such as prior-knowledge, in particular the quality of this prior-knowledge—how well this knowledge is organized inside the LTM. According to the levels of processing framework (Craik & Lockhart, 1972) better organized knowledge structures, which are a result of deeper and more detailed encoding, lead to an increased probability of information retrieval. Given that WM is responsible for organizing information in LTM, prior-knowledge, particularly how well it is organized, is both a cause and an effect of successful processing in the WM.

The idea of working memory is implicit in all models of text comprehension. As an example, van Dijk and Kintsch’s Construction-Integration (CI) model (1983) takes into account the limited capacity of working memory by postulating that only a limited number of propositions—building blocks in the CI model—can be processed in the WM at one time. The constraints imposed on comprehension processes by the limits of memory resources, especially the working memory, are considered in the next section.

Text Comprehension Processes and Memory

Comprehension involves several complex processes that take place in parallel. For successful comprehension, each of these processes has to be completed rapidly and accurately. These processes occur at micro and macro levels; the processes range from letter and phoneme identification, to word identification, to comprehension of individual sentences, paragraphs, and entire chapters in a book. Each process in this hierarchy is more complex than the processes earlier in the hierarchy (Adams, 1994).
For example a series of processes is triggered when a reader reads a word. This series originates in the visual sketchpad, followed by an activation of the pronunciation of the word in the phonological loop. A rapid activation of the pronunciation upon identification of the word is contingent on the availability of orthographic knowledge (in the case of non-ideographic languages)—a network of associations between the orthographic (visual) and the phonological (phonetic) information associated with the word. These associations reside in the LTM. In the case of beginning readers such orthographic knowledge is missing for all except the simplest words, and therefore, word recognition tends to be an effortful, slower and lower level process. In order to decode most words, they have to take recourse to the letter-sound mapping knowledge. Repeated practice with letter-sound mappings leads to development of higher level mappings—mappings between a collection of letters and their sounds in the spoken form of the word (phonemes). This is how, with repeated practice, readers are able to build up orthographic knowledge (de Jong, 2006).

Once an individual word has been decoded, the reader proceeds to read other words further along in the sentence in order to understand the meaning of the sentence. Upon reading a sentence the reader attempts to link the meanings of the current sentence with preceding sentences in the paragraph so as to comprehend the meaning of the paragraph as a whole. During this entire process the reader generates inferences and calls upon prior-knowledge to fill gaps in understanding. Along with these cognitive processes, meta-cognitive processes also come into play, processes such as “comprehension monitoring” that readers use to check their understanding of the text. If readers find inconsistencies in the meaning that has been derived so far, they reread the text and make another attempt at deriving an understanding. The central executive in the WM is responsible for this kind of metacognitive processing (Cain, 2006).
Given its role in comprehension processes, it is not surprising that WM ability of an individual is a good indicator of a reader’s performance on reading comprehension tasks (Cain, Oakhill, & Bryant, 2004; Seigneuric, Ehrlich, Oakhill, & Yuill, 2000). Likewise prior-knowledge (LTM) is a strong predictor of comprehension performance (McNamara & Kintsch, 1996; Shapiro, 2004). In summary, memory—both WM and LTM—plays a crucial role in comprehension processes. The reading strategies in the Web-based learning environment, particularly the text-macrostructure strategy is expected to support comprehension processes by allowing readers to externalize their macro-level representation of the instructional text on the human heart. The external macro-level representation of the texts should free up cognitive resources that would otherwise be used every time this information was retrieved from LTM. The external macro-representation is also expected to scaffold micro-level cognitive processes such as processes involved in generation of inferences. It is the successful execution of these micro-processes that ultimately leads to the generation of a mental model.

Construction-Integration Model

According to Graesser and Britton (1996), a model of text comprehension should be capable of the following: modeling the cognitive representations that are constructed during comprehension; specifying processing mechanisms that lead to the generation of these representations; and explaining performance on behavioral indices such as performance on recall and question-answering tasks. Furthermore, such a model should be applicable to different types of text (narrative, expository) and reader characteristics (cognitive styles, reading goals).

The Construction-Integration (CI) model (Kintsch, 1988; van Dijk & Kintsch, 1983) is one such model of text comprehension. The CI model is regarded as being one of the most
comprehensive models of text comprehension (Graesser, 2007). This model has withstood more than 25 years of research scrutiny during which time the model has been continually updated. The CI model is able to simulate an ever increasing number of comprehension processes and explain a large amount of behavioral data. This model has played a key role in the design of the Web-based learning environment and the Web-based measurement instruments that were investigated in this study.

Propositions as Building Blocks

In the CI model, propositions are understood as building blocks of larger text structures (sentences, paragraphs and so on), quite like the chemical perspective in which atoms are building blocks of more complex molecules. According to the CI model, both “text” (which includes printed text, verbal communication etc.) as well as reader’s prior-knowledge can be represented as a network of propositions. An assumption of the CI model is that these representations exist in a hierarchy of abstractness and increasing independence from the environment (see Figure 15). Each level in this hierarchy can be modeled as a propositional network (Kintsch, 1998).
Rouet (2006) has noted empirical evidence that supports the psychological reality of propositional networks. Kintsch, Kozminsky, Streby, McKoon, and Keenan (1975) demonstrated that psychological processes that occur during reading comprehension can be simulated in terms of propositional networks. They found the probability of recall of propositions to be a function of hierarchical position of these propositions in the text structure—propositions that were further up in the hierarchy were more likely to be recalled when compared with propositions lower in the hierarchy.

Role of Memory in the CI Model

WM plays a crucial role in the CI model. An assumption of the CI model is that only those propositions that reside in WM simultaneously can become connected. Similarly, the role of prior-knowledge (LTM) in the CI model is explicit (McNamara & Kintsch, 1996; Spilich, Vesonder, Chiesi, & Voss, 1979; Voss, Vesonder, & Spilich, 1980). Long-term memory (LTM)
is understood to be a by-product of cognitive processing that takes place in the WM—processes in WM encode elements in LTM with retrieval cues. Those elements in the LTM that are currently active are called short-term working memory (ST-WM). Elements in the LTM linked to elements in the ST-WM via retrieval cues are called long-term working memory (LT-WM) (Ericsson & Kintsch, 1995). The strength of the connections between elements in the ST-WM and LT-WM determines the likelihood of the elements in the LT-WM being activated in response to elements in the ST-WM being activated (see Figure 16). The LT-WM comes at a premium, it is limited to experts—people with superior knowledge and encoding skills.

![Diagram showing LTM, ST-WM, and LT-WM connections.](image)

*Figure 16. LTM, ST-WM and LT-WM*

Comprehension is Strategic

A strategy involves human action; it is goal-oriented, intentional and conscious; strategies become automatized with repeated practice. The CI model postulates that reading comprehension is necessarily strategic; that is, it is goal-oriented, intentional and conscious, until it becomes automatized with repeated practice.

In the CI model comprehension is understood as a process that involves both bottom-up and top-down processing. Readers use bottom-up strategies to construct preliminary propositional networks. This step is followed by a constraint satisfaction process (top-down) that attempts to integrate the network of propositions formed thus far into a coherent mental representation. The processes of construction and integration do not occur sequentially, instead they occur simultaneously.

Bottom-up processes involve tasks such as feature detection, letter identification, word recognition and sentence parsing. Top-down processing (guessing or hypothesis-testing) takes place from the opposite direction—perception of letters is influenced by the reader’s knowledge of words; recognition of words is influenced by the sentence context in which they are presented; sentence processing itself is determined by the status of the sentence within a larger chunk of text. For example, in processing a simple sentence such as “Three masked men robbed a bank yesterday,” readers first retrieve all of the meanings of the word “bank” (construction process) and only later a choice is made among these alternatives, at which time the inappropriate meanings are rapidly deactivated as part of the integration process (Kintsch, 1998).

According to the construction-integration hypothesis, good readers are better—quicker and more accurate—at decoding as well as hypothesis-testing. However, because of their
superior decoding skills these readers do not have to resort to hypothesis-testing often, but when they do, they do it well.

Given the fact that comprehension is complex and it involves a multitude of processes, it follows that reading strategies are necessarily extremely efficient and automatized when compared for example with strategies considered in problem-solving literature. In fact, comprehension takes place in real time, i.e. we do not first process and store data and only afterwards assign meaning to it. Post-hoc processing is simply not possible due to the limits of the working memory and the speed with which even average readers are able to comprehend text. Instead, readers construct several working hypotheses in real time and as they read, they continuously rule out hypotheses; the hypothesis that remains is integrated in the situation model.

The overall goal of comprehension processes is to be as effective and as efficient as possible, i.e. during reading, readers attempt to create and validate mental representations of the text as quickly as possible and as well as possible. In other words, a reader does not wait until the end of a paragraph or a chapter before being able to infer what the text is about—initial hypotheses are created early on in the process; the reader either retains these hypotheses or rejects them in favor of other hypotheses. The five reading strategies designed in the Web-based learning environment are expected to support these processes of construction and integration.

**Hierarchy of Comprehension Strategies**

Another postulate of the CI model is that comprehension is an iterative process that involves application of strategies of varying complexity. Kintsch (1998) postulates the following levels of strategies (from lower to higher level):
1. Strategies for construction of propositions: These strategies lead to generation of propositions on the basis of word meanings and the syntactic structure of clauses.

2. Strategies for interconnecting the propositions in a network: These strategies lead to generation of meaningful connections between successive sentences in a text.

3. Macro-strategies: These strategies allow a reader to infer macro-propositions from a sequence of propositions. These strategies are recursive—given a sequence of macro propositions, they may apply again and again, each time deriving a still higher level of macrostructure. Macro-strategies lead to information reduction and re-organization.

4. Superstructural strategies: These strategies allow a reader to infer the superstructure of various texts genres. For example, stories generally have the following superstructure:

   setting —> complication —> resolution

Readers familiar with this superstructure use it as a top-down processing device to organize their understanding of a story.

Levels of Knowledge Representations

Even though text models vary in the terminology used to represent different levels of knowledge representation, all models agree on the existence of multiple levels of knowledge representation (Fletcher, 1994; Graesser & Clark, 1985; Graesser, Millis, & Zwaan, 1997; Kintsch, 1988; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). The CI model postulates two dimensions that can be used to characterize the mental representations that readers generate upon reading text.

1. Micro- and Macro-structure: Micro-structure is defined as the local structure of the text, the sentence by sentence information represented via propositions. Macro-structure, on the
other hand is the hierarchically ordered set of propositions representing the global structure of the text. Macro-structure is derived from the micro-structure; it can include paragraph headings, as well as the gist or theme of the entire essay. In the CI model, formation of these macro-structures is considered to be an automatic process.

2. Textbase and Situation Model: Textbase is a semantic representation of the text. Textbases are defined in terms of propositions and the relations among these propositions. Only those propositions that are necessary to establish coherence at the local or global level become part of the textbase. The textbase is relatively faithful to the text. The textbase has both a microstructure that represents the semantic details of the text and a macrostructure that represents the gist or the main ideas that tie together larger sections of the text (Mannes & George, 1996). The textbase is developed in an iterative process. For example, information reduction strategies can apply on an initial version of the textbase to produce a macro-propositional textbase that emphasizes the more important information from the text (Goldman, Varma, & Coté, 1996). In the development of a textbase readers apply only a small number of inferences, and when they do so, it is to achieve local semantic coherence between propositions (Graesser & Britton, 1996). The propositional textbase captures the explicit ideas in the text, but it is not necessarily sufficient to establish a coherent representation (Giora, 1985).

According to the CI model, only in rare cases, is the result of comprehension a pure textbase. Usually in order to understand a text, readers supplement the information provided in the text with their knowledge and experience (long-term memory). The complete structure that is composed of both text-derived propositions (textbase) and propositions contributed from the long-term memory is called the situation model (see Figure 17). In this regard, learner’s prior-knowledge is crucial to the successful creation of the situation model which leads to coherence
or understanding of the text (Graesser, Singer, & Trabasso, 1994; Magliano, Zwaan, & Graesser, 1999; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). A postulate of the CI model is that the textbase and the situation model are continuously compared with each other and updated.

**Situation Model = Textbase + Comprehender’s Prior-Knowledge**

*Figure 17. Situation model.*

Four out of the five strategies designed in the Web-based learning environment (text-macrostructure, summarization, imagery and reading self-assessment) are expected to affect the construction of knowledge representations at the macro and situation model levels (macro-textbase, micro-situation model, macro-situation model). The note-taking strategy, on the other hand, is considered to be “representation neutral” in that it is expected to affect all four levels of knowledge representation.


Reading research makes a distinction between deep and shallow comprehension. Deep comprehension entails generation of inferences, making connections between prior-knowledge and the text being read. Shallow comprehension on the other hand is limited to processes such as
syntactic parsing, generation of a propositional textbase model, and interpretation of text without
the generation of inferences. The levels of knowledge representation postulate in the CI model
points to a distinction between memory and understanding.

Memory vs. Understanding

According to the CI model the two extreme outcomes of comprehension are mere
memory and rich understanding. These extremes map to the textbase <—> situation model
continuum (Kintsch, 1994). Schmalhofer and Glavanov (1986) demonstrated that providing
different goals to readers led them to focus on one or the other level of representation. When
participants were asked to read the text so that they could summarize it, they were found to
develop better verbatim and textbase representations of text. On the other hand, readers who
were asked to read the text to acquire knowledge, focused on the situation model. This was
evident from their superior performance on tasks that required the situation model (for example
problem solving tasks), these participants performed poorly on tasks that required verbatim and
textbase representations.

Research makes a distinction between memory and understanding and pointes to a need
to develop means for assessing these different representations (see Table 3).
Table 3. Memory vs. Understanding

<table>
<thead>
<tr>
<th>Memory</th>
<th>Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good memory is a result of a good textbase</td>
<td>Deep understanding is a result of a good situation model</td>
</tr>
<tr>
<td>Text memory may be achieved on the basis of only superficial understanding.</td>
<td>Deep understanding requires that the information provided in the text be integrated with reader’s prior-knowledge, so that it can support comprehension and problem solving in new situations.</td>
</tr>
</tbody>
</table>

**Measures:**
We test learner’s memory (textbase) when we test for information that is explicitly mentioned in the text.

E.g. Factual questions, recognition tasks etc.

**Measures:**
We test learner’s understanding (situation model) when we test information/knowledge that is not explicitly mentioned in the text.

E.g. Inference questions, problem solving, keyword-sorting tasks, knowledge organization tasks etc.

**Critique of the CI model**

The CI model is not without criticism. For example, Fletcher, van der Broek, and Arthur (1996) note that although the model addresses the role of short-term and long-term memory it “ignores the fact that understanding a text is largely a problem-solving task” (p. 141). In comparison, Trabasso and van den Broek’s model (1985) “emphasizes the role of problem solving and ignores the constraints imposed by long- and short-term memory” (p. 141). Fletcher and Bloom (1988) have proposed their own model—a hybrid model that explains the comprehension of narrative texts. They claim that their model is consistent with the two models just mentioned. Graesser (2007) has expressed a similar criticism of the CI model:
Strategies take a back seat in the CI model. Strategies exist, but they do not drive the comprehension engine. Instead, the front seat of comprehension lies in the bottom up activation of knowledge in the long-term memory from textual input (the construction phase) and the integration of activation ideas in the working memory (the integration phase). ...a strategy is simply a piece of knowledge stored in long-term memory that is periodically activated and recruited during integration (p. 11).

Comprehension Processes

Block and Pressley (2002) have noted more than 30 cognitive and metacognitive processes relating to reading comprehension.

...making connections to background knowledge, interpreting text structures, questioning clarifying meaning, comparing, contrasting, summarizing, imagery, setting purposes, using fix-up strategies, monitoring, cognizing, interpreting authors’ intentions, pausing to reflect, paraphrasing, analyzing, recognizing personal perspectives, identifying gists, changing hypotheses, adding hypotheses, searching for meaning, being alert to main ideas, creating themes, determining importance, drawing inferences, corroborating congenial and non-congenial data, contextualizing, engaging in retrospection, generating, using mnemonic devices, predicting, organizing, and reorganizing text (p. 3).

A subset of these cognitive processes can be mapped to the five reading strategies that are designed in the Web-based learning environment (see Figure 13). Although, conceptually,
comprehension processes can be thought to occur sequentially (Ferreira & Clifton, 1986), in reality many of these processes likely occur in parallel (Wiley & Rayner, 2000).

Irwin (1991) has proposed a model for reading comprehension processes with five categories: (1) **Microprocesses**: Derivation of meaning from individual idea units within sentence; (2) **Integrative processes**: Understanding and/or inference of the relationships between individual clauses and sentences; (3) **Macroprocesses**: Use of macro structures to synthesize and organize individual (micro) idea units; (4) **Elaborative**: Inferences, not necessarily intended by the author, that have to be made in order to understand the text and relate it to the reader’s prior-knowledge; and (5) **Metacognitive**: Processes involved in selection of reading strategies and comprehension monitoring or reading self-assessment.

Elaborative or inferential processes are crucial to obtaining a deep understanding of a text. Graesser and Britton (1996) define knowledge based inferences as “those inferences that are constructed when knowledge structures from long-term memory are activated and incorporated into the meaning representation of the text” (p. 11). Knowledge based inferences can be copied directly from prior-knowledge, or in the case when novel inferences are required, these inferences are constructed after several iterative cycles of information exchange between the LTM and STM (Just & Carpenter, 1992).

Comprehension processes bring together information presented in the text and the reader’s prior-knowledge. In doing so new memory structures or representations are created; these structures occur at multiple levels.
Graesser (2007) has defined a reading strategy as “…a cognitive or behavioral action that is enacted under particular contextual conditions, with the goal of improving some aspect of comprehension” (p. 6).

In contrast to knowledge of facts which is understood as a type of declarative knowledge, knowledge of strategies is considered a form of procedural knowledge. Strategic and declarative knowledge are not unrelated though. A reader who possesses sound reading strategies (procedural knowledge) is more likely to develop better knowledge structures (declarative knowledge) and vice versa (Pressley & Harris, 2006). Research underscores the need to develop good reading strategies—the sooner learners acquire these habits the better placed they will be to acquire new knowledge and skills. Stanovich (1986) has described this situation as “rich-get-richer and poor-get-poorer patterns of reading achievement” (p. 360).

Comprehension strategies are a part of our general knowledge; they represent the procedural knowledge that we have about understanding text. Some strategies such as those related to word and clause comprehension are acquired at an early age; others such as gist inferring are acquired rather late, if at all. Strategies such as those related to understanding the structure of research articles may only be acquired with special training. It is also worth noting that we perform many actions without the use of a strategy. Strategies become important only when the means for reaching the end goals become very costly and/or risky—exactly the situation readers encounter while reading challenging texts.
Kintsch (1998) has noted the differences between strategic processing and rule-governed algorithmic processing (see Table 4). This table explains why text comprehension is strategic and not rule-governed.

Table 4. Rule-Governed Processes vs. Strategic Processes

<table>
<thead>
<tr>
<th>Rule-governed Algorithmic Processes</th>
<th>Strategic Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rules define possible moves. They are well defined and absolute.</td>
<td>Strategies determine which choices are made among the possible moves so that the goals are optimally met.</td>
</tr>
<tr>
<td>Algorithms rely on blind, methodological application of rules.</td>
<td>Strategies are intelligent.</td>
</tr>
<tr>
<td>Algorithms guarantee that the rules, if applied correctly will eventually produce a solution. Success is guaranteed, but only in principle, not in real situations—there are no guarantees as to the quickness or the computational costs.</td>
<td>Strategies are intelligent guesswork, and unlike algorithms, carry no guarantee for a solution. However, they do make it possible to solve complex problems (such as comprehension) given the time and resources available. Strategies face the risk of failure (no understanding) or error (misunderstanding).</td>
</tr>
</tbody>
</table>

There is ample research evidence that demonstrates that good readers are successful strategy users (National Reading Panel, 2000; Palincsar & Brown, 1984; Pressley, 2000). At the same time, it has been found that college students vary a great deal in their knowledge and actual use of reading strategies (Lonka, Lindblom-Ylanne, & Maury, 1994; Simpson & Nist, 2000).

Metacognitive ability plays a crucial role in tasks that require strategic processing. For example, Pressley and Harris (2006) have noted two forms of metacognitive knowledge that are important indicators of successful execution of tasks that require strategies: (a) knowledge of when and where specific strategies should be applied (conditional knowledge), and (b) knowledge about the value of cognitive strategies which motivates the use of these strategies.
Pressley and Harris have noted that readers are more likely to be able to learn new strategies and apply them in novel settings if the strategy instruction that they receive is metacognitively rich.

Frameworks for Organizing Understanding of Research on Reading Strategies

Graesser (2007) has identified a set of attributes of reading strategies that can be used to organize our understanding of these strategies. These attributes are: (a) Level of representation that is being tapped by the strategy; (b) Prerequisite knowledge and skills needed to apply the strategy; (c) What prerequisite knowledge and skills will yield maximal gains from the strategy? (d) How much training is needed for the mastery of the strategy? (e) Does the strategy need to be explicit and conscious, or is unconscious induction adequate? (f) Is the strategy executed before, during or after the mental engagement with the context and subject matter? (g) What are the relevant genres and domain knowledge for the strategy? (h) Is the strategy best scaffolded by human or computer? Graesser (2007) suggests that even though answers to these questions will vary substantially from one strategy to another, investigation of a large number of strategies within this framework may lead to “meta-principles” (p. 10).

McNamara, Ozuru, Best, & O’Reilly (2007) have proposed the following framework for organizing reading strategies (see Figure 18).
At the center of this framework is comprehension monitoring. Successful execution of processes that enable the construction of a robust and effective situation model is contingent upon the reader being metacognitively aware and mindful of the outcome of these processes (for example failure or success). The four “prongs” of the framework are:

1. *Preparing to read*: Strategies that readers use to plan the reading task, for example setting of goals.

2. *Interpret words, sentences and ideas in the text*: Strategies in this category include word level strategies such as guessing the meaning of words based on the context; and higher level strategies that have to do with construction of meaning of individual sentences, paragraphs...
and the entire text. In essence the strategies in this category pertain to the construction of the textbase.

3. Go beyond the text: Strategies that readers use to construct a situation model by making connections between information that is provided in the text and their prior-knowledge. In order to be able to construct a robust mental model, readers should be able to make inferences. In some situations inference generation can happen with very little effort, while in other situations it may require explicit use of strategies such as question asking and checking for coherence.

4. Organize, restructure, and synthesize: Effortful processing that takes place by means of strategies that include organization, synthesis, and restructuring of knowledge networks is required for the construction of a robust, well organized, coherent mental model.

These models provide a framework for understanding reading strategies and informed the design of reading strategies in the Web-based learning environment being investigated in this study.

Reading Strategies in the Web-Based Learning Environment

1. Text-macrostructure (chunking) strategy.

Although most of the information contained in expository texts is content information, some of it also concerns the structure. The structural information is important, because if it used effectively it can aid in the process of construction a coherent mental representation of the text. For example, Meyer and Rice (1982) found that skilled readers typically make use of some form of text structure strategy. Structure information could be of different types. For example, it could be headings and titles that orient the reader to the overall organization of the text. It could be
phrases, such as *so far, next, let us consider*, that not only quickly identify a particular genre (narrative or expository), but also a particular type of structure within a genre (Williams, 2007). Meyer and Freedle (1984) point to evidence that supports the psychological reality of structure information.

Text structure information can represent useful information about logical connections between parts of a text. According to Rouet (2006), “Complex text comes with a variety of cues and adjunct information that help competent readers identify the document’s top-level organization, locate important information, and establish meaningful connections between text segments” (p. 35). Awareness of the existence of this information and ability to use it can aid comprehension (Meyer & Poon, 2001).

Likewise, Rouet (2006) notes that skilled comprehension depends not only on prior-knowledge of the readers in relation to the content of the text being read, it also depends on the reader’s knowledge of the “shape” of the text, that is the “visual and verbal devices that are used to structure the text” (p. 31). Knowledge of rhetorical schemata—universal communicative patterns that authors consciously or unconsciously use in text—is used by readers in comprehending text. Different text genres involve different rhetorical schemata and skilled readers are aware of these differences. For example, Graesser, Golding, and Long (1991) investigated the use of story grammars in the comprehension of narrative texts. They identified several components in narrative texts (characters, temporal and spatial relationships, character goals and communication acts, plots, complications, and resolutions) and found that expert readers look for these components while reading and use this information as a basis for structuring their understanding of the story. In contrast, the role of rhetorical schemata in the comprehension of expository texts is less well known (Rouet, 2006).
Meyer and Wijekumar (2007) have contrasted a structure-strategy approach with a list-strategy approach that presents text as a list of facts that needs to be remembered. Research (Meyer, Brandt, & Bluth, 1980; Meyer & Rice, 1982; Loman & Mayer, 1983) shows that some readers who are predisposed to using the list-strategy switch to a structure-strategy when they come across signals that highlight the super structure of the text (e.g. headings in a text).

Meyer and Poon (2001) have elaborated a typology of rhetorical structures for expository texts. Likewise, Rouet (2006) has proposed a typology for “text organizers.” In his typology, Rouet considers text organizers that range from phrases such as “for example” to titles and headings, introductions, table of contents, page number and section numbers. Some of these organizers are visual (those that have to do with position and spacing of information) while others are verbal (those that reinforce and make explicit the semantic structure of the text). Since both visual and verbal organizers add to the meaning of the text, the ability to use both forms of information is crucial in successful comprehension of a text. Rouet also discusses individual differences in the use of these text organizers.

It is worth noting that even though there is substantial research on the readers’ use of the structural information contained in expository texts, the researcher did not find support in research literature for text-macrostructure strategy designed in the Web-based learning environment being investigated in this study.

Instruction on text structure strategy involves teaching readers how to identify structure information in texts and to use this information to plan their reading task. For example, students are instructed to look for phrases such as “in contrast” and “on the other hand” in order to identify expository texts that have a “comparison” structure (Meyer & Wijekumar, 2007). Readers use this structural information to organize their reading comprehension as well as recall.
Research has demonstrated the benefits of instructing students on the use of structure strategy (Armbruster, Anderson, & Ostertag, 1987; Lorch & Lorch, 1996, Meyer & Poon, 2001; Meyer, Middlemiss, Theodorou, Brezinski, McDougall, & Bartlett, 2002; Williams, Hall, & Lauer, 2004). Likewise, Gersten, Fuchs, Williams, & Baker (2001) demonstrated that instruction that teaches students to recognize and use structure information in texts can lead to improvements in comprehension. Theodorou (2006) trained medical students to identify the “problem and solution” structure in medical texts. Interestingly, even though these students were able to successfully apply this strategy with medical texts, the strategy did not readily transfer to texts from other domains.

According to Williams (2007) the goal of structure strategy instruction should be to make students aware of the structural information contained in texts and to provide them enough practice so that they can pickup and use structural cues that are present in expository texts. Such instruction should also strive to inculcate in readers the ability to apply their knowledge of text structures to texts that are seemingly disorganized or lacking in structure so as to be able to reorganize or add structural information that is otherwise missing in these texts. “Ideally this will happen automatically; however, if it does not, then the students should be able to apply their knowledge consciously, knowing that they are using a cognitive strategy” (p. 201).

2. Summarization strategy.

Summarization encourages readers to test their knowledge and take remedial action to correct any inconsistencies and gaps in understanding. In particular, it provides readers an opportunity to revisit their macro-level organization of the text and update it as needed. This process can scaffold the creation of macro-structures (Armbruster, Anderson, & Ostertag, 1987).
3. Imagery strategy.

A premise of Paivio’s dual coding theory (Sadoski & Paivio, 2004) is that information is stored in verbal and non-verbal forms and that learners’ knowledge representations are composed of complex associative networks between information stored in these two forms. Early research (Pressley, 1977) to test this model demonstrated that when students were induced to construct mental images of the content covered in the text, their memory as well as understanding of the text increased. Instructional texts, particularly those that contain explicit spatio-visual information can benefit from dual coding of information.


Unskilled readers are often poor at evaluating their level of comprehension (Baker, 1985; Pressley & Ghatala, 1990). Research offers at least two explanations (a) readers set low standards of comprehension—they focus on and are satisfied with a low level of understanding, or (b) they monitor their comprehension incorrectly, i.e. they overestimate their understanding of a text (McNamara et al., 2007).

Afflerbach (2002) makes a case for teaching readers comprehension monitoring skills. He notes that even though researchers agree that skills such as decoding, vocabulary, and knowledge of reading strategies are crucial to reading success, the importance of reading self-assessment is often overlooked. Yet, as Afflerbach points out, it is reading self-assessment that allows readers to be truly independent readers: “Every reading standard that demands students’ independence implies students’ ability to access their own reading effectively” (p. 98). McNamara, Ozuru, Best, & O’Reilly (2007) underscore the importance of metacognitive strategies by noting research (Alexander & Judy, 1988; O’Reilly, Symons & MacLatchy-Gaudet, 1998) that
demonstrates how success of reading strategies in general depends on the metacognitive ability and goals of the reader, “…although having a repository of strategies is advantageous, the reader must also self-regulate (or monitor) the success of these strategies and the reading process” (p. 469). They use the term *metacomprehension* to describe metacognitive strategies such as comprehension monitoring.

Block and Pressley (2002) have noted that successful readers skillfully monitor multiple aspects of their reading such as, “whether text is relevant to a current reading goal, the difficulty level of the text, the style of the text, the text’s linguistic characteristics, the biases in the text, the relationship of parts of a text to larger themes in the text, the relationship of this text to other texts, when text is ambiguous, the relationship of the reader’s background knowledge to the text, the tone of the text, and problems encountered in reading (e.g. loss of concentration, reading too quickly or too slowly, poorly written text, lack of background knowledge to understand text)” (p. 17). Skillful readers spontaneously shift their attention to one among many possibilities: “attempting to figure out the meaning of a word detected as unknown, deciding whether to interpret text as strictly or liberally, decide whether to attend to or read carefully only certain parts of the text that are most likely to be understood or most likely to be helpful, deciding to look up background material (e.g., a word in a dictionary) before continuing to read the text, attempting to pinpoint the parts of the text that are confusing, and deciding to reread material that might be understood with more effort” (p. 17). Furthermore, metacognitively aware readers avoid certain behaviors, for example, these readers avoid getting distracted.
5. Note-taking strategy.

Note-taking can induce comprehension by allowing readers to externally record their understanding, maintain attention, and provide a summary of the main points from the text. In this way note-taking can also help readers monitor their comprehension.

DiVesta and Gray (1972) have distinguished between two possible functions of note-taking (a) *storage*—students use notes as a form of external storage that they refer to for reviewing purposes; (b) *encoding*—while students are taking notes they engage in processes that can lead to reorganization of knowledge structures. On the other hand, Kiewra et al. (1991) have questioned the hypothesis that encoding actually takes place during note-taking. They have argued that encoding only occurs when notes are reviewed. While reviewing notes, readers generate connections and integrate ideas presented in the text with their prior-knowledge.

Models that explain the note-taking process can be classified into quantitative and qualitative. Quantitative theories suggest that note-taking primarily affects *how much* information is encoded. Within this view, note-taking should lead to increased levels of recall for all levels of information. The qualitative theories on the other hand suggest that note-taking affects comprehension by affecting the *nature and quality* of the processing—in that it facilitates deeper comprehension and knowledge integration. I.e. learners create more sophisticated knowledge structures because of note-taking. Based on this view, note-taking should lead to superior performance on tasks that require higher-order knowledge, for example problem-solving tasks. In fact, Peper and Mayer (1986) found that note-takers perform better than non-note-takers on far-transfer tasks, but worse on near-transfer tasks, such as fact retention. Their hypothesis is that note-taking involves integration (with prior-knowledge) and reorganization of information.
Since the information has been reorganized, performance on near transfer tasks such as verbatim recall might actually drop.

A difference between high ability learners and low ability learners is the spontaneous use of generative strategies during learning. This explains why low ability learners are found to gain more from note-taking (note-taking directs them to engage in generative strategies) than high ability learners (Shrager & Mayer, 1989).

Kiewra et al. (1991) found that the number of times a lecture is presented correlates positively with the overall amount of information that note-takers integrate in their notes. Their hypothesis is that repetition allows learners to adjust their strategies each time the lecture is presented. They found that learners focus on different aspects of the lecture during successive repetitions, a strategy they called “successive differentiation.” While repetition of face-to-face lectures is not realistic, online lessons can typically be viewed by learners any number of times. In this regard, an online note-taking system in a Web-based learning environment could be beneficial.

Different techniques for creating notes have been investigated. For example, Kiewra et al. (1991) compared a linear framework with a matrix framework. On the other hand, Dean and Kulhavy (1981) investigated the potential of maps and learner-generated drawings in facilitating comprehension and retention of extended expository texts. Their hypothesis was that construction of maps and drawings requires learners to process the text more “thoroughly in an attempt to organize the content within the confines of the spatial structures” (p. 63).
Multiple Strategies

Early research on reading strategies entailed setting up studies that evaluated individual strategies. But as Pressley and Harris (2006) point out, this approach does not represent how strategies are used in situ, especially in the case of expert learners. In executing tasks such as text comprehension, expert learners routinely apply a network of strategies—dynamically choosing optimal strategies from a pool of strategies. Likewise, successful readers do not rely on individual reading strategies; instead they use a repertoire of strategies from which they select individual strategies as they encounter local and global comprehension challenges. A repertoire of reading strategies can include strategies such as making predictions; asking questions; reflecting; going back and forth between different portions of the text; estimating the importance, difficulty level and degree of comfort with different portions of the text and adjusting reading rates based on this estimation; pausing to look up certain unfamiliar words in the dictionary while guessing the meaning of other words based on the content.

The Web-based learning environment being investigated in this research is designed in this spirit of providing readers a repertoire of strategies to work with.

Reading Strategies Instruction

Instruction on Reading Strategies

Pressley and Harris (2006) contend that understanding human performance requires an understanding of the psychology of strategies. Even though strategies play a crucial role in our learning, many learners are unable to effectively use strategies. Given this situation, Pressley and
Harris call for research on finding efficient ways in which strategies can be developed in
learners.

Durkin’s (1978) study, which exposed a lack of reading strategies instruction in reading
and social science classrooms at the time the research was carried out, is considered to have
triggered a series of studies on reading strategies instruction. Her study unequivocally
demonstrated that little to no time was spent teaching comprehension strategies; instead, the
focus was on assessing comprehension. According to the Pressley (2002), the situation has not
improved much over the years. This is surprising because, since the publication of the Durkin
study, a substantial amount of research has demonstrated that students who are taught reading
strategies use these strategies in ways that leads to improvement in memory as well as
Likewise, Palincsar et al. (2007) note, that despite the evidence regarding the positive impact of
reading comprehension instruction, researchers and practitioners have struggled to translate
research findings into student achievement. A possible explanation may lie in findings from
studies by Bryant, Linan-Thompson, Ugel, Hamf and Hougen (2001) and Vaughn, Moody and
Schuman (1998) that provide evidence that teachers feel inadequately prepared to teach reading
comprehension strategies, especially to struggling readers. The National Institute of Child Health
and Human Development (2000) report confirms this hypothesis, “reading comprehension
instruction is extremely complex and that teaching reading comprehension is also extremely
complex” (p. 4-125).

Despite these findings, a plethora of comprehension strategy programs have been
developed over the years. For example, Block and Presley’s (2002) edited book describes at least
14 programs for teaching comprehension: transactional strategies instruction, thinking-processes
development, reciprocal teaching, CORI, CSR, SAIL, QAR, K-W-L, explicit elaborate instruction, informed strategies training, cognitive apprenticeships, imaginary training, *Reason to Read* strategies, and WebQuests. A common goal of most of these programs is to provide enough opportunities to practice so that the reader internalizes a strategy and after a point its use becomes automatic (Williams, 2007). At the same time, McNamara, Ozuru, Best and O’Reilly (2007) note that the goal of strategy instruction should not be limited to teaching students *how* (procedural knowledge) to use a particular strategy, it should also include instruction on *when* (conditional knowledge) to use a given strategy.

Reading strategy instruction not only leads to improvement in learner’s strategic processing of text, it can impact them in other ways as well. For example, King (2007) contends that reading strategies instruction should also promote a disposition towards deep understanding and higher standards of coherence.

Ogle (2007) notes the following problem with reading strategies instruction at the middle school level upwards: teachers that are focused on content generally do not feel responsible for developing the sophisticated reading strategies in students. In this situation students are left without guidance in comprehending complex texts in science, mathematics, social studies, practical arts and literature (Snow, 2002). Students at these grade levels are expected to be able to interpret primary-source documents, scientific reports, visual displays and charts, and mathematical representations—all non-trivial tasks, especially if students are not provided instruction on strategies for dealing with such content (Pressley, Wharton-McDonald, Hampson, & Echevarria, 1998). Ogle points out that the situation is further exacerbated by the increasingly wide range of competence and interests of students.
Although not investigated in this study, it is expected that after multiple use of the reading strategies in the Web-based learning environment, readers would internalize the reading strategies and be able to use them outside of the Web-based learning environment (Elshout-Mohr & van Daalen-Kapteijns, 2002). In this way the Web-based learning environment can also serve the purpose of providing instruction on reading strategies.

Direct Instruction on Strategies

Direct explanation of reading strategies is an approach to teaching reading strategies that begins with teacher explanations. With the help of examples, learners are provided explicit instruction on—how strategies are used (procedural knowledge), when strategies should be used (conditional knowledge) and why they work (metacognitive knowledge). Following this step, teachers model the use of the strategy for students (Dole, Duffy, Roehler, & Pearson, 1991). These steps are repeated over several cycles, with feedback and instruction reduced as students become more proficient with the strategy. Two year-long experimental studies involving direct explanation of strategies instruction with poor readers demonstrated that learners who were taught with this strategy were more metacognitively aware of comprehension processes and they were able to read better (Duffy et al., 1987). Duke and Pearson (2002) support explicit instruction about when and how to apply strategies.

Duffy (2002) conducted an analysis of several approaches to reading strategies instruction to identify those approaches that include direct strategy instruction. He found very few that actually did. For example, approaches such as K-W-L (Ogle, 1986), Q-A-R (Raphael & Au, 2005), reciprocal teaching (Palincsar & Brown, 1984) all operate on the assumption that after repeated exposure to the strategies, students will be able to internalize these strategies and
begin to use the spontaneously. Duffy, notes the problem with these approaches is that they expect readers to pick up the “relatively subtle cues and prompts” that are part of the strategy instruction (p. 38). Duffy contends that this does not necessarily happen, especially in the case of poor readers. On the other hand, approaches such as metacognitive strategies (Paris & Winograd, 1990), inference training (Dewitz, Carr, & Patberg, 1987), prereading strategies (Dole, Brown, Trathen, 1996), explanatory feedback (Winne, Graham, & Prock, 1993), and transactional strategies instruction (Brown, Pressley, Van Meter, & Shuder, 1996) do incorporate some aspect of direct instruction on strategies. According to Duffy,

> Explicit teaching is intentional and direct about teaching individual strategies on the assumption that clear information about how strategies work will put struggling readers in a better position to control their own comprehension; other approaches on the other hand, emphasize quality instruction with text content but avoid explicit teacher talk designed to develop student metacognitive awareness of when and how to use a particular strategy (p. 30).

Furthermore, Duffy points out that in explicit teaching a strategy represents a technique that readers employ as a means to developing a better understanding of the text, while in other approaches a strategy can mean a technique that teachers control to guide student teaching.

Based on these findings an animated demonstration that provided explicit instruction on the reading strategies in the Web-based learning environment was designed for the Phase IV study.
Multiple Strategies Instruction

Whether strategies should be taught one at a time or as a set has been vigorously debated in reading strategies instruction literature (Block & Pressley, 2002). Pearson and Gallagher (1983) argue that it is best to teach reading strategies one at a time. Each strategy should be modeled by the instructor with a variety of texts, after which students should be given a chance to rehearse each strategy with a variety of texts. Keene and Zimmerman (1997) also support this notion.

Pressley (2002), on the other hand, has argued that it is more effective to instruct students so that they develop skills that allow them to apply a repertoire of reading strategies on a given text, “[It makes] good sense to teach young readers to coordinate multiple strategies as they read” (p. 19). Pressley supports his argument by noting research that demonstrates how skilled readers articulate multiple strategies when they read (e.g., Brown, Bransford, Ferrara, & Campione, 1983; Levin & Pressley, 1981). A good example of multiple strategies instruction is the reciprocal strategies approach developed by Palincsar and Brown (1984).

The National Institute of Child Health and Human Development (2000) report includes a meta-analysis of 38 research studies on comprehension strategy programs that used a multiple strategy approach. Based on this analysis, the authors of the report concluded that “the evidence supports the use of combinations of reading strategies in natural learning situations” (p. 4-83). Rosenshine and Mesister (1994) concluded similarly upon analyzing results from 10 studies on reciprocal teaching strategies. Similarly, Pressley (2002) found that even though some instructors initially taught strategies individually, in most cases such instruction “yielded rather quickly to an emphasis on the repertoire of strategies” (p. 19).
It is worth noting that even though in practice a multiple-strategy approach may work better, it might not be the best approach to research the efficacy of individual strategies. For example, Graesser (2007) calls a multiple-strategy approach a “kitchen-sink” approach. He notes that as far as the development of theory is concerned, these approaches should be avoided since “it is impossible to pin down which strategy and theoretical prediction is responsible for any significant gain in comprehension” (p. 17). The current design of the Web-based learning environment allows readers to use a set of five reading strategies on the instructional text on the human heart. As noted by Graesser, allowing readers to use multiple strategies at once had implication on the analysis of data collected in the study. These implications are discussed in Chapter 5.

Technology Supported Strategy Instruction

Reutzel (2007) has made a case for differentiated literacy instruction, “Because teachers’ experiences and expertise in managing the complexity of the classroom vary greatly, and because students’ needs are equally complex and challenging in today’s increasingly diverse classroom environments, the question of how to differentiate instruction is of critical importance to all teachers—novice and experienced alike” (p. 314). In today’s classroom extraordinary demands are put on a teacher who wishes to practice rich literacy instruction. To address this situation researchers are beginning to investigate technology-based reading environments that are designed to support differentiated literacy instruction. In fact, this idea is similar to the idea of computer adaptive testing and it can lead to what may be called computer adaptive reading environments. Graesser (2007) for example has investigated computer-based instructional interventions and compared them with human interventions.
Johnson-Glenberg (2007) notes how affordances such as ability to provide individualized instruction, repetitive practice, and immediate feedback can support the otherwise daunting task of teachers attempting to address the reading strategies instruction needs of every student in the class, each of whom has a unique profile. Similarly, McKeena, Labbo, Reinking, and Zucker (2007) note the following affordances that technology makes available for designing compelling learning experiences: customized instruction, scaffolding, engagement through multimedia, unique ways of manipulating text, online note taking and collaboration. McKeena et al. note that given the ubiquity and penetration of digital applications in the workplace and at home it has become imperative for curricula to prepare children for success in such environments.

The design of the Web-based learning environment being investigated in the current research makes use of affordances new Web technologies.

Characteristics of the Text and Learner

*Characteristics of Text: Expository vs. Narrative Texts*

The skills required for understanding expository texts differ from the skills required for comprehension of narrative texts (Goldman, 1997; Wilson & Roupley, 1997). For example, while reading skill is a better predictor of comprehension of narrative texts, prior-knowledge is a better predictor of comprehension of expository texts (McNamara, Floyd, Best, & Louwerse, 2004). Palincsar, Dalton, Magnusson, Hapgood, Proctor, and Khasnabis (2004) have found that skilled as well as poor readers use knowledge of story grammars to comprehend narrative texts, however, there is no analogue to this knowledge that readers can draw upon while reading expository texts.
Expository text presents unique challenges to readers. For example, with regard to science texts there are marked differences among readers in prior-knowledge. Furthermore, there is greater variance in readers’ criteria on what it means to have comprehended a science text when compared with the same criteria for narrative texts that are typically much easier to understand. The same can be said about the variance in readers’ motivation to persevere in mastering science content (Graesser, 2007). The Dwyer and Lamberski (1977) instructional unit on the human heart that is used in this research is expository in nature.

Expository text in general are more difficult to understand when compared with narrative texts not only because such texts often deal with unfamiliar content (after all readers mostly read expository texts to acquire new knowledge), but also because expository texts vary greatly in how they are organized structurally. For example, Meyer, Brandt and Bluth (1980) have listed six patterns of structure information with regard to expository texts: description, sequence, listing, compare/contrast, cause-effect, and problem-solution. Richgels, McGee, Lomax, and Sheard (1987) investigated this taxonomy and found that although sixth-grade students were able to recognize structure information in texts, they were more sensitive to the compare/contrast structure than they were to the cause-effect structure. Dickson (1999) found that middle-school students could be successfully taught the cause/effect structure strategy.

Characteristics of Learners

1. Prior-knowledge.

Research has demonstrated that if learners have adequate prior-knowledge they will likely be able to construct a situation model of the text as long as the reading task is challenging
enough to actively engage them with the text—forcing them to make inferences, fill gaps, generate macrostructures, elaborate etc. (McNamara & Kintsch, 1996). Prior-knowledge, not only the quantity, but also the quality—how well it is organized in long-term memory, plays a crucial role in our responses to every situation, including reading text (Shapiro, 2004).

To investigate the impact of prior-knowledge on readers’ construction of textbase and situation models, Mannes and Kintsch (1987) set up the following two conditions. In one condition participants were shown an advanced organizer in the form of an outline that was consistent in structure with the text, whereas the other group was presented with an outline that was inconsistent with the structure of the text. Upon reading the outline and the text, participants were given two groups of tests—one that tested memory retrieval (summarize the text, verify the truth of a number of statements, and recall a particular paragraph from the text) while the other group of question was of the problem-solving type (students were asked to consider solutions to a serious problem identified in the text). Participants who studied the consistent outline did much better on tasks that required retrieval form memory whereas those participants who were given the inconstant outline excelled at the tasks that required inferences or problem solving. In the context of the levels of representation proposed in the construction-integration model these results can be explained as follows: Students who were given inconsistent outlines had to make an effort at reconciling information provided in the text with the situation model that they developed on the basis of information that was provided in the outline. As a result of this processing, few resources were left for the development of a robust textbase and thus, while these students fared much better on problem solving tasks, they underperformed on textbase tasks as measured by memory retrieval tasks. In contrast, the other group that read the consistent
outline had ample resources to strengthen the textbase and little motivation to work on the situation model.

Similarly, Bransford and Johnson (1972) demonstrated that just by providing a thematic title to participants before they read an otherwise ambiguous passage dramatically affected the quality of information that they were able to recall. In this case the thematic title provided the cue that was needed to activate appropriate prior-knowledge structures.

Given the crucial role that prior-knowledge plays in text comprehension, this study included knowledge of human anatomy (Dwyer & Lamberski, 1977) as a covariate.

2. Spatial ability.

Given that the instructional text used in this study included spatio-visual information, readers’ spatial skills were expected to be a significant predictor of their ability to comprehend the text. Hegarty (1992) has provided a detailed account of the mental processes involved in the comprehension of dynamic systems. Two possible explanations are put forth:

1. Parallel Processing Explanation: In a dynamic system several components of the system work together, for example, in the case of the human heart, the pulmonary and the aortic valves in the human heart open and close together, or the left and the right ventricles expand and contract together. Therefore a mental process that is isomorphic to the functioning of the system would involve mentally animating different components of the system at once.

2. Piecemeal or Serial Processing Explanation: Learners try to understand the functioning of dynamic systems by animating the different components of the machine “piecemeal.” In other words, this kind of processing involves decomposing the behavior of a complex system into smaller sub-processes and then animating these sub-process in sequence. To be able to explain the sub-processes learners must understand the cause and effect relations
between the various components of the system. This also means that to be able to explain the functioning of a component later in the causal chain, the learner must mentally run (or animate) the components and sub-process that occur earlier in the causal chain. Hegarty (1992) has called this process mental animation. Hegarty found evidence to conclude that learners (at least non-experts) do not process all the movements of the various parts of a system all at once (i.e. learners do not parallel process). Instead learners process the information piecemeal (i.e. serially) by inferring the causal chain of events in the sub-systems.

The relationship between mental animation ability and spatial ability has been studied in several studies. For example, Hegarty and Kozhevnikov (1999) and Hegarty and Steinhoff (1997) found mental animation ability to be highly correlated with spatial ability of learners. Hegarty and Kozhevnikov (1999) have called this ability visual imagery—“the ability to form mental representations of the appearance of objects and to manipulate these representations in mind” (p. 684).

*Interaction Between Text and Learner Characteristics*

Text and learner characteristics interact. In other words the degree of comprehension achieved by an individual is a function of the text characteristics (for e.g., whether the text is narrative or expository) and the ability of the reader: phonological skills, decoding skills, fluency, vocabulary, ability to make inferences, comprehension strategies, comprehension monitory skills, as well as motivation (Graesser, Millis, & Zwaan, 1997; Bell & Perfetti, 1994; Snow, 2002).

In fact, making the reading task too easy for a student may be a significant impediment to learning. At the same time, increasing the difficulty of the learning phase can have beneficial
effects if it challenges the student to engage in active, deep processing of the text (McNamara & Kintsch, 1996). This can be done by placing impediments in the path of comprehension, but impediments of the right kind and in the right amount. These must be impediments that students can overcome with enough effort, and the act of overcoming these impediments must be made relevant to learning. The reading strategies and the overall design of the Web-based learning environment being investigated in this research are expected to provide such challenges and scaffolds to readers.

Comprehension Assessment

**Goals of Comprehension Assessment**

The National Research Council’s [NRC] (2001) report on assessment has identified three important components that should be considered in designing assessments: a model of how students represent knowledge and develop competence, tasks or situations that will allow instructors to observe students’ performance, and a well defined procedure to interpret performance based on the evidence that is collected. The report also emphasizes the importance of finding ways to expose learners’ knowledge representations and their thought processes, and to find out whether or not learners are applying metacognitive skills. Similarly, Magliano, Millis, Ozuru, and McNamara (2007) provide a framework for developing comprehension assessment that takes into account three factors: (a) comprehension processes and products including learner activities that the assessments is designed to observe and measure; (b) ability levels of learners; and (c) the text involved in assessment.
Reading tests, like any other tests serve two purposes: (a) classification of learners, for example, how an individual in performing in comparison to the overall population of students; (b) diagnosing readers’ specific weaknesses and strengths so that remedial measures can targeted to individuals. Over the years, the notion that results obtained from tests should be used to inform remedial instruction has become an integral part of the concept of a test’s validity. Administrators and teachers are beginning to expect more from tests than mere numbers and tests are being designed so that they can be used to identify specific weaknesses in test takers so that remedial action can be taken (Magliano, Millis, Ozuru, & McNamara, 2007).

Afflerbach (2007) notes that today researchers have a rich understanding of the cognitive processes involved in reading, the skills and strategies required to execute these processes, and instruction that can promote these skills and strategies among readers. He has argued that if the assessments that are designed draw upon this rich conceptualization of reading, then such assessments will truly measure the kind of learning that is considered important and that the inferences that we draw from the assessment will be valid. In keeping with this argument, it was important to use assessments in the study that measured the four types of representations that readers were expected to generate because of reading in the Web-based learning environment.

Assessment of Levels of Knowledge Representations

Readers construct representations of texts at multiple levels. It is possible to test each of these levels of representations. For example, Magliano et al. (2007) have proposed the following taxonomy for multiple-choice questions:

1. Local textbase: Questions in this category require processes for searching information that is explicitly mentioned in a sentence in the text and/or verifying which answer most closely
matches text content. Students have to consider only one or two sentences to answer these questions.

2. Global-textbase: Questions in this category differ from the previous category in the amount of text that the reader is expected to consider, “…potential answers provide paraphrases or summary statements of the theme that are reflected in multiple propositions in the textbase” (p. 117). These questions may also require reference to the situation model.

3. Inference: Questions in this category entail processes associated with generating inferences (bridging, explanatory, predictive or elaborative) based on information provided in the text and reader’s prior-knowledge. Some of these questions may assess inferences that are expected to be normally generated while reading text, while others require the reader to reason beyond information that is explicitly mentioned in the text.

A hypothesis of the CI model is that readers generate mental representations of texts at multiple levels. In the literature at least two dimensions of these mental representations are discussed—micro-macro (local-global) level structures and the textbase-situation model structures (Fletcher, 1994; Graesser & Clark, 1985; Graesser, Millis, & Zwaan, 1997; Kintsch, 1988; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). The micro representation pertains to comprehension at the word and clause level, whereas the macro representation relates to comprehension at the global level (section headings, gist inferring etc.). The textbase leads to memory of the text, whereas understanding is a result of the construction of a situation model.

Four levels arise upon crossing these two dimensions—micro-textbase, macro-textbase, micro-situation model, macro-situation model (see Figure 10, Table 1 in Chapter 1). Although the micro-macro and textbase-situation model representations have been investigated separately,
the researcher did not find evidence in literature on the use of the levels of representations mentioned above. This research study hypothesizes that the four levels—micro-textbase, macro-textbase, micro-situation model, macro-situation model—could be used to identify the representations that readers generate in response to reading texts. Based on this hypothesis, four sets of Web-based measurement instruments for the instructional unit on the human heart (Dwyer & Lamberski, 1977) were designed and validated.

Application of Technology in Assessment

Technology not only makes possible large scale diagnostic tests, but also customized remedial instruction that is tailored for individual students on the basis of assessment results (Glaser, 1986; National Education Goals Panel, 1991; Nitko, 1989; Pellegrino, Baxter, & Glaser, 1999; Stiggins, 1994). This area continues to attract new research and innovation. For example, using cognitive task modeling with the Critical Reading Section of the Scholastic Aptitude Test, VanderVeen, Huff, Gierl, McNamara, Louwerse at al. (2007) identified categories of questions, with questions in each category measuring a particular aspect of the learner’s comprehension. On the basis of scores obtained by participants in each of these categories, participant profiles were developed so that targeted remedial action could be taken.

According to the NRC report (2001), “some of the most intriguing applications of technology extend the nature of the problems that can be presented and the knowledge and cognitive processes that can be accessed” (p. 9). One of the goals of this research is to make a case for the role that new Web technologies can play in measuring or “getting at” learners’ knowledge representations at multiple levels.
CHAPTER 03
METHODOLOGY

Purpose and Research Goals

This research study had two purposes, (a) to design and develop a Web-based learning environment that supports the use of a set of reading strategies, and (b) to investigate the impact of this Web-based learning environment on readers’ memory and understanding of an instructional unit on the human heart (Dwyer & Lamberski, 1977). These purposes led to four major research goals:

1. Guide the design of a Web-based learning environment that supports the use of a set of five reading strategies: (a) Text-macrostructure or chunking strategy: Readers can chunk the instructional unit on the human heart into smaller sections by moving elements (one or more paragraphs of text and an image) that make up the instructional unit into tabs that they create in the Web-based learning environment. (b) Summarization strategy: Readers can write a summary for each section that they create. (c) Imagery strategy: Readers can select an image from a library of images that is most representative of the contents of a given section. (d) Reading self-assessment or comfort-meter strategy: Readers can mark on a scale of 1-5 how comfortable they feel with their understanding of each section of the instructional unit. (e) Note-taking strategy: Readers can take notes on an element-by-element basis—these notes are attached to the elements that make up the instructional unit.

2. Establish validity and reliability of Web-based measurement instruments that were designed to measure memory and understanding of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model and macro-situation model.
3. On the basis of these measurement instruments, determine whether participants who read the instructional unit on the human heart in the Web-based learning environment developed better memory and understanding of the instructional unit when compared with participants who read the same text on a regular Web page.

4. Develop an understanding of participants’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.

Methodological Approach

The design and development of the Web-based learning environment, starting from an early-stage paper-prototype and culminating in a Web-based learning environment developed with current Web technologies, involved making numerous design decisions throughout a process that spanned over 20 months. Updates to the Web-based learning environment were made on the basis of feedback collected from a series of studies in which participants were invited to interact with prototypes of the Web-based learning environment. Web-based measurement instruments that measured readers’ memory and understanding of an instructional unit on the human heart at four levels of knowledge representation were also developed and tested. A design-based research methodology (Barab, 2006; Barab & Squire, 2004; Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003; Collins, Joseph, & Bielaczyc, 2004; Design-Based Research Collective, 2003; Fishman, Marx, Blumenfeld, Krajcik, & Soloway, 2004; Shavelson, Phillips, Towne, & Feuer, 2003) was considered to be an ideal framework for guiding this process.

Reinking and Bradley (2004) have argued that while experimental methods are well suited for identifying interventions that work best on average they do not necessarily provide
guidance when it comes to identifying factors that determine successful implementation of such interventions in *specific* contexts. On the other hand, naturalistic methods that focus on detailed examination of specific instructional contexts lack *generalizability*. Instead, a design-based approach allowed the researcher to set up several studies, most of them with a small number of participants, to determine what “worked” and what did not in the Web-based learning environment and the Web-based measurement instruments. The process undertaken was not unlike an engineering experiment (Bell, Hoadley, & Linn, 2004; Design-Based Research Collective, 2003) in which finding-out and revising was carried out iteratively. This process allowed the researcher to fine tune the design of the Web-based learning environment and the design of items in the Web-based measurement instruments. Not only did the iterative process inform the design of the Web-based learning environment and the Web-based measurement instruments, it also helped the researcher develop a better understanding of the *cognitive*, *metacognitive* and *motivational* processes that readers engaged in while reading in the Web-based learning environment.

The design-based research framework guided the design of a series of studies that addressed these research goals: (a) Phase I: Exploratory study related to the design of the Web-based learning environment; (b) Phase II: Design, validate and revise the Web-based measurement instruments; (c) Phase III: Design, develop, and update the Web-based learning environment; develop a feedback survey regarding readers’ use of the five reading strategies in the Web-based learning environment, their experience in the Web-based learning environment, and their experience with the Web-based human heart tests; and (d) Phase IV: Large-scale quasi-experimental study designed to estimate the impact of the Web-based learning environment on readers’ memory and understanding of the instructional unit on the human heart.
Findings from each of the first three phases of the investigation were used to inform and update the design of the Web-based learning environment, the Web-based measurement instruments, and the research design of the subsequent phase. The research goal(s), number of participants and materials used in each phase of the research are summarized in Table 5.

Table 5. Research Goal(s), Number of Participants, and Materials in the Four Phases of the Design-Based Research Investigation

<table>
<thead>
<tr>
<th>Phase</th>
<th>Research Goals</th>
<th>Number of Participants</th>
<th>Primary Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase I</td>
<td>Research Goal 1: Guide the design of a Web-based learning environment.</td>
<td>10</td>
<td>Paper prototype of the Web-based learning environment with only the text-macrostructure strategy</td>
</tr>
<tr>
<td>Phase II</td>
<td>Research Goal 2: Establish validity and reliability of Web-based instruments that are designed to measure memory and understanding of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model and macro-situation model.</td>
<td>57</td>
<td>Web-based human heart tests; instructional unit on the human heart presented on a regular Web-page</td>
</tr>
<tr>
<td>Phase III</td>
<td>Research Goal 1: Guide the design of a Web-based learning environment.</td>
<td>43</td>
<td>Web-based and paper-form of the Web-based learning environment with all five reading strategies; animated demonstration of the Web-based learning environment; Web-based human heart tests; feedback survey</td>
</tr>
<tr>
<td></td>
<td>Research Goal 4: Develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phase IV</td>
<td>Research Goal 3: Determine the impact of reading in the Web-based learning environment on readers’ memory and understanding of the instructional text on the human heart.</td>
<td>685</td>
<td>Web-based learning environment with all five reading strategies; two animated demonstrations of the Web-based learning environment; Web-based human heart tests; feedback survey</td>
</tr>
<tr>
<td></td>
<td>Research Goal 4: Develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Instructional Unit on the Human Heart

The Dwyer Heart Content (Dwyer & Lamberski, 1977; see Appendix A) was chosen as the instructional material in all the four phases of this research investigation. The Dwyer Heart Content is an approximately 2000-word long expository text that presents the terminology and describes the functioning of individual parts of the human heart and how these parts work as a system. Illustrations identifying different parts of the heart as well as their functions are interspersed throughout the text. On average, it takes about 60 minutes for participants to read the original instructional text and respond to the associated assessments.

The text used in the four phases of this research was only slightly modified from the original text from Dwyer. Some of the terminology was updated (for example, the term “auricle” was replaced with the term “atrium”) and some sentences were added keeping in mind the set of measurement instruments used in this study. Updates to the text were done in consultation with a biology instructor and the author.

Measurement instruments based on the original Dwyer and Lamberski assessments were developed (see Appendixes C, D, E, F and G); some of the items in the original assessments were updated and several new items were added. These changes are discussed in detail in this chapter.
PHASE I STUDY—EXPLORATORY STUDY RELATED TO THE DESIGN OF THE WEB-BASED LEARNING ENVIRONMENT

Introduction

Prior to starting development work on the Web-based learning environment, an exploratory “design exercise” with an early-stage paper prototype of the Web-based learning environment was carried out in the fall 2007 semester. The paper prototype used in this study included only the text-macrostructure or chunking strategy. The text-macrostructure strategy allowed readers to break up and reorganize the instructional unit on the human heart at the macro-level; this strategy is explained in detail later on in this section. The researcher provided participants the paper prototype and observed what they did with it. The goal was to find out if participants used the text-macrostructure strategy, and if so, were there differences in the use of the strategy across participants.

Out of the five strategies designed in the Web-based learning environment, the text-macrostructure strategy was chosen to be the first strategy to be explored for multiple reasons. Even though there is substantial research on the readers’ use of the structural information contained in expository texts (Kintsch, 1998; Meyer, Brandt, & Bluth, 1980; Meyer, Middlemiss, Theodorou, Brezinski, McDougall, & Bartlett, 2002; Meyer & Poon, 2001; Meyer & Wijekumar, 2007; van Dijk & Kintsch, 1983), the researcher did not find support in research literature for the text-macrostructure strategy designed in the Web-based learning environment. Other strategies in the Web-based learning environment such as summarization, imagery and note-taking are well researched.
Furthermore, the text-macrostructure strategy was expected to play a pivotal role in the overall design of the Web-based learning environment as well as readers’ experience in the Web-based learning environment because: (a) This strategy formed the basis of three other strategies in the Web-based learning environment—summarization, imagery and reading self-assessment (comfort-meter); and (b) This strategy allowed readers to customize the instructional text on the human heart to suit their reading preference. Because of this, the researcher expected the strategy to trigger processes that would be both cognitively as well as motivationally beneficial to the readers.

Research Goal

The goal of the Phase I study was to inform the design of the Web-based learning environment within which readers can use a set of five reading strategies. The Phase I study focused on only one out of the five reading strategies—the text-macrostructure strategy.

Participants

Participants in the Phase I study were 10 doctoral-level students who were enrolled in a research apprenticeship class at a large public university in northeastern United States. This sample was a convenience sample since the researcher was a student in the class.
Materials

1. Instructional Material.

For the Phase I study, the instructional unit on the human heart (Dwyer & Lamberski, 1977) was divided into 25 “elements.” Each element contained one or more paragraphs of text (about 80-100 words). Some elements also contained an image (see Figure 1 in Chapter 1). Each element was printed on card stock paper in the form of a 5 in. x 8.5 in. card. A number on the back of each card identified its place in the sequence of cards. The instructional unit on the human heart was also printed in the form of a letter-sized booklet (see Appendix A).

2. Instructions Sheet.

The instructions sheet described what a participant was expected to do in the study. A sample response was also provided (see Appendix B).


The response sheet included a blank table on which participants were expected to record their macro-level organization of the instructional unit on the human heart. In the top row of the table, participants were expected to write the labels of the sections that they created. Under each label they were expected to note the card number of elements that they placed in that section (see Appendix B).

Procedure

Each of the 10 participants was provided the instructional unit on the human heart in two forms: a letter-sized booklet and the set of 25 cards. Participants were asked to read from the
booklet and reorganize the 25 cards into as many “sections” as they “saw fit.” Participants were asked to note their organization of the instructional unit on the human heart on the response sheet. Participants were told that they could write on the booklet or the cards if they wanted to.

The instructor read these instructions from an instructions sheet. A copy of the instruction sheet was provided to the participants. Participants were given 20 minutes to complete the exercise.

Responses from Participants

Out of the 10 participants, only 6 were able to read the entire the instructional unit and record their responses on the response sheet. The response sheet from one of the participants who completed the exercise is presented in Table 6.

Table 6. Phase I Study: Response from a Participant

<table>
<thead>
<tr>
<th>Elements</th>
<th>Overview</th>
<th>Parts: Wall/Outside Containers</th>
<th>Parts: Inside</th>
<th>Flow: In</th>
<th>Flow: Out</th>
<th>Functioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element 1</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>11</td>
<td>17</td>
</tr>
<tr>
<td>Element 2</td>
<td>3</td>
<td>7</td>
<td>6</td>
<td>12</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Element 3</td>
<td>15</td>
<td>8</td>
<td>13</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element 4</td>
<td>16</td>
<td>9</td>
<td>14</td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element 5</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element 6</td>
<td>21</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element 7</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element 8</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element 9</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element 10</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note: Responses from the participant are italicized.*
Responses from the six participants who completed the exercise are presented in Table 7.

Table 7. Phase I Study: Summary of Responses

<table>
<thead>
<tr>
<th>Participant</th>
<th>Section Label</th>
<th>Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overview</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Parts: Wall/Outside Containers</td>
<td>2, 3</td>
</tr>
<tr>
<td></td>
<td>Parts: Inside</td>
<td>4, 7, 15, 16</td>
</tr>
<tr>
<td></td>
<td>Flow: IN</td>
<td>5, 6, 8, 9, 10</td>
</tr>
<tr>
<td></td>
<td>Flow: OUT</td>
<td>11, 12, 13, 14</td>
</tr>
<tr>
<td></td>
<td>Functioning</td>
<td>17, 18, 19, 20, 21, 22, 23, 24, 25</td>
</tr>
<tr>
<td>2</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Heart Wall</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>Circulation of Blood</td>
<td>5, 6, 7, 8, 9, 10, 11, 12, 13, 14</td>
</tr>
<tr>
<td></td>
<td>Blood Flow</td>
<td>15, 16, 17, 18, 19, 20, 21, 22</td>
</tr>
<tr>
<td></td>
<td>Diastolic Phase</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Systolic Phase</td>
<td>24, 25</td>
</tr>
<tr>
<td>3</td>
<td>Location, description, basic introduction</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>to parts of the heart</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Activities on the right side</td>
<td>5, 6, 7, 8, 9</td>
</tr>
<tr>
<td></td>
<td>Activities on the left Side</td>
<td>10, 11, 12</td>
</tr>
<tr>
<td></td>
<td>Transactions between lung and heart</td>
<td>13, 14</td>
</tr>
<tr>
<td></td>
<td>Blood flow in the heart</td>
<td>15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25</td>
</tr>
<tr>
<td>4</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>How does it look like?</td>
<td>2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>Blood circulation (1 cycle)</td>
<td>5, 6, 7, 8, 9, 10, 11, 12, 13, 14</td>
</tr>
<tr>
<td></td>
<td>Blood circulation (more complex view)</td>
<td>15, 16, 17, 18, 19, 20, 21, 22</td>
</tr>
<tr>
<td></td>
<td>The cycle of blood pressure</td>
<td>23, 24, 25</td>
</tr>
<tr>
<td>5</td>
<td>Heart Parts</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td></td>
<td>Blood flow + valve operation</td>
<td>13, 14, 15, 18, 19, 20, 21, 22</td>
</tr>
<tr>
<td></td>
<td>Valves</td>
<td>7, 8, 9, 10</td>
</tr>
<tr>
<td></td>
<td>Blood Flow</td>
<td>5, 6, 11, 12, 16, 17, 23, 24, 25</td>
</tr>
<tr>
<td>6</td>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Structure and Parts</td>
<td>2, 3, 4, 7, 15, 6</td>
</tr>
<tr>
<td></td>
<td>Flow of Blood</td>
<td>5, 6, 8, 9, 10, 11, 12, 13, 14</td>
</tr>
<tr>
<td></td>
<td>Functions of Parts</td>
<td>17, 18, 19, 20, 21, 22</td>
</tr>
<tr>
<td></td>
<td>Cycles of Blood Pressure</td>
<td>23, 24, 25</td>
</tr>
</tbody>
</table>
Conclusions

The goal of this study was to inform the design of the Web-based learning environment, in particular one of the five reading strategies—the text-macrostructure strategy. This study helped the researcher understand how participants used the text-macrostructure strategy. The researcher was interested in finding out, whether participants, when given an opportunity to break up and reorganize the instructional unit on the human heart at the macro-level, did so and to what extent. Responses from each of the six participants were analyzed; the following patterns in the use of the strategy were noted.

1. The number of sections that participants chunked the instructional unit on the human heart into ranged from 4-6. Participants labeled the sections that they created differently, and the elements that participants put in the sections differed. These differences indicated differences in the macro-level organization of the text. For example, to represent the flow of blood in the heart, Participant 1 created two sections and labeled them *Flow: IN, Flow: OUT*. Participant 2 created four sections instead, and labeled them *Circulation of Blood, Blood Flow, Diastolic Phase, Systolic Phase*. Participant 4 created three sections and labeled them *Blood circulation (1 cycle), Blood circulation (more complex view), The cycle of blood pressure*.

Only two section labels repeated over participants (*Introduction, Blood flow*); all other section labels used were unique. The three participants who used the label *Introduction* used it to create a section that included only one element (Element 1). This was the only section that was identical (same label and elements) across more than one participant.

2. In creating the sections, participants did not limit themselves to selecting only consecutive elements. For example, Participant 1 created a section titled *Parts: Inside* and assigned elements 4, 7, 15, 16 to this section.
3. Responses from some of the participants point to inconsistencies and possible misconceptions. For example, in Participant 1’s organization, each of the two sections Flow: IN and Flow: OUT included elements that contained text pertaining to both flow of blood into the heart and out of the heart. Likewise, Participant 5’s representation: Heart Parts, Blood flow + valve operation, Valves, Blood Flow did not make a distinction between the portion of the text that describes sequential flow of blood and the portion of the text that describes parallel flow of blood. Moreover, the section titled Valves included elements that contained text that was not related to the four heart valves.

Did the participants use the text-macrostructure strategy and were there differences in the way participants chunked the instructional unit on the human heart? It is evident from data presented in Table 7 that the answer to both questions is in the affirmative. At least at the macro-level, participants processed the instructional unit on the human heart differently—these differences were reflected in the labels participants gave the sections they created, the elements they assigned to the sections they created, and the order in which they placed elements in sections. This evidence provided support for the hypothesis that participants used the text-macrostructure strategy to develop a unique “macro-understanding” of the text. This hypothesis is consistent with Rouet (2006) who noted that skilled comprehension depends not only on prior-knowledge of the readers in relation to the content of the text being read, it also depends on the reader’s knowledge of the “shape” of the text, that is the “visual and verbal devices that are used to structure the text” (p. 31).

Since no post-tests were administered, and no control conditions were set up, it was not possible to conclude that the application of the text-macrostructure strategy led to improvements in learning. Even if the strategy did not directly impact participants’ learning, it allowed them to
customize the text at the macro-level to meet their needs. This, in turn, could lead to increased motivation and engagement, and improvements in learning outcomes could follow.

Based on observations of participants’ use of the text-macrostructure strategy, it was determined that affordances (for example, drag-and-drop) of current Web technologies such as AJAX and DOM were ideally suited to implement the text-macrostructure strategy in a Web-based learning environment.

Discussion

Since post-tests were not part of this study it was not possible to quantitatively estimate the quality of participants’ organizations. But on the basis of the data collected, it was possible to qualitatively compare representations across participants. This analysis demonstrated that some of the organizations were qualitatively superior to others. Several explanations can be offered for qualitatively poorer organizations—limited time that participants had to process the text, individual differences in prior-knowledge, learning style, and comfort level with the English language (some participants were non-native speakers).

Not only did this exploratory design study provide support for implementing the text-macrostructure strategy in the Web-based learning environment, it also provided insights into the use of the strategy and two new questions emerged from these insights.

1. Would participants’ macro-level organization of the text have been significantly different if they were provided more time? If so, would these organizations be more similar across participants than the ones obtained in this study? In other words, would the substantial differences in organization that were observed in the current study disappear?
2. Would the organization of the elements by the participants still be significantly different if they were provided titles of sections into which they had to move the 25 elements? Providing participants this macro-structure could be used as a means of scaffolding the cognitive processes entailed by the text-macrostructure strategy.

The first set of questions was addressed in Phase III and Phase IV. In both these studies there was no constraint on the time that participants could spend reading and reorganizing the instructional unit on the human heart. The second question merits a separate study; it will be discussed in Chapter 5.

In conclusion, participants’ organization of the individual elements that made up the instructional unit on the human heart into sections and the labels participants gave these sections, differed substantially across the six participants that completed this study. This finding demonstrated that these participants used the text-macrostructure strategy to develop unique macro-level representations of the instructional unit on the human heart. Taken together, these findings provided support for incorporating the text-macrostructure strategy in the Web-based learning environment. This strategy played a key role in the overall design of the Web-based learning environment.
As mentioned in the previous chapter, an hypothesis of the Construction-Integration (CI) model is that readers generate mental representations of texts at multiple levels. In research literature at least two dimensions of these mental representations are discussed—*micro-macro* (local-global) level structures and the *textbase-situation model* structures (Fletcher, 1994; Graesser & Clark, 1985; Graesser, Millis, & Zwaan, 1997; Kintsch, 1988; Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). The micro representation pertains to comprehension at the *local* level (word and clause), whereas the macro representation relates to comprehension at the *global* level (section headings, gist inferring etc.). The textbase representation leads to *memory* of the text, whereas *understanding* is a result of the construction of a situation model.

Four levels arise upon crossing these two dimensions—micro-textbase, macro-textbase, micro-situation model, macro-situation model (see Figure 10, Table 1 in Chapter 1). Although the micro-macro and textbase-situation model representations have been investigated separately, the researcher did not find evidence in literature on the simultaneous use of the four levels of representations mentioned above. An assumption of this research study was that the four levels—micro-textbase, macro-textbase, micro-situation model, macro-situation model—can be used to identify the representations that readers generate in response to reading texts. The Phase II study, or studies in any other phase in this research, did not test this assumption. Rather, based on this assumption, four sets of Web-based measurement instruments for the instructional unit on the human heart (Dwyer & Lamberski, 1977) were designed and validated. These instruments are provided in Appendixes C, D, E, F, and G.
Research Goals

The primary goal of the Phase II study was to establish the validity and reliability of Web-based instruments that measured memory and understanding of the instructional text on the human heart at four levels—micro-textbase, macro-textbase, micro-situation model, macro-situation model. This goal led to the following sub-goals.

1. Establish validity and reliability of the Web-based measurement instruments. Update the measurement instruments on the basis of data obtained from reliability analysis.

2. Establish algorithms for the “rearranging-type” questions in the Web-based measurement instruments, for example, the “submarine” question in the macro-situation model test (see Appendix G).

3. Establish correlations between scores on the micro-textbase, macro-textbase, micro-situation model, macro-situation model tests and scores on the knowledge of human anatomy and spatial ability tests in order to determine whether scores on the knowledge of the human anatomy and spatial ability tests should be used as covariates in the Phase III and Phase IV studies.

4. Test technology that was used to develop the Web-based measurement instruments, for example, the implementation of the autocomplete design-pattern (Mahemoff, 2006), drag-and-drop, and AJAX (Garrett, 2005). Also test online delivery of the items, in particular, test to make sure that data, including timestamps, were being stored in the database.

Participants

Participants in the Phase II study were recruited from two undergraduate courses offered in summer of 2008 in the Energy and Geo-Environmental Engineering, and Materials Science
and Engineering departments at a large public university in the northeastern United States. Students from various undergraduate programs at the university typically enroll in these courses to fulfill university’s general education requirements.

Participants in the study were offered extra credit which amounted to 2% of the entire course grade. An alternative extra credit opportunity was made available to students who chose not to participate in the study but still wanted to obtain the extra credit. The recruitment email and the informed consent form for the study are available in Appendix I.

Participants were recruited from a pool of 125 students. Of these 47 students completed both parts of the study; eight students completed Part 1 but not Part 2; two students completed only the knowledge of human anatomy test in Part 1. Data from all these students was used in the analysis. Fourteen students completed the alternative extra credit assignment.

Materials

The materials used in this study included the instructional unit on the human heart (Dwyer & Lamberski, 1977; see Appendix A) which was presented on a Web page. Measurement instruments included tests on the human heart that measured participants’ memory and understanding of the instructional unit on the human heart at four levels—micro-textbase, macro-textbase, micro-situation model, macro-situation model (see Appendixes C, D, E, F and G). About half of the items on the Web-based human heart tests were from the Dwyer and Lamberski (1977) tests for the instructional unit on the human heart. The other half were new items developed to measure the micro-textbase, macro-textbase, micro-situation model, macro-situation model levels of knowledge representation. Two prior-knowledge tests that measured knowledge of human anatomy (Dwyer, 1978; see Appendix H) and spatial ability (Ekstrom,
French, & Harman, 1976) were also used. Each of these instruments is described in detail in the section on measurement instruments.

Two Web sites were used in the study: (1) Reservation Web site which enabled participants to book a time slots for Part 1 and Part 2 of the study. The Web site also enabled participants to cancel and reschedule their reservations. (2) Study Web site: This site provided links to the prior-knowledge tests, the instructional unit on the human heart, and the human heart tests. Participation status was updated on this Web site as participants completed various sections of the study. Both Web sites were password protected. Screenshots of these Web sites are available in Appendix J.

Procedure

Two constraints influenced the procedures that were followed in the Phase II study—physical availability of students on the university campus and the time required to complete the two parts of the study. Since this study was conducted during the summer session when very few students were physically present on the university campus, all parts of the study were set up for online delivery. Furthermore, it was estimated that, on average, the total time required to complete the study—taking the prior-knowledge tests, reading the instructional unit on the human heart, and responding to the Web-based human heart tests—would be well over an hour. It would be difficult to maintain participant motivation and concentration for this duration, especially when participation alone and not the performance on tests determined the extra credit. To address this motivational constraint, the study was split in two parts. In Part 1, participants were asked to complete the prior-knowledge tests—knowledge of human anatomy and spatial ability. In Part 2, participants were asked to read the instructional unit on the human heart. After reading the instructional unit they were asked to respond to the four tests—micro-textbase,
macro-textbase, micro-situation model, and macro-situation model. The procedures used in this study are summarized in Figure 19.

![Figure 19. Schematic for Phase II study.](image)

To encourage participants to commit time for participating in the study they were asked to book time slots for both parts of the study in advance. Participants completed each part of the study by logging into the Study Web site within 30 minutes of the time they had booked for that part. There was no time limit for participation for either part of the study except for the spatial ability tests in Part 1, for which, participants were allowed a maximum of 12 minutes.
Measurement Instruments—Web-Based Human Heart Tests

Tests that measured memory and understanding of the instructional unit on the human heart at four levels of representation—micro-textbase, macro-textbase, micro-situation model, and macro-situation model—were designed and validated. About half of the items in these tests were from the Dwyer and Lamberski (1977) tests for the instructional unit on the human heart. The Dwyer and Lamberski tests consist of a 20-item drawing test and three sets of 20 multiple-choice items—identification test, terminology test and comprehension test. In previous studies, each of the three sets was found to have a reliability coefficient of .80 or better (Dwyer & Lamberski, 1977).

Validation of the Human Heart Tests

The Dwyer & Lamberski heart tests consisted of four tests—drawing, identification, terminology and comprehension. In preparing the measurement instruments for the current study, some items from the Dwyer & Lamberski heart tests were updated, some other items were eliminated, and several new items were added. The tests in the current investigation were intended to measure constructs—micro-textbase, macro-textbase, micro-situation model, and macro-situation model—that were different from the original Dwyer & Lamberski heart tests. Given these changes, there was a need to validate the newly developed tests. The following steps were taken to establish the content validity of the tests (Henkel, 1976).

1. A thorough search of the literature was conducted to identify the attributes that defined the micro-textbase, macro-textbase, micro-situation model, and macro-situation model constructs
(see Table 8). These attributes are discussed in the description of each of the four tests.

Representative item(s) are also provided.

2. Items from the Dwyer & Lamberski (1977) heart tests were considered as a starting point. Those items from the Dwyer & Lamberski tests that met the criterion identified in Table 8 were included in the respective test (micro-textbase, macro-textbase, micro-situation model, and macro-situation model).

3. New items were developed keeping in mind the criterion identified in Table 8.

Table 8. Key Attributes of the Four Human Heart Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Key Attributes</th>
</tr>
</thead>
</table>
| Micro-Textbase          | 1. Limited to assessing information that was explicitly mentioned in the text  
2. Only one or two sentences in the text needed to be considered in order to answer these questions |
| Macro-Textbase          | 1. Limited to assessing information that was explicitly mentioned in the text  
2. At least a few sentences needed to be considered to answer these questions |
| Micro-Situation Model   | 1. To answer these questions, readers would have to supplement information provided in the text with their prior-knowledge (long-term memory).  
2. These questions tested understanding of small portions of the text. |
| Macro-Situation Model   | 1. To answer these questions, readers would have to supplement information provided in the text with their prior-knowledge (long-term memory).  
2. These questions tested global understanding or the mental model for the entire text—the big picture. |

As noted by Henkel (1976), one of the limitations of the content-validity approach to validation is that in most psychological contexts “it is impossible to sample content. Rather, one
formulates a set of items that is intended to reflect the content of a given theoretical concept. Without a random sampling of content, however, it is impossible to insure the representativeness of the particular items” (p. 22). Other approaches to validation such as criterion and construct validity were beyond the scope of the current investigation.

*Micro-Textbase Test*

*Construct attributes.*

The test was designed to measure readers’ *textbase* knowledge at the *micro* (local) level. Items in this test satisfied two key attributes: (a) Information assessed by the items was explicitly mentioned in the text; and (b) Only one or two sentences in the text needed to be considered to answer these items.

This test consisted of two sets of questions. The first set contained 20 items and the second set contained 15 items. Each item was worth 1 point. The maximum score on this test was 35 points. These two sets are described next.

*Set 1 test description.*

1. Set 1: Questions in this set asked participants to identify individual parts of the heart. This set included 20 questions, all of which were from the Dwyer and Lamberski Identification Test (1977). Some items were updated to make them consistent with the updates to the instructional unit on the human heart, for example, the term “auricle” was replaced by the term “atrium” throughout the questions. A representative sample from this test is provided below (see also Figure 20). The entire set of questions is included in Appendix C.
Q. Arrow number one (1) points to the:
   a. Septum
   b. Aorta
   c. Pulmonary Artery
   d. Pulmonary Vein
   e. None of These

Figure 20. Sample question from micro-textbase test (Set 1).

The questions in the Dwyer and Lamberski Identification Test were multiple-choice. In this study, instead of responding to multiple-choice questions, participants entered their responses using a Web-based implementation of the autocomplete design pattern (Mahemoff, 2006; see also Figure 21); the implementation of the autocomplete design pattern is described below.

Scoring of responses.

Participants were given 1 point for a correct response and 0 points for an incorrect response. The maximum score on this test was 20 points and the minimum score was 0 points. The descriptive statistics based on responses from 47 participants in the study are provided in Table 9.

Table 9. Micro-Textbase Test Set 1: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
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<td>0</td>
<td>20</td>
<td>12.68</td>
<td>6.13</td>
</tr>
<tr>
<td>Time (h:mm:ss)</td>
<td>47</td>
<td>0:03:22</td>
<td>0:25:46</td>
<td>0:07:51</td>
<td>0:04:18</td>
</tr>
</tbody>
</table>
Reliability.

Cronbach’s alpha for this set of questions in the micro-textbase test was .926. Since the Cronbach’s alpha was high, further analysis of item-total statistics or discrimination indices of individual questions was not necessary.

Set 2 test description.

2. Set 2: Questions in this set measured knowledge of specific facts and terms pertinent to the parts of the heart. This set included 15 items. Of these, 14 questions were from the 20-item Dwyer and Lamberski Terminology Test (1977); some items were updated to make them consistent with the updates to the instructional unit on the human heart, for example, the term “auricle” was replaced by the term “atrium” throughout the questions; one new item was added. Five items from the Dwyer and Lamberski Terminology Test were excluded since they were considered to measure the situation model representation; these items were included in the micro-situation model test. A representative sample from this test is provided below. The entire set of questions is included in Appendix D.

Q. The strongest chamber of the heart is the: __________.
   a. Left Ventricle
   b. Right Ventricle
   c. Left Atrium
   d. Right Atrium

The questions in the Dwyer and Lamberski Terminology Test were multiple-choice. In this study, instead of responding to multiple-choice questions, participants entered their responses using a Web-based implementation of the autocomplete design pattern; the implementation of the autocomplete design pattern is described below.
**Scoring of responses.**

Participants were given 1 point for a correct response and 0 points for an incorrect response. The maximum score on this test was 15 points and the minimum score was 0 points. The descriptive statistics based on responses from 47 participants in the study are provided in Table 10.

### Table 10. Micro-Textbase Test Set 2: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
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<td>0</td>
<td>15</td>
<td>8.40</td>
<td>4.33</td>
</tr>
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<td>Time (h:mm:ss)</td>
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<td>0:23:39</td>
<td>0:06:05</td>
<td>0:03:43</td>
</tr>
</tbody>
</table>

**Reliability.**

Cronbach’s alpha for this set of questions in the micro-textbase test was .868. Since the Cronbach’s alpha was high, further analysis of item-total statistics or discrimination indices of individual questions was not necessary.

**Implementation of the autocomplete design pattern.**

As discussed above, items in the Dwyer and Lamberski Identification Test and Terminology Test were multiple-choice. This study used a Web-based implementation of the autocomplete design pattern for these questions (see Figure 21). Similar to the fill-in-the-blank format, the autocomplete format offers the advantage of eliciting recall processes. In comparison, the multiple-choice question format elicits recognition. When compared with fill-in-the-blanks format, the autocomplete format offers the advantage of making it easier for
participants to enter their responses since participants do not have to enter complete words or phrases. The autocomplete design has the added benefit of allowing for mechanical grading since in this design there is no scope of spelling mistakes and typographical errors in participants’ responses.

![Vessels that carry blood from the rest of the body to the heart are called:](image)

*Figure 21. Implementation of the autocomplete design pattern.*

**Macro-Textbase Test**

*Construct attributes.*

The test was designed to measure readers’ *textbase* knowledge at the *macro* (global) level. Items in this test satisfied two key attributes: (a) Information assessed by the items was explicitly mentioned in the text; and (b) At least a few sentences in the text needed to be considered to answer these items.

*Test description.*

This test measured readers’ memory of the macro-level structure of the instructional unit on the human heart. There were three questions in this test with 8, 5, and 6 sub-items. A
A representative sample from this test is provided below. The entire set of questions is included in Appendix E.

The following sentences belong to paragraphs in the human heart instruction that introduce “new” sections in the instruction. Your task is to arrange these sentences in the order in which they appear in the instruction.

- Let us consider the flow of blood on the right side of the heart.
- Let us consider the two distinct phases of blood pressure caused by the contraction and relaxation of the heart.
- You should be able to identify the left and the right side of the heart.
- In reality several movements in the heart occur simultaneously and in parallel.
- Let us consider the flow of blood on the left side of the heart.
- To understand the functioning of the heart you will need to be able to identify the parts of the heart.

Participants were asked to rearrange the six sentences on the Web page by dragging-and-dropping.

Scoring of responses.

A response to this question (and other rearranging-type questions) was recorded as a string of characters. For example, a possible response to the question above could be the string “5 4 1 2 3 6” which represents the order in which a participant arranged the six choices. The correct response to this question is the string “3 6 1 5 4 2” which represents the sentences arranged in the correct order. The Damerau-Levenshtein distance (DLD) algorithm (http://en.wikipedia.org/wiki/Damerau-Levenshtein_distance) was used to score responses to ordering questions like this one. The DLD algorithm computes the “distance” between two strings. For example the distance between “123456” and “123645” is 1 since the second string can be transformed into the first string by just one operation—that of moving the character 6 to
the end of the string. Pseudo code for the Damerau-Levenshtein distance algorithm is included in Appendix K. The PHP programming (http://www.php.net/) language includes the “similar_text” function that implements a variant of the DLD algorithm. This function was used to score responses to the rearranging-type questions in this study.

The maximum score for the example discussed above was 6 points and the minimum score was 0 points. The maximum score on this test was 19 points and the minimum score was 0 points. The descriptive statistics based on responses from 47 participants in the study are provided in Table 11.

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
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<th>Minimum</th>
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<td>0:01:06</td>
<td>0:06:44</td>
<td>0:03:02</td>
<td>0:01:21</td>
</tr>
</tbody>
</table>

Reliability.

Since none of the items in this test were multiple-choice, reliability analysis was not performed.

Micro-Situation Model Test

Construct attributes.

Items in this test were designed to measure readers’ situation model at the micro (local) level. Items in this test satisfied two key attributes: (a) To answer these items readers had to
supplement information provided in the text with their prior-knowledge (long-term memory); and (b) These items tested understanding of small portions of the text.

Test description.

This test asked participants about the functions of the individual parts of the heart. The test consisted 17 multiple-choice items. Twelve items in this instrument were from the Dwyer and Lamberski Comprehension Test (1977) which was designed to measure knowledge of the functions of individual parts of the heart; one new item was added; some items were updated to make them consistent with the updates to the instructional unit on the human heart, for example, the term “auricle” was replaced by the term “atrium” throughout the questions. Five items from the Dwyer and Lamberski Terminology Test (1977) were also included.

Seven items from the Dwyer and Lamberski Comprehension Test (1977) that measured situation model knowledge at the macro level were excluded from this test; these items were included in the macro-situation model test. One item from the Dwyer and Lamberski Comprehension Test (1977) was excluded because it was similar to another question in the test. Two representative questions from this test are presented below. The entire set of questions is included in Appendix F.

Q. When blood is being forced out the right atrium, in which position is the tricuspid valve?

Q. During the first-stage contraction of the systolic phase, in what position will the mitral valve be?

It is worth noting that these items, as well as other items in this test targeted local situation models—knowledge about interaction of adjacent parts of the heart or consecutive steps in the sequence of blood flow.
Scoring of responses.

Participants were given 1 point for a correct response and 0 points for an incorrect response. The maximum score on this test was 17 points and the minimum score was 0 points. The descriptive statistics based on responses from 47 participants in the study are provided in Table 12.

Table 12. Micro-Situation Model Test: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>47</td>
<td>0</td>
<td>16</td>
<td>8.89</td>
<td>5.08</td>
</tr>
<tr>
<td>Time (h:mm:ss)</td>
<td>47</td>
<td>0:01:18</td>
<td>0:13:49</td>
<td>0:05:03</td>
<td>0:02:25</td>
</tr>
</tbody>
</table>

Reliability data.

Cronbach’s alpha for the micro-situation model test was .893. Since the Cronbach’s alpha for this test was high, further analysis of item-total statistics or discrimination indices of individual questions was not necessary.

Macro-Situation Model Test

Construct attributes.

Items in this test were designed to measure readers’ situation model at the macro (global) level. Items in this test satisfied two key attributes: (a) To answer these items readers had to supplement information provided in the text with their prior-knowledge (long-term memory);
and (b) These items tested global understanding or the mental model for the entire text—the big picture.

Test description.

This instrument consisted of 18 questions. Fourteen questions were multiple-choice; seven of these questions were from the Dwyer and Lamberski Comprehension Test (1977). The remaining four questions involved the following tasks: rearranging a list to represent the correct sequence of blood flow in the heart, card sorting (putting the parts of the human heart into categories), visual imagery (selecting an image from a library of images that best represented what participants learned from the instructional unit) and writing a 50-100 word summary of what participants learned from the instructional unit. Two questions from this test are presented below (see also Figure 22, Figure 23). The entire set of questions is included in Appendix G.

Q. Imagine you are in a tiny submarine that is about to enter the heart at the location shown in the diagram below. In your mind think of the path you would travel through the heart, the lungs and the rest of the body if you were to follow the blood flow. Based on this, rearrange the following:

- Pass through the tricuspid valve.
- Flow to the rest of the body.
- Enter the right atrium through the superior and inferior vena cava.
- As blood is pumped out of the right ventricle, pass through the pulmonary valve.
- Pass through the mitral valve.
- Travel to the lungs.
- Enter the left atrium via the pulmonary veins that carry oxygenated blood.
- As blood is pumped out of the left ventricle, pass through the aortic valve.

Figure 22. Sample question from macro-situation model test.
Q. Below, on the left, you are provided a list of 20 parts of the human heart and on the right are 6 empty bins. In your mind organize the parts of the heart into groups and then drag and drop them from the list on the left into bins on the right. Move as many parts into bins as you like. You do not have to use all six bins but you MUST label the bins that you fill.

Example: Given the list {Red, Pennsylvania, New Jersey, Yellow, Tree, Blue} you might drag and drop {Red, Yellow, Blue} into a bin and name it “Color” and then drag and drop {Pennsylvania, New Jersey} into a bin and name that bin “States.” You might decide to leave Tree unmoved.

Figure 23. Sample question from macro-situation model test.
It is worth noting that these items, as well as other items in this test targeted readers’
global situation model or mental model. For example, this test included questions regarding non-
adjacent steps in the flow of blood in the human heart. To respond to such questions, participants
were expected to mentally animate their mental model for the text so as to be able to consider
non-consecutive steps in the model.

Scoring of responses.

Participants were given 1 point for a correct response to the 14 multiple choice questions
and 0 points for an incorrect response. PHP programming language’s “similar_text” function was
used to score the rearranging-type question. This algorithm is described in the section on the
macro-textbase test. The maximum score for the rearranging-type question was 8 and the
minimum score was 0. Scoring of the card sorting, visual imagery and essay questions was
beyond the scope of this study. The maximum score on this test was 22 points and the minimum
score was 0 points. The descriptive statistics based on responses from 47 participants in the study
are provided Table 13. Data from the card sorting, visual imagery and essay task are not included
in the table.

Table 13. Macro-Situation Model Test: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>47</td>
<td>16</td>
<td>6</td>
<td>22</td>
<td>15.11</td>
<td>5.00</td>
</tr>
<tr>
<td>Time (h:mm:ss)</td>
<td>47</td>
<td>0:48:02</td>
<td>0:04:55</td>
<td>0:52:57</td>
<td>0:13:48</td>
<td>0:08:00</td>
</tr>
</tbody>
</table>
Reliability data.

Cronbach’s alpha for this set of questions in the macro-situation model test was .770. Since the Cronbach’s alpha for this set of questions was high, further analysis of item-total statistics or discrimination indices of individual questions was not necessary.

Measurement Instruments—Prior-Knowledge Tests

Tests that measured participants’ prior-knowledge—knowledge of human anatomy (Dwyer, 1978) and spatial ability (Ekstrom, French, & Harman, 1976), were also pilot tested.

Knowledge of Human Anatomy Test

Test description.

This measure was derived from the 36-item knowledge of the human anatomy test developed by Dwyer (1978). The test used in this study contained 30 multiple-choice questions; six items from the Dwyer test were eliminated; several items were updated to improve clarity. An item from this measure is presented below; the entire set of questions is included in Appendix H.

Q. Sweating is a primary means of _____.
   a. eliminating body odor
   b. opening of pores
   c. reduction of body weight through fluid loss
   d. regulation of body temperature
Descriptive statistics.

Participants were given 1 point for a correct response and 0 points for an incorrect response. The maximum score on this test was 30 points and the minimum score was 0 points. The descriptive statistics based on responses from 57 participants in the study are provided in Table 12.

Table 14. Micro-Situation Model Test: Descriptive Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>57</td>
<td>7</td>
<td>25</td>
<td>15.60</td>
<td>4.22</td>
</tr>
<tr>
<td>Time (h:mm:ss)</td>
<td>57</td>
<td>0:03:07</td>
<td>0:43:37</td>
<td>0:07:41</td>
<td>0:06:03</td>
</tr>
</tbody>
</table>

Reliability.

Cronbach’s alpha for this test was .713. Since the Cronbach’s alpha for this test was low, item-total statistics and discrimination indices of individual questions were considered (see Table 15, Table 16).

Table 15. Knowledge of Human Anatomy Test: Index of Discrimination

<table>
<thead>
<tr>
<th>Question</th>
<th>High</th>
<th>Middle</th>
<th>Low</th>
<th>Index of Discrimination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.95</td>
<td>.50</td>
<td>.63</td>
<td>.32</td>
</tr>
<tr>
<td>2</td>
<td>.58</td>
<td>.50</td>
<td>.38</td>
<td>.20</td>
</tr>
<tr>
<td>3</td>
<td>.47</td>
<td>.18</td>
<td>.19</td>
<td>.29</td>
</tr>
<tr>
<td>4</td>
<td>.58</td>
<td>.55</td>
<td>.06</td>
<td>.52</td>
</tr>
<tr>
<td>5</td>
<td>1.00</td>
<td>1.00</td>
<td>.88</td>
<td>.13</td>
</tr>
<tr>
<td>6</td>
<td>.84</td>
<td>.59</td>
<td>.44</td>
<td>.40</td>
</tr>
<tr>
<td>7</td>
<td>1.00</td>
<td>.55</td>
<td>.25</td>
<td>.75</td>
</tr>
<tr>
<td>8</td>
<td>.84</td>
<td>.68</td>
<td>.44</td>
<td>.40</td>
</tr>
<tr>
<td>9</td>
<td>.26</td>
<td>.09</td>
<td>.06</td>
<td>.20</td>
</tr>
<tr>
<td>10</td>
<td>.89</td>
<td>.73</td>
<td>.38</td>
<td>.52</td>
</tr>
<tr>
<td>11</td>
<td>1.00</td>
<td>.91</td>
<td>.75</td>
<td>.25</td>
</tr>
<tr>
<td>12</td>
<td>.95</td>
<td>.82</td>
<td>.69</td>
<td>.26</td>
</tr>
</tbody>
</table>
### Table 16. Knowledge of Human Anatomy Test: Item-Total Statistics

<table>
<thead>
<tr>
<th>Question</th>
<th>Cronbach’s Alpha if Item Deleted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.712</td>
</tr>
<tr>
<td>2</td>
<td>.717</td>
</tr>
<tr>
<td>3</td>
<td>.711</td>
</tr>
<tr>
<td>4</td>
<td>.701</td>
</tr>
<tr>
<td>5</td>
<td>.708</td>
</tr>
<tr>
<td>6</td>
<td>.700</td>
</tr>
<tr>
<td>7</td>
<td>.683</td>
</tr>
<tr>
<td>8</td>
<td>.701</td>
</tr>
<tr>
<td>9</td>
<td>.710</td>
</tr>
<tr>
<td>10</td>
<td>.699</td>
</tr>
<tr>
<td>11</td>
<td>.709</td>
</tr>
<tr>
<td>12</td>
<td>.711</td>
</tr>
<tr>
<td>13</td>
<td>.715</td>
</tr>
<tr>
<td>14</td>
<td>.731</td>
</tr>
<tr>
<td>15</td>
<td>.685</td>
</tr>
<tr>
<td>16</td>
<td>.698</td>
</tr>
<tr>
<td>17</td>
<td>.695</td>
</tr>
<tr>
<td>18</td>
<td>.715</td>
</tr>
<tr>
<td>19</td>
<td>.719</td>
</tr>
<tr>
<td>20</td>
<td>.697</td>
</tr>
</tbody>
</table>
Revisions.

On the basis of item-total statistics and the discrimination index data, questions 14 and 22 were identified as being most problematic. These questions are discussed next.

14. The carbon dioxide-oxygen exchange occurs in the _____.
   a. nose
   b. trachea
   c. *lungs
   d. bronchi
   e. don’t know

   Note: * denotes the correct response

Table 17. Distractor Analysis for Question 14 in the Knowledge of Human Anatomy Test

<table>
<thead>
<tr>
<th>Percentage answering distractor</th>
<th>Total</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
<th>100.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>High 1/3</td>
<td></td>
<td>47.4%</td>
<td>47.4%</td>
<td>5.3%</td>
<td></td>
<td>100.0%</td>
</tr>
<tr>
<td>Middle 1/3</td>
<td></td>
<td>68.2%</td>
<td>31.8%</td>
<td></td>
<td>100.0%</td>
<td></td>
</tr>
<tr>
<td>Low 1/3</td>
<td></td>
<td>6.3%</td>
<td>62.5%</td>
<td>25.0%</td>
<td>6.3%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Total</td>
<td>1.8%</td>
<td>59.6%</td>
<td>35.1%</td>
<td>3.5%</td>
<td></td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Distractor analysis for this question indicated that the incorrect option d (bronchi) was attracting a high percentage of responses from the high scoring group (see Table 17). This option was replaced by the term “esophagus.”
22. Secretions of the ductless glands pass _____.
   a. into the bone structure
   b. *directly into the blood
   c. directly into the organs where they are used
   d. out of the body
   e. don’t know
   Note: * denotes the correct response

Table 18. Distractor Analysis for Question 22 in the Knowledge of Human Anatomy Test

<table>
<thead>
<tr>
<th>Percentage answering distractor</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>High 1/3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>100.0%</td>
</tr>
<tr>
<td>Middle 1/3</td>
<td>9.1%</td>
<td>4.5%</td>
<td>9.1%</td>
<td>4.5%</td>
<td></td>
<td>72.7%</td>
</tr>
<tr>
<td>Low 1/3</td>
<td>18.8%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>81.3%</td>
</tr>
<tr>
<td>Total</td>
<td>8.8%</td>
<td>1.8%</td>
<td>19.3%</td>
<td>5.3%</td>
<td></td>
<td>64.9%</td>
</tr>
</tbody>
</table>

Distractor analysis for this question indicated that none of the participants in the high-scoring group responded to this question correctly (see Table 18). The choices for this question were determined to be confusing. This question was replaced by the following question:

Q. Inability of the eye to focus on distant objects is called _________.
   a. astigmatism
   b. *myopia
   c. refraction
   d. hyperopia
   e. don’t know
   Note: * denotes the correct response
Spatial Ability Tests

Description.

This test consisted of two subsets: paper folding and card rotation (Ekstrom, French, & Harman, 1976). The paper folding test consisted of 20 multiple-choice questions and the card rotation test consisted of 20 questions, each with 8 sub-parts. An item from each subset is presented below.

Figure 24. Sample question from paper folding test.

Figure 25. Sample question from card rotation test.

Scoring of responses.

Participants were given one point for a correct response and 0 points for an incorrect response. The maximum score on the paper folding test was 20, while the maximum score on the card rotation tests was 160. The minimum score on both tests was 0 points. The original paper-based tests were converted to electronic format for online delivery. One question in the paper-
folding test was improperly digitized, data for this question was not considered in the analysis. Given this, the maximum score on the paper folding test in this study was 19 points. Descriptive statistics based on responses from 47 participants in the study are provided in Table 19.

Table 19. Spatial Ability Tests: Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Range</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Folding Test</td>
<td>55</td>
<td>15.00</td>
<td>4.00</td>
<td>19.00</td>
<td>10.24</td>
<td>3.94</td>
</tr>
<tr>
<td>Card Rotation Test</td>
<td>55</td>
<td>144.00</td>
<td>10.00</td>
<td>154.00</td>
<td>102.38</td>
<td>28.38</td>
</tr>
</tbody>
</table>

Reliability analysis.

Reliability analysis for scores on the spatial ability tests could not be performed since the number of responses (N = 55) were much fewer than the total number of questions in the tests. Research literature indicated the internal consistency reliability for both tests to be above .70 (Winfred, Doverspike, & Bell, 2004)

Correlations among Scores on the Measurement Instruments

Correlations among scores on the four human heart tests were high (see Table 20). Given that the dependent measures were significantly correlated, it was determined that there would be an advantage to using multivariate analysis of variance procedures over separate ANOVAs in phases of the study that followed (Bray & Maxell, 1985; Tabachnick & Fidell, 2001).
Table 20. Correlation among Scores on the Web-Based Human Heart Tests

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (N = 47)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Micro-Textbase</td>
<td>— .712**</td>
<td>.781**</td>
<td>.751**</td>
<td></td>
</tr>
<tr>
<td>2. Macro-Textbase</td>
<td>— .707**</td>
<td>— .674**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Micro-Situation Model</td>
<td>—</td>
<td>— .899**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Macro-Situation Model</td>
<td>—</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).

Correlations between scores on the prior-knowledge tests (covariates) and the human hearts tests were also calculated (see Table 21).

Table 21. Correlations among Scores on the Prior-Knowledge Tests and Human Heart Tests

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (N = 47)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Knowledge of Human Anatomy</td>
<td>—</td>
<td>.058</td>
<td>.200</td>
</tr>
<tr>
<td>2. Paper Folding</td>
<td>.058</td>
<td>— .347*</td>
<td></td>
</tr>
<tr>
<td>3. Card Rotation</td>
<td>.200</td>
<td>.347*</td>
<td>—</td>
</tr>
<tr>
<td>4. Micro-Textbase</td>
<td>.335*</td>
<td>.452**</td>
<td>— .244</td>
</tr>
<tr>
<td>5. Macro-Textbase</td>
<td>.290*</td>
<td>.369*</td>
<td>.150</td>
</tr>
<tr>
<td>6. Micro-Situation Model</td>
<td>.599**</td>
<td>.470**</td>
<td>.273</td>
</tr>
<tr>
<td>7. Macro-Situation Model</td>
<td>.433**</td>
<td>.371*</td>
<td>.181</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Given that these correlations were high, it was determined that there would be an advantage to using scores on the knowledge of human anatomy and spatial ability tests as covariates in phases of the study that followed (Wildt & Ahtola, 1978).
Testing Technology Used to Develop the Measurement Instruments

Technologies that were used to develop items in the measurement instruments, viz. implementation of the autocomplete design-pattern, drag-and-drop, and AJAX, were tested. Programming updates were made as appropriate. All measurement instruments were setup for online delivery. The database was checked to ensure that responses from participants and the timestamp data were being stored in the database. As needed, programming bugs were fixed.

Results

The content validity of the four measures—micro-textbase, macro-textbase, micro-situation model, macro-situation model—for the instructional unit on the human heart was established. Reliability analysis was performed on the multiple-choice format questions on the Web-based human heart tests and the knowledge of human anatomy test to identify problematic items (see Table 22). On the basis of item-total statistics and the discrimination index data, two items in the knowledge of human anatomy tests were identified as being most problematic; one item was updated, the other item was replaced. Reliability analysis on the spatial ability tests could not be performed because of insufficient data.
Table 22. Phase II Study: Reliability of Measurement Instruments

<table>
<thead>
<tr>
<th>Test</th>
<th>Maximum Score</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of Human Anatomy Test</td>
<td>30</td>
<td>.713</td>
</tr>
<tr>
<td>Spatial Ability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper folding test</td>
<td>19</td>
<td>—</td>
</tr>
<tr>
<td>Card rotation test</td>
<td>160</td>
<td>—</td>
</tr>
<tr>
<td>Human Heart Tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-Textbase Test (Set 1)</td>
<td>20</td>
<td>.926</td>
</tr>
<tr>
<td>Micro-Textbase Test (Set 2)</td>
<td>15</td>
<td>.868</td>
</tr>
<tr>
<td>Macro-Textbase Test</td>
<td>19</td>
<td>—</td>
</tr>
<tr>
<td>Micro-Situation Model Test</td>
<td>17</td>
<td>.893</td>
</tr>
<tr>
<td>Macro-Situation Model Test</td>
<td>22</td>
<td>.770</td>
</tr>
</tbody>
</table>

An implementation of the Damerau-Levenshtein distance (DLD) algorithm was found to be suitable for scoring the “rearranging-type” questions in the macro-textbase and macro-situation model tests.

Correlations among the scores on all four human heart tests were statistically significant (see Table 20). Given these correlations, it was determined that there would be an advantage to using multivariate analysis of variance procedures over separate ANOVAs in phases of the study that followed.

Given that the correlations between scores on the human heart tests on the one hand and the knowledge of the human anatomy test and the paper-folding test were high (see Table 21), it was determined that there would be an advantage to using scores on the knowledge of human anatomy and paper-folding tests as covariates in studies in the subsequent phases (Wildt & Ahtola, 1978). Correlations between scores on the Web-based human heart tests and the card-rotation test were not statistically significant.
Technology used to develop the measurement instruments (implementation of the autocomplete design-pattern, drag-and-drop, and AJAX) and online delivery of measurement instruments was tested; bugs that were identified were fixed. The Web-based measurement instruments developed in this study were used in the subsequent phases of the investigation.
PHASE III STUDIES—WEB-BASED LEARNING ENVIRONMENT DESIGN

Research Goals

The Phase III studies had two primary goals: (a) guide the design of a Web-based learning environment that supports the use of a set of five reading strategies; and (b) develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.

Four small-scale studies that addressed these research goals were conducted over a four-week period. The goals, number of participants, and days on which sessions were held for each of the four studies in Phase III are summarized in Table 23. In all 43 sessions were held—one participant per session; each session lasted about two hours.

Table 23. Goals, Number of Participants, Days on which Sessions were held in the Four Studies in Phase III

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of Participants</th>
<th>Day   (# of sessions)</th>
<th>Study Goals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study 1</td>
<td>8</td>
<td>Day 1 (1)</td>
<td>1. Update the Web-based learning environment on the basis of feedback received from participants.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Day 2 (4)</td>
<td>2. Develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Day 3 (3)</td>
<td></td>
</tr>
<tr>
<td>Study 2</td>
<td>7</td>
<td>Day 4 (3)</td>
<td>Goals 1 and 2 from Study 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Day 5 (4)</td>
<td>3. In preparation for the large-scale Phase IV study, develop and pilot test an animated demonstration of the Web-based learning environment that provided participants an overview of the user interface of the Web-based learning environment.</td>
</tr>
<tr>
<td>Study 3</td>
<td>13</td>
<td>Day 6 (3)</td>
<td>Goals 1, 2 and 3 from Study 2</td>
</tr>
</tbody>
</table>
4. Develop and pilot a Web-based feedback survey for collecting data under the following categories:
   - Day 7 (4) demographics
   - Day 8 (3) experience in the Web-based learning environment
   - Day 9 (3) experience with the Web-based human heart tests

5. Compare the behavior and experience of readers who read the instructional unit on the human heart in a paper-form of the Web-based learning environment with the behavior and experience of readers who read the instructional unit in the Web-based learning environment.

Participants

Participants in the Phase III studies were recruited from two undergraduate courses offered in fall of 2008 in the Energy and Geo-Environmental Engineering departments at a large public university in the northeastern United States. Students from various undergraduate programs at the university typically enroll in these courses to fulfill university’s general education requirements.

Participants in the study were offered extra credit which amounted to 3% of the entire course grade. An alternative extra credit opportunity was made available to students who chose not to participate in the study but still wanted to obtain the extra credit. The informed consent form for the study is included in Appendix L.

Participants were recruited from a pool of 124 students. Of these, 43 students participated in the four studies in Phase III; three students completed the alternative extra credit assignment.
Materials

The studies in Phase III used the following material:

1. Instructional unit on the human heart (Dwyer & Lamberski, 1977) that was used in the Phase I and II studies (see Appendix A).

2. Web-based human heart tests that measured readers’ memory and understanding of the instructional text on the human heart at the micro-textbase, macro-textbase, micro-situation model, and macro-situation model levels. The reliability and validity of these tests was established in the Phase II study (see Appendices C, D, E, F and G). The knowledge of human anatomy and spatial ability tests were also used (see Appendix H).

3. The Web-based learning environment that was designed to support the use of five reading strategies. Over the course of this research, the design of the Web-based learning environment went through multiple iterations. What follows is a description of the final iteration of the user interface of the Web-based learning environment; screenshots from the animated demonstration of the Web-based learning environment used in the Phase IV study are used in the description. The instructional text used in the demonstration was titled “How Airplanes Work.”

Documents in the Web-based learning environment are composed of elements. Each element consists of one or more paragraphs of text. Some elements also contain an image (see Figure 26).
Readers could use five reading strategies in the Web-based learning environment. Each of these strategies is described below.

1. **Text-macrostructure (chunking) strategy**: A reader can chunk the instructional unit on the human heart into smaller sections by moving elements that make up the instructional unit into *tabs* that they create on the interface of the Web-based learning environment. A reader can also label these tabs. In this way each tab on the user interface corresponds to a reader-generated *section* of instructional unit. An example of a sequence of steps that a reader would take in executing this strategy is provided below (see Figure 27, Figure 28, Figure 29, Figure 30). It is expected that in the process of reorganizing the instructional unit at the macro-level, the reader would begin to develop a macro-level understanding of the text—the “big picture.” Being able to *customize* the instructional unit in this way should also motivate the reader to engage with it deeply.
Figure 27. Text-macrostructure strategy: Creating a new section (tab on the interface).

Figure 28. Text-macrostructure strategy: Two new sections are created (top-left hand corner).
Figure 29. Text-macrostructure strategy: An element is moved to a section (tab).

Figure 30. Text-macrostructure strategy: The “aerodynamic force” tab with element 2 and element 3 in it.
2. **Summarization strategy**: A reader can write summaries for each section (tab) that she creates (see Figure 31). It is expected that in the process of writing summaries the reader would access her *macro-level understanding* of the instructional unit. In the process of writing summaries, gaps in macro-level understanding, if any, would be exposed. In the event the reader found gaps in understanding, she could take action—for example, rereading a particular section of the instructional unit (Armbruster, Anderson, & Ostertag, 1987).

*Figure 31. Summarization strategy.*
3. **Imagery strategy**: A reader can select an image from a library of images that is most representative of the contents of a given section (see Figure 32). This strategy is expected to encourage readers to integrate knowledge across modalities, which in turn should lead to creation of well integrated and robust knowledge representations (Sadoski & Paivio, 2004; see also Ainsworth, 1999).

![Image of an interactive selection of images related to airplanes](image.png)

*Figure 32. Imagery strategy.*
4. **Reading self-assessment (comfort-meter) strategy**: A reader can mark on a scale of 1-5 how comfortable she feels with her understanding of each section of the instructional unit (see Figure 33). It is expected that a metacognitively aware reader would realize that not all sections of the instructional unit are equally challenging. On the basis of this knowledge, the reader could decide to allocate cognitive resources to the more difficult sections, for example by choosing to revisit and reread them (Pressley & Harris, 2006; Pressley & Ghatala, 1990).

*Figure 33. Reading self-assessment (comfort-meter) strategy.*
5. **Note-taking strategy**: A reader can take notes on an *element-by-element* basis—these notes are attached to the elements that make up the instructional text (see Figure 34). It is expected that note-taking will support comprehension by allowing the reader to externalize her understanding, maintain attention, and provide a summary of the main points for a given element in the instructional unit (DiVesta & Gray, 1972; Peper & Mayer, 1986; see also Kiewra et al., 1991).

![Figure 34. Note-taking strategy.](image)

Participants were *required* to use all strategies. Upon clicking the “Finish” button on the user interface (top right-hand corner) a status window was displayed. This window displayed the status of use of the summarization, imagery and comfort-meter strategies for each section created by the reader (see Figure 35).
4. Multiple sources were used to collect data during the lab sessions:

a. Screen capture software: A screen capture software (Qarbon ViewletBuilder4), was used to record participants’ interaction with the Web-based learning environment. This software took image shots of the computer screen every time a participant clicked the mouse button or typed a keystroke. This data was used to develop an understanding of how participants interacted with the user interface of the Web-based learning environment, in particular how they used the reading strategies in the Web-based learning environment.

b. Video camera and microphone: Participants were asked to think aloud while they were reading in the Web-based learning environment. A video camera was used to capture this think aloud data. The video camera was focused on the computer screen, in this way it also acted as a backup for data collected with the screen capture software. Since participants in the study did not face the video camera, the camera’s built in microphone was not very effective at picking up
participants’ audio feedback. Participants were asked to wear a headset with a built-in microphone. This headset was used to feed sound to the video camera.

c. Web-cam: A Web cam was used to capture readers’ facial expressions while they read in the Web-based learning environment. Although the web cam recorded audio, the quality of the audio recording was poor.

d. MP3 Audio Recorders: As a backup for the audio recorded with the video camera, two mp3 players with sound recording capability were used.

Given that multiple equipment were used for data collection, the researcher prepared a checklist to make sure that all the equipment were turned on before each session. This checklist is provided in Appendix N.

5. Two Web sites were used in the study: (1) Reservation Web site which enabled participants to book a time slot for Part 1 and a lab slot for Part 2 of the study. The Web site also enabled participants to cancel and reschedule their reservations. (2) Study Web site: This site provided links to prior-knowledge tests, the instructional unit on the human heart, and the human heart tests. Participation status was updated on this Web site as participants completed various sections of the study. Both Web sites were password protected. Screenshots of these Web sites are available in Appendix M.

6. Lab: A lab was booked for Part 2 of the study.
Procedure

Prospective participants in the study were emailed a recruitment message two weeks prior to the study.

Like the Phase II study, studies in this phase were split into two parts. In Part 1, participants were asked to complete the prior-knowledge tests (knowledge of human anatomy and spatial ability tests). Participants could complete this part online at any time. Participants were asked to visit a research lab for Part 2. To encourage participants to commit time for participating in the study, they were asked to book a time slot for Part 1 and a lab session for Part 2 in advance; only one participant could book a given lab session for Part 2. Reservation of lab sessions for Part 2 was on a first-come-first-serve basis.

Participants were given one week to complete Part 1. For Part 2, participants could book a lab session on one of thirteen days on which sessions were held. Participants completed Part 1 by logging into the Study Web site within 30 minutes of the time they had booked for this part. Participants visited the research lab to complete Part 2. A lab session lasted about two hours. Only one participant was present in each lab session. A reminder email was sent to participants one day prior to their lab session for Part 2.

Upon arrival at the lab, a participant was given instructions for Part 2 of the study. After this the researcher asked the participant to log into the Study Web site. All participants were asked to think aloud as much as possible while they were reading the instructional unit on the human heart in the Web-based learning environment. In particular, they were asked to remember to think aloud during two specific situations:

1. Whenever they engaged in cognitive processes that would help them understand the instructional unit on the human heart, for example, when they were using one of the reading
strategies in the Web-based learning environment. As an example, the researcher provided them the following instruction: “For example, please think aloud whenever you decide to add a new section or tab in the Web-based learning environment. If you can, please mention why you were creating this particular section.”

2. Whenever they had a comment or suggestion about the user interface of the Web-based learning environment. As an example, the researcher provided them the following instruction: “If you want to rename the title of a section that you have previously created, but you do not know how to do so in the Web-based learning environment, please say that aloud.”

There was no time limit for either part of the study, except for the spatial ability tests in Part I for which participants were allowed a maximum of 12 minutes. On average, participants took less than 25 minutes to complete Part 1; a typical lab session lasted about 2 hours; some lab sessions lasted up to three hours.

Additional procedures that were unique to the four studies in Phase III are noted in the procedures section for the respective study.
PHASE III—STUDY 1

Research Goals

Two research goals were pursued in this study: (a) update the Web-based learning environment on the basis of feedback received from participants, and (b) develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.

Participants

Eight participants participated in Study 1 in Phase III. Sessions in this study were held on Day 1, Day 2 and Day 3 of Part 2 of the Phase III study (see Table 23). Only one participant was present in each lab session.

Materials

The materials used in this study included the instructional unit on the human heart which was presented in the Web-based learning environment; the knowledge of human anatomy and spatial ability tests (see Appendix H). The equipment described above was used to capture participants’ interactions with the Web-based learning environment and their think-alouds. Interview questions regarding participants’ experience in the Web-based learning environment were prepared. These interview questions went through multiple revisions during the course of
the study. The list of questions that were used with the last participant in this study is provided in Table 24.

Table 24. Study 1 in Phase III: Interview Questions

<table>
<thead>
<tr>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q. So what do you think? What is your overall impression? Is this a tool that you can see yourself use?</td>
</tr>
<tr>
<td>Q. Can you recollect some of the strategies you used?</td>
</tr>
<tr>
<td>Q. What do you think of the strategies? Did you find them useful?</td>
</tr>
<tr>
<td>Q. What did you like most about the Web-based learning environment?</td>
</tr>
<tr>
<td>Q. What did you like least about the Web-based learning environment? What would you like changed?</td>
</tr>
<tr>
<td>Q. Do you think you spend more time reading in the Web-based learning environment than what you would have if you read the same text on a Web page? If yes, by how much?</td>
</tr>
<tr>
<td>Q. Do you think this extra time helped you? Do you think you learned more? In other words, if you were to take a test, would you score higher having read the text in the Web-based learning environment?</td>
</tr>
<tr>
<td>Q. Have you used the online tool called Google Docs?</td>
</tr>
</tbody>
</table>

Procedure

Upon arrival at the research lab, a participant was provided an overview of Part 2 of the study. Following this, the researcher gave the participant an oral overview of the reading strategies in the Web-based learning environment. The researcher then asked the participant to log into the Study Web site. The Study Web site directed the participant to the Web-based learning environment; the instructional unit on the human heart was displayed in the Web-based learning environment. At this point the researcher described the interface of the Web-based learning environment and the five reading strategies.
Participants were asked to read the instructional unit on the human heart. Participants were informed about the think aloud protocol and asked to think aloud as much as possible. Participants were given examples of specific situations where they should remember to think aloud. At this time the researcher left the lab.

The researcher could track a participant’s progress in the study from a remote computer. Once a participant completed reading the instructional unit in the Web-based learning environment, the researcher returned to the lab to interview the participant about her experience in the Web-based learning environment. The procedures used in this study are summarized in Figure 36.

![Figure 36. Schematic for Study 1 in Phase III.](image)
Data Analysis

The researcher kept a journal for each of the eight participants in Study 1 in Phase III. The journal entries were structured into separate sections: notes before the participant’s arrival, responses to interview questions, other notes during the session, and notes after the participant left the lab. In these journal entries the researcher recorded evidence that was related to the use of the reading strategies in the Web-based learning environment, its user interface and participants’ experience in the Web-based learning environment. A typical journal entry for a session is shown in Figure 37.

<table>
<thead>
<tr>
<th>Participant ID: xyz123</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date: October 15, 2008</td>
</tr>
</tbody>
</table>

**Notes (PRE)**
- I am trying the digital video camera’s built-in wireless microphone for capturing sound
- I am trying Viewlet Builder for screen capture

**Responses to Interview Questions**
- participant liked the chunking strategy
- participant said he is more comfortable taking notes with pen/paper
- participant offered many suggestions regarding the interface:
  - enter to submit (YUI SimpleDialog --> Panel)
  - “rename tab” still allows 15 characters

**Other Notes**
- participant really seemed to have liked the LE [Web-based learning environment]
- participant did a lot of thinking aloud

**Notes (POST)**
- Viewlet Builder seems to have worked, but it somehow triggered Symantec. Next time try with Symantec disabled.
- Participant was very happy to have participated in the study. He offered to participate in future studies.

Figure 37. Journal entry from a session in Study 1 in Phase III.
The data collected from the multiple data sources was extremely rich and voluminous. The researcher made his best attempt to review this data before the next day’s sessions. Information noted in the research journal was used to identify and review those episodes during a given session that were particularly interesting or insightful.

A detailed analysis of all the data collected in Study 1 in Phase III is beyond the scope of the current research investigation. However, results from a preliminary analysis of this data, in particular how this analysis influenced the design of the Web-based learning environment, are presented.

Results

*Updates to the Web-Based Learning Environment*

Participants suggested updates to the Web-based learning environment based on their experience. Many of these ideas for design updates emerged from the researcher-participant discussions during the interview sessions. These recommendations and design ideas were categorized into two categories: short- and long-term design updates. Recommendations in the short-term category were typically implemented at the end of the day (before the next day’s sessions); sometimes updates were made in between sessions. Suggestions in the long-term category were appended to the long-term “to-do” list.

1. Short-term recommendations for updating the Web-based learning environment are noted in Table 25. These recommendations were addressed before the next day’s sessions.
Table 25. Study 1 in Phase III: Short-Term Recommendations for Updating the Web-Based Learning Environment

Allow more than 15 characters in tab labels.

Elements 24 and 25 are the same.

When no tab exists and the reader right clicks on an element to try to move it, the element disappears.

Allow copy and paste to notes and summary [make these dialogs non-modal]

[While creating notes, summaries, images, comfort-meter, readers should be able to press the enter button to submit their responses—change YUI SimpleDialog to Panel]

[Make notes textarea a RTE (Rich Text Editor)]

[When a reader attempts to delete a tab, she should be informed that the summary, images and comfort-meter settings associated with this tab will also be deleted]

Note: The researcher’s comments are placed inside [square brackets]

2. Longer-term recommendations for updating the Web-based learning environment are noted in Table 26. These recommendations were added to the long-term to-do list.

Table 26. Study 1 in Phase III: Long-Term Recommendations for Updating the Web-Based Learning Environment

[Find ways so that readers could update text in summary boxes and notes more easily.]

Ability to highlight text, like it is possible in Microsoft Word and Adobe Acrobat Reader

Find ways to make the level that was set on the comfort-meter more obvious [Maybe have the background color of a tab reflect the level. Or maybe hover-over. Certainly, a reader should not have to click on the tab to see the level that was set.]

Readers should be able to select more than one image in the imagery tab

Make adding tabs easier. A participant suggested that instead of clicking the + button to add a
tab, maybe the reader should be able to “right click and add a tab.”

Easier way to create notes would be to copy and paste from text.

Ability to make your own elements.

Ability to delete parts of the text.

[Look for a better way to represent the moved elements. Maybe fade them out (making them unclickable) or reduce the font size. Also instead of the text “element moved to a different tab” include information indicating which tab the element was moved to.]

Display all the notes, all the summaries, all the images, all the comfort-meter settings in one place and make this printable. [Display this information inside a pop-up window.]

[The imagery strategy did not make sense to many of the participants, especially with the current selection of images in the library. Allow participants to upload their own images to the library.]

[In preparation for future studies, prepare an online feedback survey that captures readers’ experience in the Web-based learning environment. Use questions from the set of interview questions.]

Note: The researcher’s comments are placed inside [square brackets]

Use of Reading Strategies in the Web-Based Learning Environment

During the interview one of the participants in the study said that he did not use the summarization, imagery and comfort-meter strategies. He said, he took “comprehensive notes and did not feel the need to write summaries.” This pointed to the possibility that some participants could choose not to use one or more reading strategies in the Web-based learning environment because they did not want to make the effort. The researcher considered this to be a potential issue given that a comparison between reading in the Web-based learning environment with reading on a regular Web page was planned in the Phase IV study. To encourage participants to at least consider using all the strategies, the design of the Web-based learning
environment was updated so that it did not allow participants to complete their reading session in the Web-based learning environment unless they had made use of all the reading strategies except the note-taking strategy, which was still not required. This update to the Web-based learning environment required participants to write a summary, select an image, and set a comfort-meter level for each section that they created. Of course participants could circumvent this requirement by entering bogus data.

*Experience in the Web-Based Learning Environment*

Even though the researcher did not go through all the features of the user interface of the Web-based learning environment during the oral orientation, participants did not seem to have problems navigating the Web-based learning environment. The researcher had a feeling that on the whole, participants in the Study 1 in Phase III found the interface of the Web-based learning environment to be intuitive and they did not have problems using it. This claim is supported by feedback from one of the participants, “*I liked the interface, it was intuitive, for example to rename a tab, I right clicked, and it worked! The interface offered flexibility.*”

*Updates to the Prior-Knowledge Tests*

The researcher used this opportunity to collect feedback from participants about their experiences with the prior-knowledge tests in Part 1. Several participants noted that they were surprised by how quickly the allotted time for the spatial ability tests ran out. This issue was addressed by displaying a count-down timer on the Web-pages for the spatial-ability tests.
Updates to the Interview Questions

As sessions in the Study 1 in Phase III progressed, some patterns of use of the Web-based learning environment began to emerge. New questions were added to the set of interview questions to investigate these patterns of use. For example, the researcher found that most participants spent much more time reading the instructional unit on the human heart in the Web-based learning environment as compared to participants in Phase II who read the instructional unit on a regular Web page. On average, participants in the Phase II study spent about 15 minutes to the read the instructional unit on the human heart when it was presented on a regular Web page. On the other hand, participants in the Study 1 in Phase III spent over 30 minutes reading the instructional unit on the human heart in the Web-based learning environment. Were participants aware that the time they spent reading was longer than average? Was this extra time helping participants learn more? To investigate this phenomenon, the following questions were added to the set of interview questions:

Q. Do you think you spend more time reading in the Web-based learning environment than what you would have if you read the same text on a Web page? If yes, by how much?

Q. Do you think this extra time helped you? Do you think you learned more? In other words, if you were to take a test, would you score higher having read the text in the Web-based learning environment?

The researcher found some participants to be more “savvy” about the new Web technologies than others. To gauge participants’ exposure to current Web technologies the following question was added to the set of interview questions:

Q. Have you used the online tool called Google Docs?
Exposure to current Web technologies could possibly impact participants’ use of the Web-based learning environment.

Discussion and Conclusions

With every session in the Study 1 in Phase III, the researcher developed insights into participants’ use of the Web-based learning environment and participants’ experience in it. Participants spent over 30 minutes reading the instructional unit on the human heart. In Phase II study in which the instructional unit on the human heart was presented on a regular Web page, participants spent only half as much time. Participants seemed to engage more deeply with the text and they seemed to enjoy their reading experience in the Web-based learning environment. Did the increase in effort translate into improvement in learning outcomes (memory and understanding for the instructional unit)? This question could not be answered in this study since participants did not respond to the human heart tests.

Critical bugs and limitations in the user interface of the Web-based learning environment were identified and updates were made based on this information. Long-term recommendations for updating the Web-based learning environment were noted. The list of interview questions was updated to probe the patterns of use of the Web-based learning environment that emerged from the sessions in this study.

Given that one-on-one explanation of the interface of the Web-based learning environment would not be possible in the large-scale Phase IV study, a decision was made to develop an animated demonstration of the Web-based learning environment that would provide participants an overview of the user interface of the Web-based learning environment.
Research Goals

A third goal was added to the two goals from the previous study. This goal was to develop and pilot test an animated demonstration of the Web-based learning environment that would provide participants an overview of the user interface of the Web-based learning environment.

Participants

Seven participants participated in Study 2 in Phase III. Sessions in this study were held on Day 4 and 5 of Part 2 of the Phase III study (see Table 23). Only one participant was present in each lab session.

Materials

The materials used in this study included the materials from Study 1 in Phase III—the instructional unit on the human heart, the Web-based learning environment, the knowledge of human anatomy and spatial ability tests (see Appendix H), equipment used to capture participants’ interactions with the Web-based learning environment and their think-alouds, and the set of interview questions regarding participants’ experience in the Web-based learning environment.

An animated demonstration of the Web-based learning environment was developed using a screen capture software. This demonstration was designed to provide participants an orientation of the user interface of the Web-based learning environment. The instructional unit
on the human heart was used in the demonstration. The animated demonstration included
screenshots of the Web-based learning environment, the location and movements of the mouse
pointer, as well as keystrokes (both text and sound). The captured images were played in
sequence giving the impression of an animated movie. Mouse pointer movements and keystrokes
were also animated during the playback. Overlay text was added to the screenshots. The
demonstration was 4 minutes and 45 seconds long. Daily updates to the demonstration were
made on the basis of the feedback received in this study. The final version of the demonstration
that was used in the last Phase III study is located at http://www.learning-

Procedure

Upon arrival at the research lab, a participant was provided an overview of Part 2 of the
study. Following this, the researcher gave the participant an oral overview of the reading
strategies in the Web-based learning environment. After this the participant was asked to watch a
demonstration of the Web-based learning environment. The researcher observed the participant
as she watched the demonstration. After the demonstration was complete, the researcher asked
the participant if she had any questions about the Web-based learning environment or what she
was expected to do in the study. Next, the participant was asked to log into the Study Web site.
The Study Web site directed the participant to the Web-based learning environment; the
instructional unit on the human heart was displayed in the Web-based learning environment. The
participant was asked to read the instructional unit.
All participants were informed about the think aloud protocol and asked to think aloud as much as possible. Participants were given examples of specific situations where they should remember to think aloud. At this time the researcher left the lab.

The researcher could track a participant’s progress in the study from a remote computer. Once the participant had completed reading the instructional unit in the Web-based learning environment, the researcher returned to the lab to interview the participant about her experience in the Web-based learning environment. The procedures used in this study are summarized in Figure 38.

*Figure 38. Schematic for Study 2 in Phase III.*
Data Analysis

The researcher kept a journal for each of the seven participants in Study 2 in Phase III. The journal entries were structured into separate sections: notes before the participant’s arrival, responses to interview questions, other notes during the session, and notes after the participant left the lab. In these journal entries the researcher recorded evidence that was related to the use of the reading strategies in the Web-based learning environment, its user interface and participants’ experience in the Web-based learning environment.

The data collected from the multiple data sources was extremely rich and voluminous. The researcher made his best attempt to review this data before the next day’s sessions. Information noted in the research journal was used to identify and review those episodes during a given session that were particularly interesting or insightful.

A detailed analysis of all the data collected in Study 2 in Phase III is beyond the scope of the current research investigation. However, results from a preliminary analysis of this data, in particular how this analysis influenced the design of the Web-based learning environment and the animated demonstration of the Web-based learning environment, are discussed.

Results

Updates to the Web-Based Learning Environment

Participants suggested updates to the Web-based learning environment based on their experience. Many of these ideas for design updates emerged from the researcher-participant discussions during the interview sessions. These recommendations and design ideas were
categorized into two categories: short- and long-term design updates. Recommendations in the short-term category were typically implemented at the end of the day (before the next day’s sessions); sometimes updates were made in between sessions. Suggestions in the long-term category were appended to the long-term “to-do” list.

1. Short-term recommendations for updating the Web-based learning environment are noted in Table 27. These recommendations were addressed before the next day’s sessions. Only one critical bug was noted during the sessions in this study—this was a sign that the Web-based learning environment was getting more stable.

Table 27. Study 2 in Phase III: Short-Term Recommendations for Updating the Web-Based Learning Environment

<table>
<thead>
<tr>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>After an element was moved, the scroll wheel on the mouse becomes buggy. If scrolled too low on the page, the text disappears.</td>
</tr>
</tbody>
</table>

During the interview, one of the participants requested a feature—ability to change the label of an existing tab—that was already designed in the Web-based learning environment. This feature was not described in the animated demonstration though. Although the demonstration of the Web-based learning environment could have been updated to address this feature, the researcher decided against doing so for the following reasons: (a) some participants who wanted to use this feature, were able to discover it on their own; and (b) including instructions on this feature would increase the duration of the demonstration that was already quite long.

2. Longer-term recommendations for updating the Web-based learning environment are noted in Table 28. These recommendations were added to the long-term to-do list.
Table 28. Study 2 in Phase III: Long-Term Recommendations for Updating the Web-Based Learning Environment

| Ability to have the text narrated |
| Ability to rearrange the order in which notes are displayed [currently the notes are displayed vertically in reverse chronological order] |
| Ability to put the same element in more than one section |
| Ability to create sub-sections inside sections |

*Note: The researcher’s comments are appended inside [square brackets]*

*Updates to the Demonstration of the Web-Based Learning Environment*

The researcher watched the demonstration of the Web-based learning environment along with the participants. During these episodes, the researcher attempted to experience the demonstration from the perspective of someone who was experiencing the Web-based learning environment for the first time. The researcher noted those screens in the demonstration on which the instructions might have came across as unclear to a first-time user. Instructions on these screens were updated to improve clarity. Another goal of the updates to the demonstration was to reduce its overall duration and to adjust the display time for some of the screens so that the demonstration “flowed” better (Csikszentmihalyi, 1990).

During the interview participants were asked whether the demonstration provided them adequate orientation to the Web-based learning environment. Updates to the demonstration were made based on the feedback from participants.
Experiences in the Web-Based Learning Environment

Some observations illustrating participants’ experience in the Web-based learning environment are provided in Table 29.

Table 29. Study 2 in Phase III: Experiences in the Web-Based Learning Environment

| A participant liked the spell check facility and ability to bold, bullet etc. (in the rich text editor) when preparing summaries |
| A participant mentioned that she was a perfectionist and she liked being able to customize the instructional text the way she liked it. She said she was so excited that she would tell her mother. She taught school kids, and she thought that these kids would really benefit from reading in the Web-based learning environment as well |
| A participant said that since this was not something that was required for class, she did not pay as much attention to reading the text |
| A participant liked the fact that there were many different ways in which he could interact with the text. He liked the Web-based learning environment for its “flexibility” |

Discussion and Conclusions

With every session in the Study 2 in Phase III, the researcher developed insights into participants’ use of the Web-based learning environment and participants’ experience in it.

Findings in this study were consistent with findings in Study 1 in Phase III. Participants spent over 30 minutes reading the instructional unit on the human heart in the Web-based learning environment. Participants seemed to engage deeply with instructional unit on the human heart and they seemed to enjoy their reading experience.

One of the participants noted that she liked being able to “customize the text the way she liked.” This participant liked the ability to customize the instructional text, which might have
motivated her to spend more time reading it and engage more deeply with it. Participants in Phase III studies were able to *customize* the instructional unit in the Web-based learning environment quite like participants in the Phase I study who customized the instructional text using the early-stage paper prototype of the Web-based learning environment.

Several updates were made to the demonstration of the Web-based learning environment based on the feedback from the participants. Overall, the demonstration was found to be effective in providing participants an orientation of the Web-based learning environment.

Only one critical bug in the Web-based learning environment was noted during the sessions in this study—this indicated that the Web-based learning environment was becoming more stable.

Given that one-on-one interviews with participants would not be possible in the large-scale Phase IV study, a decision was made to develop a Web-based feedback survey for collecting data under the following categories: demographics, experience in the Web-based learning environment, experience with the Web-based human heart tests, and overall experience in the research study. These surveys were based on the interview questions used in this study.
**PHASE III—STUDY 3**

Research Goals

A fourth goal was added to the three goals from the previous study. This goal was to develop and pilot a Web-based feedback survey for collecting data under the following categories: demographics, experience in the Web-based learning environment, experience with the Web-based human heart tests, and overall experience in the research study.

Participants

Thirteen participants participated in Study 3 in Phase III. Sessions in this study were held on Day 6, 7, 8, and 9 of Part 2 of the Phase III study (see Table 23). Only one participant was present in each lab session.

Materials

The materials used in this study included the materials used in the previous studies in this Phase—the instructional unit on the human heart; the Web-based learning environment; a demonstration of the Web-based learning environment developed in Study 2 in Phase III; the knowledge of human anatomy and spatial ability tests (see Appendix H); equipment used to capture participants’ interactions with the Web-based learning environment and their think-alouds. Web-based human heart tests that were developed and validated in the Phase II study were also used (see Appendix C, D, E, F and G).
A Web-based feedback survey was prepared. Questions in these surveys were organized under four sections: demographics; experience in the Web-based learning environment; experience with the Web-based human heart tests; and overall experience in the research study. Interview questions used in Study 1 and Study 2 in Phase III were used to prepare questions related to participants’ experience in the Web-based learning environment. Frequent updates were made to the survey questions; new questions were added based on understandings that emerged from the sessions in this study. The survey questions that were used in the Phase IV study are included in Appendix Q.

**Procedure**

Upon arrival at the research lab, a participant was provided an overview of Part 2 of the study. Following this, the researcher gave the participant an oral overview of the reading strategies in the Web-based learning environment. After this, the participant was asked to watch a demonstration of the Web-based learning environment. The researcher observed the participant as she watched the demonstration. After the demonstration was complete, the researcher asked the participant if she had any questions about the Web-based learning environment or what she was expected to do in the study. After this the participant was asked to log into the Study Web site. The Study Web site directed the participant to the Web-based learning environment; the instructional unit on the human heart was displayed in the Web-based learning environment. The participant was asked to read the instructional unit on the human heart in the Web-based learning environment. After the participant had read the instructional unit, she was asked to respond to the Web-based human heart tests. Finally, the participant was asked to respond to a set of survey questions.
Participants in the study were informed about the think aloud protocol and asked to think aloud as much as possible. Participants were given examples of specific situations where they should remember to think aloud. At this time the researcher left the lab.

The researcher could track a participant’s progress in the study from a remote computer. Once the participant had completed reading the instructional unit in the Web-based learning environment, the researcher returned to the lab to interview the participant about her experience in the Web-based learning environment. Since participants in this study responded to questions on the Web-based feedback survey, interviews with participants were shorter as compared to interviews in the first two studies in Phase III. The procedures used in this study are summarized in Figure 39.

Figure 39. Schematic for Study 3 in Phase III.
Data Analysis

The researcher kept a journal for each of the 13 participants in Study 3 in Phase III. The journal entries were structured into separate sections: notes before the participant’s arrival, responses to interview questions, other notes during the session, and notes after the participant left the lab. In these journal entries the researcher recorded evidence that was related to the use of the reading strategies in the Web-based learning environment, its user interface and participants’ experience in the Web-based learning environment.

The data collected from the multiple data sources was extremely rich and voluminous. The researcher made his best attempt to review this data before the next day’s sessions. Information noted in the research journal was used to identify and review those episodes during a given session that were particularly interesting or insightful.

A detailed analysis of all the data collected in Study 3 in Phase III is beyond the scope of the current research investigation. However, results from a preliminary analysis of this data, in particular how this analysis influenced the design of the Web-based learning environment, the animated demonstration of the Web-based learning environment, and the Web-based feedback survey, are discussed.

Results

Updates to the Web-Based Learning Environment

Participants suggested updates to the Web-based learning environment based on their experience. Many of these ideas for design updates emerged from the researcher-participant discussions during the interview sessions. These recommendations and design ideas were
categorized into two categories: short- and long-term design updates. Recommendations in the short-term category were typically implemented at the end of the day (before the next day’s sessions); sometimes updates were made in between sessions. Suggestions in the long-term category were appended to the long-term “to-do” list.

1. Short-term recommendations for updating the Web-based learning environment are noted in Table 30. These recommendations were addressed before the next day’s sessions. The number of bugs that were identified by the participants in the Web-based learning environment remained very few in number.

Table 30. Study 3 in Phase III: Short-Term Recommendations for Updating the Web-Based Learning Environment

[Once a reader adds a note to an element and then moves the element to a new tab, the note becomes hidden; this makes it difficult to know which element has a note and which one does not]

Some participants lost elements while they were attempting to move them [a quick solution is to refresh the page]

Note: The researcher’s comments are placed inside [square brackets]

2. Longer-term recommendations for updating the Web-based learning environment are noted in Table 31. These recommendations were added to the long-term to-do list.

Table 31. Study 3 in Phase III: Long-Term Recommendations for Updating the Web-Based Learning Environment

Make the comfort-meter scale continuous

In the demonstration use a text different from the instructional unit on the human heart
Ability to reorder the tabs [without having to delete and recreate them]

A participant wanted to be able to create her own elements; she found the pre-defined elements to be constraining

Note: The researcher’s comments are placed inside [square brackets]

Experiences with the Demonstration of the Web-Based Learning Environment

One participant nodded in agreement as he watched the part of the demonstration that showed the creation of tabs and moving elements into the tabs. He said “cool” when he saw the demonstration on the note-taking strategy. This participant seemed to have enjoyed using the Web-based learning environment. At the end of the session he asked, “So when can we use this, can we use this next semester?”

One other participant thought aloud while he watched the demonstration. He nodded as he watched the demonstration of the text-macrostructure (chunking) strategy and said “this would be beneficial to studying.” While watching the demonstration of the note-taking strategy, he said “that’s convenient.” For the comfort-meter he remarked, “that would definitely be useful...something you already do in your mind.” At the end of the session, when this participant was asked whether he would like to read other texts in the Web-based learning environment, he said he would like to “read everything in the Web-based learning environment.”

Experiences in the Web-Based Learning Environment

One of the participants seemed initially skeptical of the Web-based learning environment. While the researcher was describing the text-macrostructure (chunking) strategy, she asked “Why would anyone do that?” After watching the demonstration she said she thought she might
like the Web-based learning environment. At the end of the session, she remarked that she found
the Web-based learning environment to be innovative and interesting, and that she was excited.
She said that she really liked “breaking up the text” (the text-macrostructure strategy) and the
comfort-meter strategy. She saw the comfort-meter as being analogous to the list of questions
that she received in advance of the lesson materials in a class she was taking. For her class, she
“erased” those questions from the initial list that she knew she would be able to answer and
retained the ones she could not. If she used this learning environment, she said she would revisit
those tabs that she had marked as difficult, updating the difficulty level (analogous to erasing
questions) once she was more confident with the contents. She made a suggestion that the
comfort-meter should be allowed to be set on a continuous scale. She also suggested that a text
different from the instructional unit on the human heart should be used in the demonstration,
since in the experiment participants were asked to read the instructional unit on the human heart.

Another participant said that he “thought more” since he had to move the elements into
tabs. He said that he first skimmed the text and then started creating tabs, the text-macrostructure
strategy (chunking) helped him focus more on the reading. He compared this to a strategy he
already used—quickly reading the text the first time, looking at the questions that needed to be
answered (as advance organizers), and then going back to reread the text more carefully and
answering the questions. When he was asked if the tool would help him do better on the tests, he
said at first he thought it would, but then he realized that he was too busy trying to reorder the
text. If he went back to the Web-based learning environment and reread the text, he would do
much better on the tests. When asked whether he would like to read other texts in the Web-based
learning environment, he said it depended on the type of text, for example he would not like to
read novels, but for scientific texts this would “work better.” Interaction with this participant
made the researcher wonder if some of the participants approached the task in the Web-based learning environment as a game in which the goal was to empty the original tab.

*Web-Based Feedback Survey*

The interview questions that were used in Study 1 and Study 2 in Phase III were used to develop the Web-based learning environment section of the Web-based feedback survey. Questions regarding demographic information, experience with the Web-based human heart tests, and the overall experience in the research study were also prepared. These surveys questions were frequently updated based on feedback from the participants as well as the insights that were obtained from considering the data collected in the sessions. For example, during the interview one of the participants said that although he liked the idea of the Web-based learning environment he did not pay much attention to the reading since he was “not at all interested in biology.” Given that interest in reading about the human heart could play a potentially significant role in determining participants’ use of the reading strategies in the Web-based learning environment, two questions were added to the Web-based feedback survey:

- Q. Do you like reading science texts in general? [Yes, No]
- Q. Do you like reading science texts in general? [Yes, No]

The survey questions that were used in the Phase IV study are included in Appendix Q.

**Discussion**

The user interface of the Web-based learning environment is relatively involved, especially for someone experiencing the Web-based learning environment for the first time. This
explained why some participants who did not pay attention at the beginning of the demonstration were unable to grasp the overall purpose of the Web-based learning environment and because of this they were not able to use the Web-based learning environment effectively. This issue could be addressed by adding an introductory screen that provided an overview of the Web-based learning environment. The overview screen would serve two purposes: (a) Trigger the creation of a mental model, albeit rudimentary, for the Web-based learning environment early on in the demonstration. Then, as the reading strategies were introduced, readers would “fit” the five strategies in this mental model of the Web-based learning environment. (b) Build up expectations, which would engage the reader and increase the chances of them watching the demonstration more carefully. An introductory screen was prepared and added to the demonstration.

From observations in the first three studies in Phase III, it was clear that participants were engaging deeply with the text in the Web-based learning environment and they seemed to enjoy their reading experience. Did this effort translate into gains in learning? Participants in this study were asked if the Web-based learning environment prepared them for the tests. One participant said that she felt she would do better on the tests as compared to when she read the same text on a regular Web page because the Web-based learning environment kept her focused. Being able to manipulate the text made her feel like she was in charge.

On the other hand, some of the participants noted that they spent most of their energy and time “manipulating” the text and that this might not really get them ready for the tests. This situation can be analogous to the situation in which beginning players in a soccer camp are asked to practice a different skill on the first nine days of a ten-day camp. Given that the players only
practice skills individually, it would be unlikely that they would be able to successfully apply these skills on the final day of the camp when they were asked to play against a visiting team.

Another participant pointed out that if he was to return to the instructional unit and revise his work he would benefit more from the Web-based learning environment. One way to encourage readers to revisit their work in the Web-based learning environment before they took the tests would be to provide incentives for doing well. For example, by offering a reward for doing well on the tests, may motivate participants to spend some time revising their work. In fact, this strategy was used in the Phase IV study.

Conclusion

With every session in the Study 3 in Phase III, the researcher developed insights into participants’ use of the Web-based learning environment and their experience in it. Findings in this study were consistent with findings in Study 1 and Study 2 in Phase III. Participants spent over 30 minutes reading the instructional unit on the human heart. Participants seemed to engage deeply with instructional unit on the human heart in the Web-based learning environment and they seemed to enjoy their reading experience.

The demonstration of the Web-based learning environment was found to be effective in providing participants an orientation of the user interface of the Web-based learning environment. An introductory screen that provided participants an overview of the Web-based learning environment was added to the demonstration.

Only two critical bugs were noted during the sessions in this study—this was an indication that the Web-based learning environment was becoming more stable.
A Web-based feedback survey that included questions under four categories—demographics, experience in the Web-based learning environment, experience with the Web-based human heart tests, and overall experience in the research study, was developed and pilot tested.
PHASE III—STUDY 4

Research Goals

A fifth goal was added to the four goals from the previous study. This goal was to compare the behavior and experience of readers who read the instructional unit on the human heart in a paper-form of the Web-based learning environment with the behavior and experience of readers who read the instructional unit on the human heart in the Web-based learning environment.

Participants

Fifteen participants participated in this study; one participant per session. Nine participants read the instructional unit on the human heart in the paper-form of the Web-based learning environment (analog condition) and six participants read the instructional unit on the human heart in the Web-based learning environment (digital condition). The assignment of participants to the two conditions was a convenience assignment. More participants were assigned to the analog condition, since ample data regarding behavior and experience of participants in the Web-based learning environment was collected in Study 1, Study 2 and Study 3 in Phase III.
The materials used in this study included the materials used in Study 3 in Phase III— the instructional unit on the human heart; the Web-based learning environment; a demonstration of the Web-based learning environment developed in Study 2 in Phase III; the knowledge of human anatomy and spatial ability tests (see Appendix H); equipment used to capture participants’ interactions with the Web-based learning environment and their think-alouds; Web-based human heart tests that were developed and validated in the Phase II study (see Appendix C, D, E, F and G); Web-based feedback survey developed in Study 3 in Phase III (see Appendix Q).

A paper-form of the Web-based learning environment was prepared (see Appendix P). It is worth noting that while the early-stage paper prototype of the Web-based learning environment that was used in the Phase I study included only the text-macrostructure strategy, the paper-form of the Web-based learning environment used in this study included all five reading strategies. The props used to set up the paper-form of the Web-Based learning environment in the two studies and their counterparts in the Web-based learning environment are described in Table 32.
Table 32. Study 4 in Phase III: Props Used in the Paper Form of the Web-Based Learning Environment in Phase I and Study 4 in Phase III, and their Counterparts in the Web-Based Learning Environment

<table>
<thead>
<tr>
<th>Web-Based Learning Environment (W-BLE)</th>
<th>Paper Form of the Web-Based Learning Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original tab in the W-BLE</td>
<td>Instructional unit on the human heart in booklet form</td>
</tr>
<tr>
<td>Elements in the W-BLE</td>
<td>The instructional unit on the human heart printed on 25 cards</td>
</tr>
<tr>
<td>Labels for tabs that participants created in the W-BLE</td>
<td>Labels on which participants wrote titles for sections they created</td>
</tr>
<tr>
<td>Summaries text box in the W-BLE</td>
<td>Red colored Post-its for writing sections summaries</td>
</tr>
<tr>
<td>Notes text box in the W-BLE</td>
<td>Yellow colored Post-its for writing notes</td>
</tr>
<tr>
<td>Comfort-meter in W-BLE</td>
<td>Comfort-meter printed on paper</td>
</tr>
<tr>
<td>Library of images in the W-BLE</td>
<td>Library of images. Individual images were printed on paper</td>
</tr>
</tbody>
</table>

Participants in previous studies in Phase III had suggested that the imagery strategy should allow them to attach more than one image to a section. To explore this recommendation, participants in the analog condition were allowed to select more than one image for every section that they created. Three copies of each of the 12 images in the library of images used in the Web-
based learning environment were provided in case participants wanted to attach the same image to more than one section.

Similarly, participants in the previous studies had suggested that they should be able to highlight text in the Web-based learning environment. To explore this recommendation, participants in the analog condition were provided a highlighter.

The instructions sheet for participants in the analog condition included a checklist of actions that participants were expected to take. This instruction sheet and printable paper copies of the props described in Table 32 are provided in Appendixes O and P.

Procedure

Each of the 15 participants in this study was non-randomly assigned to one of two conditions—paper-form of the Web-based learning environment (analog condition) and Web-based learning environment (digital condition). The assignment was a convenience assignment. Upon arrival at the research lab, a participant was provided an overview of Part 2 of the study depending on the condition that this participant was assigned to:

1. Analog condition: The researcher gave the participant an overview of the props. The participant was provided an instruction sheet that included a checklist of steps required to complete the activity. The researcher asked the participant to check items on this checklist as she progressed through the study session.

   After the participant had read the instructional unit she was instructed to move to the computer and log into the Study Web site. This Web site directed the participant to the human heart tests. Finally, the participant was asked to respond to the feedback survey.
All participants were informed about the think aloud protocol and asked to think aloud as much as possible. Participants were given examples of specific situations where they should remember to think aloud. At this time the researcher left the lab.

2. Digital condition: A participant in the Web-based learning environment condition was asked to watch a demonstration of the Web-based learning environment. Unlike previous studies in Phase III, the researcher did not provide the participant an oral overview of the reading strategies before she watched the demonstration of the Web-based learning environment. The researcher observed the participant as she watched the demonstration. After the demonstration was complete, the researcher asked the participant if she had any questions about the Web-based learning environment or what she was expected to do in the Web-based learning environment.

After this the participant was asked to log into the Study Web site. The Study Web site directed the participant to the Web-based learning environment; the instructional unit on the human heart was displayed in the Web-based learning environment. The participant was asked to read the instructional unit on the human heart in the Web-based learning environment. After she had read the instructional unit, the participant was asked to respond to the human heart tests. Finally, the participant was asked to respond to a set of survey questions.

All participants were informed about the think aloud protocol and asked to think aloud as much as possible. Participants were given examples of specific situations where they should remember to think aloud. At this time the researcher left the lab.

The researcher could track progress of participants in both conditions from a remote computer. Once participants had completed responding to the Web-based feedback survey, the researcher returned to the lab to interview the participants about their experience in the paper-
form of the Web-based learning environment and the Web-based learning environment respectively. The procedures used in this study are summarized in Figure 40.

![Figure 40. Schematic for Study 4 in Phase III.](image)

Data Analysis

The researcher kept a journal for each of the seven sessions in Study 4 in Phase III. The journal entries were structured into separate sections: notes before the participant’s arrival, responses to interview questions, other notes during the session, and notes after the participant left the lab. In these journal entries the researcher recorded evidence that was related to the use of the reading strategies in the Web-based learning environment, its user interface and participants’ experience in the Web-based learning environment.
The data collected from the multiple data sources was extremely rich and voluminous. The researcher made his best attempt to review this data before the next day’s sessions. Information noted in the research journal was used to identify and review those episodes during a given session that were particularly interesting or insightful.

A detailed analysis of all the data collected in Study 4 in Phase III is beyond the scope of the current research investigation. However, results from a preliminary analysis of this data, in particular a comparison of participants’ experience in the digital (Web-based learning environment) and the analog (paper-form of the Web-based learning environment) conditions, are discussed.

Results

*Analog Condition*

In general, participants in the analog learning environment condition took longer to complete the study. One of the participants said that he was not an attentive reader. Having the text broken down into smaller pieces (cards) helped him focus. At the end of the session, the researcher showed him the animated demonstration of the Web-based learning environment. After the participants had watched the demonstration, the researcher asked him which form of the Web-based learning environment (analog or digital) he would prefer to use. He said he would prefer the paper-form since it “actually made me do things, write.” But if it was on the computer “it would keep me awake...and it would save a lot of paper.”

Another participant said that she spent a lot of time reading and writing summaries for the “parts of the heart” section of the instructional unit. She said that this section of the text had a lot of terminology and she found her time was well spent because it allowed her to read the
remaining text quickly. She said she was a visual learner and the images helped her. The researcher showed her the animated demonstration of the Web-based learning environment and then asked her which form of the Web-based learning environment she would prefer to use. She said she would prefer the analog version since she is used to hand writing notes and being able to write notes by hand helped her learn more. When asked why she thought she would learn more when she hand wrote notes, she speculated that she was slower in writing than typing, and perhaps the extra time that she spent in hand writing notes provided her more time to think and reflect. This participant wrote notes on the comfort-meter—an interesting design idea for the Web-based learning environment.

*Digital Condition*

A participant said that even though he was not very interested in biology he still liked reading in the Web-based learning environment. He said it made him pay more attention as he was “controlling things.” He liked that he could “personalize the text.” He also liked being able to “toggle” between tabs, that helped him understand what was “going on” by being able to see the “bigger picture.” Data from other participants in this condition was similar to data obtained in previous Phase III studies and is not reported here.

Unlike Study 2 and Study 3, participants in this study were not provided an oral overview of the reading strategies in the Web-based learning environment. Based on observations in this study, the researcher had a feeling that, although the existing version of the demonstration of the Web-based learning environment provided sufficient orientation of the *user interface* of the Web-based learning environment, this demonstration did not provide sufficient explanation of the *reading strategies* and how readers could benefit from the use of these reading strategies. If
this were in fact the case, then at least some participants in Study 4 would not have been able to use the reading strategies as effectively as participants in Study 2 and Study 3 who received an oral overview of the reading strategies. On the basis of the data collected in Phase III studies, it was difficult to estimate whether there was a difference in strategy use between Studies 2 and 3 in which oral orientation to the reading strategies was provided to participants, and Study 4 in which no oral orientation to the reading strategies was provided. One way to answer these questions would have been to compare scores on the human heart tests. Since the number of participants who responded to these tests in these studies was small, scores were not compared.

Given this evidence and the fact that participants in the large-scale Phase IV study would not have access to the oral orientation of the reading strategies in the Web-based learning environment, a decision was made to develop two variants of the animated demonstration for the Web-based learning environment. The first demonstration would be similar to the demonstration used in the Phase III studies. The demonstration would be limited to providing participants an orientation of the user interface of the Web-based learning environment. In addition to providing participants an orientation of the user interface of the Web-based learning environment, the second demonstration would provide explicit instruction on the five reading strategies. The two versions of the demonstrations are discussed in the section on Phase IV study.

Conclusion

Overall, participants in the analog condition did not seem very comfortable with the amount of cognitive effort that the study required of them. At the end of the session many participants appeared tired and mentally exhausted. They spend considerable time reading and
organizing the text, but once they were done with this task, they did not seem to want put in any more effort in responding to the human heart tests—they just wanted to leave. This is in stark contrast to the experience participants had reading in the Web-based learning environment. Although participants in the two conditions spent comparable time in the research lab, most participants in the digital condition did not seem to mind the time they were asked to spend in the study. It is possible that these participants were able to use the strategies in the Web-based learning environment to externalize the knowledge representations that they were creating, and in doing so they were able to offload some of the cognitive load that is intrinsic to reading an expository text such as the instructional unit on the human heart.

Overall Conclusion for Phase III Studies

The Phase III studies had two primary goals: (a) guide the design of a Web-based learning environment that supports the use of a set of five reading strategies; and (b) develop an understanding of readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.

Four studies were set up to address these research goals. On the basis of data collected in these studies, critical bugs and shortcomings in the user interface of the Web-based learning environment were identified and updates were made. Long-term suggestions for updating the Web-based learning environment were noted. Studies in Phase III provided insights into readers’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment. From these studies it was clear that participants were engaging deeply with the text in the Web-based learning environment and they seemed to enjoy their reading experience. The obvious question that arose out of these studies was, “Did this
effort translate into gains in learning?” This question could be answered on the basis of participants’ performance on the Web-based human heart tests. Although participants in Study 3 and Study 4 responded to the Web-based human heart tests, their scores on the tests were not used since the number of participants was small. This question was one of the research questions in the large-scale Phase IV study.

A demonstration of the Web-based learning environment was developed and tested. This demonstration was set up primarily to orient participants to the user interface of the Web-based learning environment. In Study 2 and Study 3 the researcher provided participants an overview of the reading strategies before participants watched the demonstration of the Web-based learning environment. To find out the effectiveness of the demonstration by itself, in Study 4 no such overview was provided to participants. On the basis of the observations in Study 4 in Phase III, the researcher had a feeling that although the existing version of the demonstration of the Web-based learning environment provided sufficient orientation of the user interface of the Web-based learning environment, this demonstration by itself (without the oral orientation that was used in Study 2 and Study 3) did not provide sufficient explanation of the reading strategies and how readers could benefit from the use of the reading strategies.

Given that participants in the study were using the reading strategies in the Web-based learning environment for the first time, it was expected that many of them would not be able to use the strategies effectively on the first attempt (Elshout-Mohr & van Daalen-Kapteijns, 2002; Williams, 2007), especially if they were not provided explicit instruction on the reading strategies (Duffy et al., 1987). With this in mind, two variants of the demonstration were developed for the Phase IV study. The first demonstration was similar to the demonstration used in the Phase III studies. This demonstration was limited to providing participants an orientation
of the user interface of the Web-based learning environment. In addition to providing
participants an orientation of the user interface of the Web-based learning environment, the
second demonstration provided explicit instruction on the five reading strategies. The two
versions of the demonstrations are discussed in the section on Phase IV study.

Participants in Study I in Phase III were interviewed about their experience in the Web-
based learning environment. These interview questions were used to prepare a section of the
Web-based feedback survey which included questions under four categories: demographics,
experience in the Web-based learning environment, experience with the Web-based human heart
tests, and overall experience in the research study. This feedback survey, along with the think
aloud data and the data collected with the screen capture software allowed the researcher to
develop an understanding of readers’ use of the five reading strategies in the Web-based learning
environment and their experience in the Web-based learning environment.

The materials developed in this study were used in the Phase IV study.
Research Goals and Questions

This Phase IV research study had two overarching goals: (a) On the basis of the micro-textbase, macro-textbase, micro-situation model, and macro-situation model tests, determine whether participants who read the instructional unit on the human heart in the Web-based learning environment developed better memory and understanding of the instructional text when compared with participants who read the same text on a regular Web page; and (b) Develop an understanding of participants’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.

These goals led to the following research questions:

(1) Did the Web-based learning environment help readers develop better memory (micro-textbase and macro-textbase) of the instructional unit on the human heart?

(2) Did the Web-based learning environment help readers develop better understanding (micro-situation model and macro-situation model) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?

(3) Did participants in the three experimental conditions take equal amount of time to read the instructional unit on the human heart?

(4) Did participants in the three experimental conditions take equal amount of time to respond to the Web-based human heart tests?

(5a) How did participants use the five reading strategies in the Web-based learning environment?

(5b) What was participants’ experience in the Web-based learning environment?
(6) What was participants’ experience with the Web-based human heart tests?

Based on observations in the Phase III studies, a decision was made to develop two variants of the animated demonstration for the Web-based learning environment. The first demonstration was similar to the demonstration used in the Phase III studies. This demonstration was limited to providing participants an orientation of the user interface of the Web-based learning environment. In addition to providing participants an orientation of the user interface of the Web-based learning environment, the second demonstration provided explicit instruction on the five reading strategies. The first two research questions in the Phase IV study were updated to take into account the use of the two versions of the demonstration for the Web-based learning environment. The updated questions are shown in Table 33.

Table 33. Original and Updated Research Questions for Phase IV Study

<table>
<thead>
<tr>
<th>Original Research Questions</th>
<th>Updated Research Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Did the Web-based learning environment help participants develop better memory (as measured by micro-textbase and macro-textbase tests) of the instructional unit on the human heart?</td>
<td>(1) Did the Web-based learning environment help participants develop better memory (as measured by micro-textbase and macro-textbase tests) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?</td>
</tr>
<tr>
<td>(2) Did the Web-based learning environment help participants develop better understanding (as measured by micro-situation model and macro-situation model tests) of the instructional unit on the human heart?</td>
<td>(2) Did the Web-based learning environment help participants develop better understanding (as measured by micro-situation model and macro-situation model tests) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?</td>
</tr>
</tbody>
</table>
Participants

Participants in the Phase IV study were recruited from three undergraduate courses offered in fall of 2008 in the Energy and Geo-Environmental Engineering, and Materials Science and Engineering departments at a large public university in the northeastern United States. Students from various undergraduate programs at the university typically enroll in these courses to fulfill university’s general education requirements.

Depending on the course participants were enrolled in, they were offered extra credit which amounted to 3% or 4% of the entire course grade. An alternative extra credit opportunity was made available to students who chose not to participate in the study but still wanted to obtain the extra credit. The informed consent form for the study is available in Appendix R.

Participants were recruited from a pool of 1466 students. Of these 1466 students, 813 reserved slots for the either the first or both parts of the study. Out of these, 128 participants completed Part 1 of the study, but not Part 2. Due to a lab scheduling conflict, 7 participants were not able to participate in Part 2 of the study. Data from these 128 students were excluded from analysis.

Six hundred and eighty five participants completed both parts of the study. Of these 685 participants, 37 completed both parts of the study online since they were not physically located on the university campus at which the study was conducted. Since there was no way to control whether these participants looked at the instructional unit on the human heart while responding to human hearts tests, responses from these participants were excluded from the analysis. Responses from another 11 participants were excluded because they either looked at hand-written notes or the instructional unit on the human heart while responding to the tests questions. Data from one participant was excluded because she incorrectly logged into the Website for the
control condition even thought she was in a session for Treatment 1 (T1). Data from the remaining 636 participants were analyzed. Twenty nine students completed the alternate extra credit assignment.

Materials

The following materials were used in this study:

1. Instructional unit on the human heart that was used in Phase I, II and III studies (see Appendix A).

2. Web-based human heart tests that were developed and validated in the Phase II study (see Appendix C, D, E, F and G).

3. Web-based learning environment that was revised in the four Phase III studies. Participants in the two Web-based learning environment groups read the instructional text on the human heart in the Web-based learning environment. Participants in the control group read the instructional text on the human heart on a regular Web page.

4. Two animated demonstrations of the Web-based learning environment produced with a screen capture software (Adobe Captivate v. 2.0). The two demonstrations produced were identical in all respects, except for the overlay text on six screens. The differences in the two demonstrations are noted in Table 34. Both demonstrations contained 55 screens and were 4 minutes and 45 seconds long. The two demonstrations can be viewed in their entirety at: http://www.learning-research.com/dissertation/index.html.
### Table 34. Phase IV Study: Demonstrations for the Web-Based Learning Environment

<table>
<thead>
<tr>
<th>Screen</th>
<th>Demonstration used in Treatment 1</th>
<th>Demonstration used in Treatment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen# 4</td>
<td>The Web-based learning environment allows you to manipulate text in 5 different ways.</td>
<td>Each of us processes text in uniquely different ways.</td>
</tr>
<tr>
<td></td>
<td>Let’s look at these one by one.</td>
<td>The Web-based learning environment allows you to use 5 different Reading Strategies to customize the text to suit your Learning Style.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Let’s look at these strategies one by one.</td>
</tr>
<tr>
<td>Screen# 7</td>
<td>#1: You can chunk this text into smaller pieces or “Sections”</td>
<td>Strategy #1: Chunking</td>
</tr>
<tr>
<td></td>
<td>This is quite like reading an article on paper with a pair of scissors in hand!</td>
<td>In the Web-based learning environment you can break-up a long Web page into smaller pieces or “Sections.” In other words, you can reorganize the text in a way that helps you understand it better.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>This is quite like reading an article on paper with a pair of scissors in hand!</td>
</tr>
<tr>
<td>Screen# 25</td>
<td>#2: Taking Notes</td>
<td>Strategy #2: Note-Taking</td>
</tr>
<tr>
<td></td>
<td>You can take notes while you read. These notes get attached to individual elements in the Learning Environment.</td>
<td>Effectively note-taking can help you remember as well as understand the text better. Remember, effective note-taking does not necessarily mean copying the text.</td>
</tr>
<tr>
<td>Screen# 34</td>
<td>#3: Attaching a Summary to a Tab</td>
<td>Strategy #3: Summarization</td>
</tr>
<tr>
<td></td>
<td>You can prepare summaries—one for each section that you create.</td>
<td>Use these to summarize the contents of each section. Remember, a good summary can help you develop a “bigger picture” of the text.</td>
</tr>
</tbody>
</table>
Screen# 36  #4: Attaching an Image to a Tab

Strategy #4: Imagery

You can attach an image to every section that you create.

Choose an image from a library of images that best represents the contents of the section. Remember, sometimes visualization can help us understand texts better. As the saying goes—a picture is worth a thousand words!

Screen# 39  #5: Setting a Comfort-meter Level

Strategy #5: Comfort-meter

You can set your comfort-level for each section that you create.

When you revisit the text, this will help you focus on the more difficult sections of the text.

5. Web-based feedback survey that was used in the Phase III studies. Questions in this survey fell under four categories: demographics, experience in the Web-based learning environment (these questions were not administered to the control group), experience with the Web-based human heart tests, and overall experience in the research study. This survey is included in Appendix Q.

6. Reservation and Study Web sites: Two Web sites were used in the study: (a) Reservation Web site which enabled participants to book a time slot for Part 1 and a lab session for Part 2 of the study. The Web site also enabled participants to cancel and reschedule their reservations. (b) Study Web site: The Study Web site provided links to the prior-knowledge tests, a Web page with the instructional unit on the human heart (control condition), demonstration of the Web-based learning environment (the two Web-based learning environment conditions), the Web-based learning environment (the two Web-based learning environment conditions), the
Web-based human heart tests and Web-based feedback survey. Participation status was updated on this Web site as participants completed various sections of the study. Both Web sites were password protected. Screenshots of these Web sites are available in Appendix S.

7. Welcome script: Two versions of a welcome script were used, one each for the control group and the two Web-based learning environment groups. The scripts were identical except for the description of the Web-based learning environment that was included in the script for the two Web-based learning environment conditions. These scripts are provided in Appendixes T and U.

8. Computer labs: 32 two-hour computer lab sessions across five lab locations on a university campus were reserved for Part 2 of the study. Because of a scheduling error, the times for two lab sessions overlapped. One of these lab sessions had to be cancelled.

Procedure

Like studies in Phase II and III, this study was conducted in two parts. Participants were asked to book a time slot for Part 1 and a lab session for Part 2. Links to the Reservation Web site were included in the recruitment script. Participants could complete Part 1 online at any time during a 10 day period. For Part 2, participants were asked to visit a computer lab during a two week period. Participants were required to complete Part 1 before visiting the computer lab for Part 2.

In Part 1, participants were asked to complete the prior-knowledge tests (knowledge of human anatomy and spatial ability tests). Part 1 of the study was identical for all participants. Upon arrival at the research lab for Part 2, participants were read instructions from a welcome script. At the end of this script participants were asked to log into the Study Web site and follow instructions that appeared on the Web pages. The sequence of steps that participants followed
depended on the condition they were in. The procedures used in this study are summarized in Figure 41.

There was no time limit for either part of the study, except for the spatial ability tests in Part I for which participants were allowed a maximum of 12 minutes. Most participants completed Part 1 in less than 20 minutes; the lab sessions for Part 2 lasted two hours.

Figure 41. Schematic for Phase IV study.
Research Design

Independent Variable

The independent variable in this study was the Web-based learning environment. Two levels of the independent variable—Web-based learning environment—were set up: (a) Web-based learning environment + demonstration without explicit instruction on reading strategies; and (b) Web-based learning environment + demonstration with explicit instruction on the reading strategies. Including the control, this design led to three conditions as described in Table 35.

In the control condition participants read the instructional unit on the human heart on a regular Web page. The treatment conditions involved reading the instructional unit on the human heart in the Web-based learning environment after watching a demonstration of the Web-based learning environment. The only difference between Treatment 1 (T1) and Treatment 2 (T2) was in the demonstration of the Web-based learning environment that the participants watched. The demonstration used in Treatment 2 (T2) included explicit instruction on the reading strategies.
Table 35. Phase IV Study: Independent Variable

<table>
<thead>
<tr>
<th>Control</th>
<th>Treatment Group 1 (T1)</th>
<th>Treatment Group 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Web-based Learning</td>
<td>Web-based Learning</td>
</tr>
<tr>
<td></td>
<td>Environment</td>
<td>Environment</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Demonstration</td>
<td>Demonstration with explicit instruction on the reading strategies</td>
</tr>
</tbody>
</table>

Participants read the instructional unit on the human heart on a regular Web page

Participants read the instructional unit on the human heart in the Web-based learning environment that supported the following reading strategies:
- text-macrostructure (chunking)
- summarization
- imagery
- reading self-assessment (comfort-meter)
- note-taking

Before entering the Web-based learning environment, participants watched a demonstration of the Web-based learning environment.

Identical to Treatment 1, except that participants watched a second variant of the demonstration of the Web-based learning environment which included explicit instruction on the reading strategies.

Dependent Variables

The four Web-based human heart tests developed in the Phase II study—micro-textbase, macro-textbase, micro-situation model, macro-situation model—were used to measure readers’ knowledge of the instructional unit on the human heart (see Table 36). The time participants took to read the instructional unit on the human heart and the time participants spent responding to the human heart tests were also compared. Knowledge of human anatomy and spatial ability were considered as covariates.
Participants in the Phase IV study used the Reservation Web site to book lab slots for Part 2 of the study (see Figure 42). Since participants booked a lab session without knowledge of which treatment was allotted to which lab session, participants were assumed to have been randomly assigned to conditions. There was a significant concern with this manner of assignment of participants to conditions though—any two participants, for example two friends, could have chosen to participate in the same lab slot as long as there were openings in that slot. Data collected from such participants would violate the assumption of independence.

Studies in Phase II and Phase III demonstrated substantial differences in the time that participants spent reading the instructional unit on the human heart on a regular Web page vs. reading the instructional unit in the Web-based learning environment. In order to minimize the variance in the time participants spent in a lab session, a given lab session was assigned to only one condition. The assignment of conditions to lab sessions was a “convenience” assignment (see Table 37). Since conditions were not assigned randomly to lab sessions, confounding factors such as the effect of lab location (five different labs were used in the study), the time of the day when the session was held, the day of the week the session was held, the weather on the day the session was held, conditions in the lab during the session (for example, the number of participants in the lab, differences in how the welcome script was read, ambient temperate etc.) cannot be ruled out. Some of these factors are considered in Chapter 4.
### Available Lab Slots

Please book one of the following lab slots. Upon making a reservation you will be receive an email confirming your reservation.

**Note 1:** Reservation is on a first-come, first-served basis.

**Note 2:** You can revisit this website any time to update or cancel your booking.

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Time Slot</th>
<th>Lab Location</th>
<th>Seats Remaining</th>
<th>Sign Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>December 01, 2008</td>
<td>3:30pm - 5:30pm</td>
<td>Bou - Room 112</td>
<td>45</td>
<td>○</td>
</tr>
<tr>
<td>Mon</td>
<td>December 01, 2008</td>
<td>6:30pm - 8:30pm</td>
<td>Bou - Room 214</td>
<td>75</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 02, 2008</td>
<td>11:00am - 1:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 02, 2008</td>
<td>2:30pm - 4:30pm</td>
<td>Ced - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 02, 2008</td>
<td>5:30pm - 7:30pm</td>
<td>Ced - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 03, 2008</td>
<td>1:15pm - 3:15pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 03, 2008</td>
<td>4:00pm - 6:00pm</td>
<td>IST - Room 203</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 03, 2008</td>
<td>7:00pm - 9:00pm</td>
<td>IST - Room 203</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Thu</td>
<td>December 04, 2008</td>
<td>12:00noon - 2:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Thu</td>
<td>December 04, 2008</td>
<td>4:00pm - 6:00pm</td>
<td>Bou - Room 112</td>
<td>45</td>
<td>○</td>
</tr>
<tr>
<td>Thu</td>
<td>December 04, 2008</td>
<td>7:00pm - 9:00pm</td>
<td>Bou - Room 112</td>
<td>45</td>
<td>○</td>
</tr>
<tr>
<td>Fri</td>
<td>December 05, 2008</td>
<td>11:10am - 1:10pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Fri</td>
<td>December 05, 2008</td>
<td>2:30pm - 4:30pm</td>
<td>Ced - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Fri</td>
<td>December 05, 2008</td>
<td>5:30pm - 7:30pm</td>
<td>Ced - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Sat</td>
<td>December 06, 2008</td>
<td>11:00am - 1:00pm</td>
<td>Ced - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Sat</td>
<td>December 06, 2008</td>
<td>2:00pm - 4:00pm</td>
<td>Ced - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Sun</td>
<td>December 07, 2008</td>
<td>3:00pm - 5:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Sun</td>
<td>December 07, 2008</td>
<td>6:00pm - 8:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Mon</td>
<td>December 08, 2008</td>
<td>11:10am - 1:10pm</td>
<td>War - Room 106</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Mon</td>
<td>December 08, 2008</td>
<td>4:00pm - 6:00pm</td>
<td>Bou - Room 112</td>
<td>45</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 09, 2008</td>
<td>11:00am - 1:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 09, 2008</td>
<td>1:15pm - 3:15pm</td>
<td>War - Room 106</td>
<td>38</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 09, 2008</td>
<td>3:30pm - 5:30pm</td>
<td>War - Room 106</td>
<td>38</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 10, 2008</td>
<td>6:00pm - 8:00pm</td>
<td>Ced - Room 134</td>
<td>58</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 10, 2008</td>
<td>1:15pm - 3:15pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 10, 2008</td>
<td>3:30pm - 5:30pm</td>
<td>War - Room 108</td>
<td>38</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 10, 2008</td>
<td>4:00pm - 6:00pm</td>
<td>IST - Room 203</td>
<td>38</td>
<td>○</td>
</tr>
</tbody>
</table>

*Figure 42.* Booking a lab session for Part 2 in the Phase IV study.
Table 37. Phase IV Study: Assigned of Lab Sessions to Conditions and Number of Participants in Each Lab Session.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Lab Session ID [day: date-start time-labID]</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Day 1: 20081201-1530-BOU112</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>Day 1: 20081201-1830-BOU214</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Day 2: 20081202-1100-WAR108</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Day 2: 20081202-1430-CED134</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Day 2: 20081202-1730-CED134</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Day 11: 20081211-1200-WAR108</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Day 11: 20081211-1415-WAR108</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Day 11: 20081211-1630-WAR108</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Day 11: 20081211-1900-BOU112</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Total: 211</td>
<td></td>
</tr>
<tr>
<td>Treatment 1 (T1)</td>
<td>Day 3: 20081203-1315-WAR108</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Day 3: 20081203-1600-IST203</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>Day 3: 20081203-1900-IST203</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Day 4: 20081204-1200-WAR108</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Day 4: 20081204-1600-BOU112</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Day 4: 20081204-1900-BOU112</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>Day 5: 20081205-1110-WAR108</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Day 5: 20081205-1430-CED134</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Day 5: 20081205-1730-CED134</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Total: 211</td>
<td></td>
</tr>
<tr>
<td>Treatment 2 (T2)</td>
<td>Day 6: 20081206-1100-CED134</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Day 6: 20081206-1400-CED134</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Day 7: 20081207-1500-WAR108</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Day 7: 20081207-1800-WAR108</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Day 8: 20081208-1110-WAR108</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Day 8: 20081208-1600-BOU112</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Day 9: 20081209-1100-WAR108</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Day 9: 20081209-1315-WAR108</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Day 9: 20081209-1530-WAR108</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Day 10: 20081209-1800-CED134</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Day 10: 20081210-1315-WAR108</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Day 10: 20081210-1530-WAR108</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Day 12: 20081212-1110-WAR108</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Total: 214</td>
<td></td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies*
Preliminary Data Analysis

Data Sets

Prior to analysis, the data collected in this study was organized into three sets.

(1) Data Set A consisted of participants’ responses to the prior-knowledge tests and the Web-based human heart tests. Time stamp data regarding the time participants spent reading the instructional unit on the human heart and responding to the Web-based human heart tests was included in this set.

(2) Data Set B consisted of participants’ responses to the Web-based feedback survey. Questions in this survey fell under four categories: demographics, experience in the Web-based learning environment (administered only to the two Web-based learning environment groups), experience with the Web-based human heart tests, and overall experience in the research study. There were three types of questions in these surveys: dichotomous, 9-point Likert-type scale, and open-ended.

(3) Data Set C consisted of data from participants in the two Web-based learning environment conditions (T1 and T2). This data pertained to the use of the five strategies in the Web-based learning environment—labels that readers used for the sections (tabs) they created, the summaries and the notes that they wrote, the images they selected for each section, and the comfort-meter levels they set for each section. Time stamp data regarding participants’ actions (for example the time at which they created a new tab or saved a note) in the Web-based learning environment was also included.
Level of Significance

The \( \alpha \)-level of significance for statistical tests in this study was set at \( \alpha = .10 \) (Cohen, 1988).

Demographics

Analyzes of responses to the demographic questions in the Web-based surveys is presented below.

1. Gender.

The condition by gender cross tabulation is presented in Table 38. As expected, the difference in distribution of participants by gender across the three conditions was not statistically significant \( \chi^2 (2, N = 636) = 0.389, p = .823 \).

Table 38. Phase IV Study: Condition * Gender Cross Tabulation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>99</td>
<td>112</td>
<td>211</td>
</tr>
<tr>
<td>T1</td>
<td>99</td>
<td>112</td>
<td>211</td>
</tr>
<tr>
<td>T2</td>
<td>106</td>
<td>108</td>
<td>214</td>
</tr>
<tr>
<td>Total</td>
<td>304</td>
<td>332</td>
<td>636</td>
</tr>
<tr>
<td>% of Total</td>
<td>47.8%</td>
<td>52.2%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

2. Do participants like reading science texts?

The difference in the distribution of responses to the question “Do you like reading science texts in general?” across the three conditions was not statistically significant \( \chi^2 (2, N = \)
Less than 26% of the participants in the study said that they liked reading science texts (see Table 39). Eight participants did not respond to this question.

Table 39. Phase IV Study: Condition * Do You Like Reading Science Texts? Cross Tabulation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Do you like reading science texts?</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Control</td>
<td>50</td>
<td>158</td>
</tr>
<tr>
<td>T1</td>
<td>48</td>
<td>160</td>
</tr>
<tr>
<td>T2</td>
<td>65</td>
<td>147</td>
</tr>
<tr>
<td>Total</td>
<td>163</td>
<td>465</td>
</tr>
<tr>
<td>% of Total</td>
<td>26%</td>
<td>74%</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

3. Do you like reading biology texts in general?

The difference in the distribution of responses to the question “Do you like reading biology texts in general?” across the three conditions was not statistically significant [$\chi^2 (2, N = 629) = 0.023, p = .988$]. Less than 18% of the participants in the study said that they liked reading biology texts (see Table 40). Seven participants did not respond to this question.

Table 40. Phase IV Study: Condition * Do You Like Reading Biology Texts? Cross Tabulation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Do you like reading biology texts?</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Control</td>
<td>37</td>
<td>171</td>
</tr>
<tr>
<td>T1</td>
<td>36</td>
<td>173</td>
</tr>
<tr>
<td>T2</td>
<td>37</td>
<td>175</td>
</tr>
<tr>
<td>Total</td>
<td>110</td>
<td>519</td>
</tr>
<tr>
<td>% of Total</td>
<td>17.5%</td>
<td>82.5%</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies
Reliability of Measurement Instruments

Cronbach’s alpha reliability coefficients for scores on the measurement instruments used in this study are shown in Table 41. Since none of the questions in the macro-textbase test were of multiple-choice format, the reliability coefficient for this test was not calculated. The Cronbach’s alpha reliability coefficients for scores on every test other than the knowledge of human anatomy test were greater than .80.

Table 41. Phase IV Study: Reliability of Measurement Instruments

<table>
<thead>
<tr>
<th>Test</th>
<th>Maximum Score</th>
<th>Cronbach’s alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of Human Anatomy Test</td>
<td>30</td>
<td>.757</td>
</tr>
<tr>
<td>Spatial Ability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper folding test</td>
<td>20</td>
<td>.833</td>
</tr>
<tr>
<td>Card rotation test</td>
<td>160</td>
<td>.979</td>
</tr>
<tr>
<td>Human Heart Tests</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-Textbase Test (Set 1)</td>
<td>20</td>
<td>.922</td>
</tr>
<tr>
<td>Micro-Textbase Test (Set 2)</td>
<td>15</td>
<td>.843</td>
</tr>
<tr>
<td>Macro-Textbase Test</td>
<td>19</td>
<td>—</td>
</tr>
<tr>
<td>Micro-Situation Model Test</td>
<td>17</td>
<td>.860</td>
</tr>
<tr>
<td>Macro-Situation Model Test</td>
<td>14</td>
<td>.805</td>
</tr>
</tbody>
</table>
Analysis of Data

Research Question 1: Did the Web-based learning environment help readers develop better memory (micro-textbase and macro-textbase) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?

Research Question 2: Did the Web-based learning environment help readers develop better understanding (micro-situation model and macro-situation model) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?

As noted above, the assignment of the three experimental conditions to the lab sessions was non-random. Given this limitation, data was analyzed to rule out the effect of the following factors: (a) Lab locations (5 different labs on the university campus); (b) Lab sessions (31 lab sessions held in the 5 labs); and (c) Course that the participants were enrolled in (participants were recruited from 3 different courses).

Following this, correlations among scores on the Web-based human heart tests and the prior-knowledge tests (knowledge of human anatomy and spatial ability) were calculated. These correlations demonstrated the following: (a) scores on the Web-based human heart tests were significantly correlated; and (b) there was a significant correlation between scores on the human heart tests and scores on the knowledge of human anatomy and paper folding test. Taken together this evidence provided support for a MANCOVA analysis of the data (Bray & Maxwell). The assumptions for MANCOVA were tested (Quinn & Keough, 2002; Wildt & Ahtola, 1978).
Research Question 3: Did participants in the three experimental conditions spend equal amount of time reading the instructional unit on the human heart?

One-way analysis of variance (ANOVA) was performed to investigate the difference in time spent reading the instructional unit on the human heart across conditions.

Research Question 4: Did participants in the three experimental conditions spend equal amount of time responding to the post-tests?

One-way analysis of variance (ANOVA) was performed to investigate the difference in time spent responding to the Web-based human heart tests across conditions.

Research Question 5a: How did participants use the five reading strategies in the Web-based learning environment?

Research Question 5b: What was participants’ experience in the Web-based learning environment?

Non-parametric statistics were used with dichotomous and Likert-type questions in the Web-based feedback survey that were related to the Web-based learning environment. Responses to the open-ended survey questions related to the Web-based learning environment were analyzed with qualitative analysis software NVivo. This software was used to identify patterns in responses from participants. This analysis provided insights into participants’ use of the reading strategies and their experience in the Web-based learning environment.

Data related to the use of the five reading strategies designed in the Web-based learning environment—labels that readers used for the sections (tabs) they created, the summaries and
the notes that they wrote, the images they selected for each section, and the comfort-meter levels they set for each section—was used to compare reading strategy use among the two Web-based learning environment groups.

*Research Question 6: What was participants’ experience with the Web-based human heart tests?*

Responses to feedback survey questions related to the Web-based human heart tests were analyzed with qualitative analysis software NVivo. This software was used to identify patterns in responses from participants. This analysis provided insights into participants’ experience with the Web-based human heart tests.
CHAPTER 04
RESULTS

Introduction

The Phase IV research study had two overarching goals: (a) On the basis of the micro-textbase, macro-textbase, micro-situation model, and macro-situation model tests, determine whether participants who read the instructional unit on the human heart in the Web-based learning environment developed better memory and understanding of the instructional text when compared with participants who read the same text on a regular Web page; and (b) Develop an understanding of participants’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.

These goals led to the following research questions:

(1) Did the Web-based learning environment help readers develop better memory (micro-textbase and macro-textbase) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?

(2) Did the Web-based learning environment help readers develop better understanding (micro-situation model and macro-situation model) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies, and was there an effect of the explicit instruction on reading strategies?

(3) Did participants in the three experimental conditions take equal amount of time to read the instructional unit on the human heart?

(4) Did participants in the three experimental conditions take equal amount of time to respond to the Web-based human heart tests?
(5a) How did participants use the five reading strategies in the Web-based learning environment?

(5b) What was participants’ experience in the Web-based learning environment?

(6) What was participants’ experience with the Web-based human heart tests?

In this chapter results from the analysis of data collected in the Phase IV study are presented. These results are organized by the research questions in the study.

Preliminary Data Analysis

As explained in Chapter 3, the assignment of the three experimental conditions to the lab sessions in the Phase IV study was non-random. Given this limitation, the following extraneous variables could have potentially affected the outcome in this study: (a) Lab locations (5 different labs on the university campus); (b) Lab sessions (31 lab sessions held in the 5 labs); and (c) Course that the participants were enrolled in (participants were recruited from 3 different courses).

To rule out competing hypothesis, and to determine if any of these three factors needed to be treated as covariates in the analysis, the means for the dependent variables (scores on the Web-based human heart tests, time to read the instructional unit on the human heart, and time to respond to the Web-based human heart tests) were compared across the levels of the three factors noted above for each of the three experimental conditions.
Effect of the Lab location

The lab sessions in this study were held in five different lab locations. Separate ANOVAs for each of the three experimental conditions were conducted to determine the effects of the lab locations on each of the dependent variables (scores on the Web-based human heart tests, time to read the instructional unit on the human heart, and time to respond to the heart tests). Results obtained are summarized in Table 42.

Table 42. ANOVA Results: Effect of Lab Location on the Dependent Variables

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Control</th>
<th>Treatment 1 (T1)</th>
<th>Treatment 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading time</td>
<td>.005</td>
<td>.406</td>
<td>.127</td>
</tr>
<tr>
<td>Micro-textbase</td>
<td>.158</td>
<td>.552</td>
<td>.001</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>.084</td>
<td>.809</td>
<td>.464</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>.045</td>
<td>.911</td>
<td>.007</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>.412</td>
<td>.883</td>
<td>.004</td>
</tr>
<tr>
<td>Test time</td>
<td>.110</td>
<td>.695</td>
<td>.002</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

The differences across lab location were most pronounced in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2). These differences are summarized in Table 43. Three lab locations were used in Treatment 2 (T2).
Table 43. Descriptive Statistics: Dependent Variables for the Three Lab Locations Used in Treatment 2 (T2)

<table>
<thead>
<tr>
<th>Lab location ID</th>
<th>Reading time</th>
<th>Micro-textbase</th>
<th>Macro-textbase</th>
<th>Micro-situation model</th>
<th>Macro-situation model</th>
<th>Test time</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOU (n = 19)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>00:25:39</td>
<td>15.21</td>
<td>13.89</td>
<td>8.79</td>
<td>13.37</td>
<td>00:23:16</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>00:16:09</td>
<td>9.19</td>
<td>2.64</td>
<td>3.82</td>
<td>5.26</td>
<td>00:09:26</td>
</tr>
<tr>
<td>CED (n = 37)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>00:34:41</td>
<td>24.62</td>
<td>14.27</td>
<td>12.24</td>
<td>17.76</td>
<td>00:30:48</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>00:18:08</td>
<td>10.054</td>
<td>3.525</td>
<td>3.961</td>
<td>4.728</td>
<td>00:11:20</td>
</tr>
<tr>
<td>WAR (n = 158)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0:33:53</td>
<td>20.56</td>
<td>14.61</td>
<td>9.89</td>
<td>15.72</td>
<td>00:26:18</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>0:17:06</td>
<td>8.596</td>
<td>2.380</td>
<td>4.745</td>
<td>4.671</td>
<td>00:07:14</td>
</tr>
</tbody>
</table>

Participants in the lab location “BOU” spent less time reading and responding to the Web-based human heart tests, and their scores were the lowest. Participants in the lab location “CED” spent the most time reading and responding to the Web-based human heart tests and their scores on these tests were the highest. To explore these differences further, differences across the 31 lab sessions were considered.

Effect of Lab Session

In all, 31 lab sessions were held in the Phase IV study. Separate ANOVAs for each of the three experimental conditions were conducted to determine the effects of the lab sessions on each of the dependent variables (scores on the Web-based human heart tests, time to read the instructional unit on the human heart, and time to respond to the heart tests). Results obtained are summarized in Table 44.
Table 44. ANOVA Results: Effect of Lab Session on the Dependent Variables

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Control (Significance)</th>
<th>Treatment 1 (T1) (Significance)</th>
<th>Treatment 2 (T2) (Significance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading time</td>
<td>.002</td>
<td>.065</td>
<td>.023</td>
</tr>
<tr>
<td>Micro-textbase</td>
<td>.666</td>
<td>.731</td>
<td>.000</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>.379</td>
<td>.981</td>
<td>.175</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>.414</td>
<td>.933</td>
<td>.000</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>.958</td>
<td>.860</td>
<td>.000</td>
</tr>
<tr>
<td>Test time</td>
<td>.055</td>
<td>.239</td>
<td>.002</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

Once again, the differences in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) were most pronounced. These differences are summarized in Table 45. Thirteen lab sessions were used in Treatment 2 (T2).

Table 45. Descriptive Statistics: Dependent Variables for the Thirteen Lab Sessions Used in Treatment 2 (T2)

<table>
<thead>
<tr>
<th>Lab session ID</th>
<th>Reading time</th>
<th>Micro-textbase</th>
<th>Macro-textbase</th>
<th>Micro-situation model</th>
<th>Macro-situation model</th>
<th>Test time</th>
</tr>
</thead>
<tbody>
<tr>
<td>20081206-1100-CED134 (n = 14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0:45:33</td>
<td>26.50</td>
<td>14.93</td>
<td>12.93</td>
<td>18.71</td>
<td>0:30:50</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>0:16:56</td>
<td>8.95</td>
<td>2.84</td>
<td>4.48</td>
<td>4.66</td>
<td>0:10:17</td>
</tr>
<tr>
<td>20081206-1400-CED134 (n = 20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0:27:38</td>
<td>22.70</td>
<td>14.05</td>
<td>11.55</td>
<td>16.90</td>
<td>0:31:02</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>0:16:18</td>
<td>11.20</td>
<td>4.02</td>
<td>3.71</td>
<td>5.00</td>
<td>0:12:58</td>
</tr>
<tr>
<td>20081207-1500-WAR108 (n = 21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0:36:13</td>
<td>17.90</td>
<td>14.81</td>
<td>8.81</td>
<td>15.19</td>
<td>0:26:17</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>0:11:16</td>
<td>8.14</td>
<td>1.83</td>
<td>4.94</td>
<td>4.04</td>
<td>0:03:47</td>
</tr>
<tr>
<td>20081207-1800-WAR108 (n = 20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0:27:03</td>
<td>22.50</td>
<td>15.20</td>
<td>11.25</td>
<td>17.30</td>
<td>0:28:04</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>0:16:02</td>
<td>8.36</td>
<td>2.24</td>
<td>4.34</td>
<td>3.96</td>
<td>0:06:00</td>
</tr>
<tr>
<td>20081208-1110-WAR108* (n = 20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0:30:16</td>
<td>15.90</td>
<td>13.15</td>
<td>7.20</td>
<td>13.70</td>
<td>0:22:35</td>
</tr>
</tbody>
</table>
The scores on the four human heart tests for two lab sessions: 20081208-1110-WAR108 (mean total score = 49.95) and 20081208-1600-BOU112 (mean total score = 51.26) were found to be farthest away from the grand mean total score for the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) (grand mean total score = 61.34). In fact, the means for the two lab sessions were lower by more than two standard error of measurement (SEM) from the grand mean for all sessions in this condition (T2). On the basis of the central limit theorem, data from these two sessions was treated as outliers (Quinn & Keough, 2002). Data from participants in these sessions (n = 39) was

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Group</th>
<th>Sample Size</th>
<th>Mean</th>
<th>Std. dev.</th>
<th>SEM</th>
<th>Grand Mean</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>20081208-1110-WAR108</td>
<td>11:00</td>
<td>BOU112</td>
<td>19</td>
<td>0:25:39</td>
<td>7.12</td>
<td>2.97</td>
<td>61.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td>0:16:09</td>
<td>3.50</td>
<td>1.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20081208-1600-BOU112</td>
<td>16:00</td>
<td>BOU112</td>
<td>19</td>
<td>0:25:39</td>
<td>7.12</td>
<td>2.97</td>
<td>61.34</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td>0:16:09</td>
<td>3.50</td>
<td>1.04</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * indicates outlier sessions
eliminated from analysis. Data from the remaining participants \((N = 597)\) was used for the remainder of the analysis in this chapter. Since both these sessions were held on the same day, a possible explanation for the lower performance on the tests could be related to the day on which these sessions were held.

It should be noted that after eliminating data from the two lab sessions, the mean total score from none of the remaining lab sessions was more than two SEMs away from the new grand mean total score for Treatment 2 (T2).

**Effect of Courses from which Participants were Recruited**

Participants in the Phase IV study were recruited from three courses. Separate ANOVAs for each of the three experimental conditions were conducted to determine the effects of the participants’ course on each of the dependent variables (scores on the Web-based human heart tests, time to read the instructional unit on the human heart, and time to respond to the heart tests). Results obtained are summarized in Table 46. Separate ANOVAs were run for each experimental condition.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Control Significance</th>
<th>Treatment 1 (T1) Significance</th>
<th>Treatment 2 (T2) Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading time</td>
<td>.328</td>
<td>.875</td>
<td>.066</td>
</tr>
<tr>
<td>Micro-textbase</td>
<td>.989</td>
<td>.081</td>
<td>.050</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>.905</td>
<td>.313</td>
<td>.267</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>.932</td>
<td>.100</td>
<td>.029</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>.867</td>
<td>.041</td>
<td>.221</td>
</tr>
<tr>
<td>Test time</td>
<td>.385</td>
<td>.349</td>
<td>.887</td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies*
The differences in the scores on the Web-based human heart tests were most pronounced for the two Web-based learning environment groups (T1 and T2). The mean total scores on the Web-based human heart tests for participants in the two Web-based learning environment groups (T1 and T2) are summarized in Table 47.

Table 47. Descriptive Statistics: Total Scores on the Web-Based Human Heart Tests for the Three Courses from which Participants were Recruited

<table>
<thead>
<tr>
<th>Participants’ course</th>
<th>Treatment 1 (T1)</th>
<th>Treatment 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGEE101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>78</td>
<td>60</td>
</tr>
<tr>
<td>Mean</td>
<td>57.35</td>
<td>63.17</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>19.84</td>
<td>19.41</td>
</tr>
<tr>
<td>EGEE102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>124</td>
<td>140</td>
</tr>
<tr>
<td>Mean</td>
<td>56.24</td>
<td>59.58</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>20.51</td>
<td>18.21</td>
</tr>
<tr>
<td>MATSE081</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Mean</td>
<td>73.00</td>
<td>71.07</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>16.29</td>
<td>19.32</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

Participants from the MATSE081 course scored higher than participants enrolled in the other two courses. Chi-square statistics were computed to determine whether participants from the three courses were equally distributed across the three experimental conditions. The condition * participants’ course cross tabulation is presented in Table 48. As expected there was no difference in distribution of participants by course across the three conditions [$\chi^2 (2, N = 597) = 3.549, p = .470$]. Given that participants from the three courses were uniformly distributed
across the three experimental conditions, high scores obtained by participants from the MATSE081 course was not a concern.

Table 48. Condition * Participants’ Course Cross Tabulation

<table>
<thead>
<tr>
<th>Participants’ course</th>
<th>Experimental condition</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>T1</td>
<td>T2</td>
<td>Total</td>
</tr>
<tr>
<td>EGEE101</td>
<td>72</td>
<td>78</td>
<td>52</td>
<td>202</td>
</tr>
<tr>
<td>EGEE102</td>
<td>128</td>
<td>124</td>
<td>110</td>
<td>362</td>
</tr>
<tr>
<td>MATSE081</td>
<td>11</td>
<td>9</td>
<td>13</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>211</td>
<td>211</td>
<td>175</td>
<td>597</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

As part of the preliminary data analysis, separate one-way ANOVAs for means scores on the prior-knowledge variables (knowledge of human anatomy and spatial ability) across the three experimental conditions were calculated (see Table 49).

Table 49. ANOVA Results: Scores on the Prior-Knowledge and Human Anatomy Tests

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of human anatomy</td>
<td>.335</td>
</tr>
<tr>
<td>Spatial ability</td>
<td></td>
</tr>
<tr>
<td>Paper folding</td>
<td>.064*</td>
</tr>
<tr>
<td>Card rotation</td>
<td>.429</td>
</tr>
</tbody>
</table>

p < .10

The differences in scores on the prior-knowledge variables (knowledge of human anatomy and spatial ability) across the three experimental conditions were not statistically significant except for scores on the paper folding tests. Descriptive statistics for scores obtained on the paper folding test are provided in Table 50. Participants in the Web-based learning
environment group with demonstration that included explicit instruction on the reading strategies (T2) scored the highest while participants in the control group scored the lowest. The maximum score on this test was 20.

Table 50. Descriptive Statistics: Scores on the Paper Folding Test

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>209</td>
<td>10.50</td>
<td>4.08</td>
</tr>
<tr>
<td>T1</td>
<td>205</td>
<td>10.79</td>
<td>4.01</td>
</tr>
<tr>
<td>T2</td>
<td>172</td>
<td>11.45</td>
<td>3.65</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

Multivariate Analysis

The correlations between the scores on the four human heart tests were high (see Table 51). Given that the dependent measures were significantly correlated, it was determined that there would be an advantage to using multivariate analysis of variance (MANOVA) procedures instead of separate ANOVAs (Bray & Maxell, 1985; Tabachnick & Fidell, 2001).
Table 51. Correlations Between Micro-Textbase, Macro-Textbase, Micro-Situation Model, Macro-Situation Model Test Scores

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Micro-textbase</td>
<td>—</td>
<td>.538**</td>
<td>.805**</td>
<td>.746**</td>
</tr>
<tr>
<td>2. Macro-textbase</td>
<td>—</td>
<td>—</td>
<td>.534**</td>
<td>.485**</td>
</tr>
<tr>
<td>3. Micro-situation model</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>.817**</td>
</tr>
<tr>
<td>4. Macro-situation model</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).

Covariates

Correlations between scores on the prior-knowledge tests (knowledge of human anatomy and spatial ability) and the scores on the Web-based human heart tests were calculated (see Table 52).

Table 52. Correlations Among Scores on the Prior-Knowledge Tests and Human Heart Tests

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge of human anatomy</td>
<td>—</td>
<td>.245**</td>
<td>.173**</td>
</tr>
<tr>
<td>2. Paper folding</td>
<td>.245**</td>
<td>—</td>
<td>.485**</td>
</tr>
<tr>
<td>3. Card rotation</td>
<td>.173**</td>
<td>.485**</td>
<td>—</td>
</tr>
<tr>
<td>4. Micro-textbase</td>
<td>.298**</td>
<td>.386**</td>
<td>.253**</td>
</tr>
<tr>
<td>5. Macro-textbase</td>
<td>.159**</td>
<td>.282**</td>
<td>.138**</td>
</tr>
<tr>
<td>6. Micro-situation model</td>
<td>.267**</td>
<td>.415**</td>
<td>.248**</td>
</tr>
<tr>
<td>7. Macro-situation model</td>
<td>.201**</td>
<td>.367**</td>
<td>.235**</td>
</tr>
</tbody>
</table>

** Correlation is significant at the .01 level (2-tailed).
Given the high correlations between scores on human heart tests and scores on the knowledge of human anatomy and the paper folding tests, it was determined that there would be an advantage to using scores on the knowledge of human anatomy and paper folding tests as covariates in an multivariate analysis of covariance (MANCOVA) (Wildt & Ahtola, 1978). Correlations of the scores on card rotations test with the scores on the Web-based human heart tests were lower; this variable was not considered in the MANCOVA.

An assumption of MANCOVA is that the slopes of regression lines between the dependent variable and the covariate are equal for each level of the independent variable. This assumption was tested by computing the interaction between each of the two covariates (scores on the knowledge of human anatomy and paper folding tests) and the independent variable (experimental condition) for the four human heart tests.

1. Interaction between scores on the knowledge of human anatomy test and the experimental conditions for the four human heart tests

A statistically significant interaction was found between scores on the knowledge of human anatomy test and the experimental conditions for each of the four human heart tests (see Table 53).

Table 53. Scores on Knowledge of Human Anatomy Test * Experimental Condition Interaction for the Four Human Heart Tests

<table>
<thead>
<tr>
<th>Human Heart Test</th>
<th>df.</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro-textbase</td>
<td>3</td>
<td>25.34</td>
<td>.000</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>3</td>
<td>7.15</td>
<td>.000</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>3</td>
<td>18.09</td>
<td>.000</td>
</tr>
<tr>
<td>Macro-situation model</td>
<td>3</td>
<td>12.52</td>
<td>.000</td>
</tr>
</tbody>
</table>
2. Interaction between scores on the paper folding test and the experimental conditions for the four human heart tests

A statistically significant interaction was found between scores on the paper folding test and the experimental conditions for each of the four human heart tests (see Table 54).

Table 54. Scores on Paper Folding Test * Experimental Condition Interaction for the Four Heart Tests

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>df.</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro-textbase</td>
<td>3</td>
<td>38.41</td>
<td>.000</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>3</td>
<td>18.05</td>
<td>.000</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>3</td>
<td>42.50</td>
<td>.000</td>
</tr>
<tr>
<td>Macro-situation model</td>
<td>3</td>
<td>32.86</td>
<td>.000</td>
</tr>
</tbody>
</table>

Since the homogeneity of regression assumption for MANCOVA was not met for either of the covariates, the covariates were not used in further analysis. Instead of MANCOVA, a MANOVA (one-way) was used to compare scores on the micro-textbase, macro-textbase, micro-situation model, macro-situation model tests across the three experimental conditions. One-way ANOVAs were used to compare time spent reading the instructional unit on the human heart, and the time spent responding to the Web-based human heart tests.
Scores on the Web-Based Human Heart Tests

Research Question 1: Did the Web-based learning environment help participants develop better memory (micro-textbase and macro-textbase) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?

Research Question 2: Did the Web-based learning environment help participants develop better understanding (micro-situation model and macro-situation model) of the instructional unit on the human heart?

Descriptive statistics for scores on the micro-textbase, macro-textbase, micro-situation model, macro-situation model tests are presented in Table 55.

Table 55. Descriptive Statistics: Micro-Textbase, Macro-Textbase, Micro-Situation model, Macro-Situation Model Tests for the Three Experimental Conditions

<table>
<thead>
<tr>
<th>Human heart test</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Memory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-textbase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>211</td>
<td>20.89</td>
<td>9.56</td>
</tr>
<tr>
<td>T1</td>
<td>211</td>
<td>18.67</td>
<td>9.93</td>
</tr>
<tr>
<td>T2</td>
<td>175</td>
<td>21.95</td>
<td>9.01</td>
</tr>
<tr>
<td>Total</td>
<td>597</td>
<td>20.42</td>
<td>9.62</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>211</td>
<td>14.24</td>
<td>2.52</td>
</tr>
<tr>
<td>T1</td>
<td>211</td>
<td>14.17</td>
<td>2.66</td>
</tr>
<tr>
<td>T2</td>
<td>175</td>
<td>14.70</td>
<td>2.47</td>
</tr>
<tr>
<td>Total</td>
<td>597</td>
<td>14.35</td>
<td>2.57</td>
</tr>
<tr>
<td><strong>Understanding</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-situation model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>211</td>
<td>9.87</td>
<td>4.45</td>
</tr>
<tr>
<td>T1</td>
<td>211</td>
<td>9.61</td>
<td>4.71</td>
</tr>
</tbody>
</table>
Before performing the MANOVA, Levene’s test of equality of variances was used to check the homogeneity of variances assumption for scores on each of the four dependent variables. Since the differences in variance were not statistically significant, the assumption of equality of variances was satisfied (see Table 56).

Table 56. Levene’s Test of Equality of Variances for the Scores on the Human Heart Tests Across the Three Experimental Conditions

<table>
<thead>
<tr>
<th>Human heart test</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro-textbase</td>
<td>2.22</td>
<td>.109</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>.79</td>
<td>.454</td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>.86</td>
<td>.422</td>
</tr>
<tr>
<td>Macro-situation model</td>
<td>2.16</td>
<td>.116</td>
</tr>
</tbody>
</table>

MANOVA for the scores on the four human heart tests across the three experimental conditions was calculated to test for overall significance (see Table 57).
Table 57. MANOVA Results: Human Heart Tests Across the Three Experimental Conditions

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>df.</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial $\eta^2$</th>
<th>Observed power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-textbase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between group</td>
<td>2</td>
<td>550.90</td>
<td>6.06</td>
<td>.002*</td>
<td>.020</td>
<td>.885</td>
</tr>
<tr>
<td>Within group</td>
<td>594</td>
<td>90.96</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macro-textbase</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between group</td>
<td>2</td>
<td>15.82</td>
<td>2.41</td>
<td>.090*</td>
<td>.008</td>
<td>.487</td>
</tr>
<tr>
<td>Within group</td>
<td>594</td>
<td>6.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Understanding</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-situation model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between group</td>
<td>2</td>
<td>60.46</td>
<td>2.88</td>
<td>.057*</td>
<td>.010</td>
<td>.563</td>
</tr>
<tr>
<td>Within group</td>
<td>594</td>
<td>21.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macro-situation model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between group</td>
<td>2</td>
<td>114.45</td>
<td>5.06</td>
<td>.007*</td>
<td>.017</td>
<td>.818</td>
</tr>
<tr>
<td>Within group</td>
<td>594</td>
<td>22.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.1

The omnibus test indicated statistically significant differences in scores for all four tests—micro-textbase, macro-textbase, micro-situation model, macro-situation model.

According to Cohen (1977), all effect sizes were small-medium [$\eta^2 = .01$ (small); $\eta^2 = .06$ (medium); $\eta^2 = .14$ (large)]. Fischer’s least significant difference (LSD) test was performed for pairwise comparisons (see Table 58).
Table 58. Human Heart Tests: Results from Fisher’s LSD Post-Hoc Test

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>(I) condition</th>
<th>(J) condition</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Memory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-textbase</td>
<td>Control</td>
<td>T1</td>
<td>.017*</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>T2</td>
<td>.274</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
<td>.001*</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>Control</td>
<td>T1</td>
<td>.776</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>T2</td>
<td>.076*</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
<td>.041*</td>
</tr>
<tr>
<td><strong>Understanding</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>Control</td>
<td>T1</td>
<td>.552</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>T2</td>
<td>.079*</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
<td>.020*</td>
</tr>
<tr>
<td>Macro-situation model</td>
<td>Control</td>
<td>T1</td>
<td>.624</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>T2</td>
<td>.012*</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>T2</td>
<td>.003*</td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

* p < 0.1
Results: Memory

1. Micro-Textbase Test: The difference in scores obtained by participants in the control group and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) on the one hand and scores obtained by participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) were statistically significant ($p = .017$ and $p = .001$ respectively). Participants in T1 scored lower than participants in control group and participants in T2 (see Figure 43). The difference in scores on this test between participants in control group and participants in T2 was not statistically significant ($p = .274$).

![Figure 43. Scores on micro-textbase test.](image-url)
2. Macro-Textbase Test: The difference in scores between participants in the control group and participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) on the one hand and participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) was statistically significant ($p = .076$ and $p = .041$ respectively). Participants in T2 performed better than participants in control group and participants in T1 (see Figure 44). The difference in scores on this test between participants in control group and participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) was not statistically significant ($p = .776$).

![Figure 44. Scores on macro-textbase test.](image)
Results: Understanding

3. Micro-Situation Model Test: The difference in scores between participants in the control group and participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) on the one hand and participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) was statistically significant ($p = .079$ and $p = .020$ respectively). Participants in T2 performed better than participants in control group and participants in T1 (see Figure 45). The difference in scores on this test between participants in control group and participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) was not statistically significant ($p = .552$).

![Figure 45. Scores on micro-situation model test.](image)
4. Macro- Situation Model Test: The difference in scores between participants in the control group and participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) on the one hand and participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) was statistically significant ($p = .012$ and $p = .003$ respectively). Participants in T2 performed better than participants in control group and participants in T1 (see Figure 46). The difference in scores on this test between participants in control group and participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) was not statistically significant ($p = .624$).

![Figure 46. Scores on macro-situation model test.](image)
Conclusions

Participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) scored significantly higher than participants in the control group on the macro-textbase, micro-situation model and macro-situation model tests. There was no significant difference in scores on the micro-textbase test.

Participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) scored significantly lower than participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) on all tests.

Reading Time

Research Question 3: Did participants in the three experimental conditions take equal amount of time to read the instructional unit on the human heart?

The time that participants spent reading the instructional unit on the human heart is provided in Table 59.

Table 59. Descriptive Statistics for Reading Time in the Three Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>211</td>
<td>00:16:54</td>
<td>00:09:49</td>
<td>00:01:08</td>
<td>00:50:05</td>
</tr>
<tr>
<td>T1</td>
<td>211</td>
<td>00:31:41</td>
<td>00:18:11</td>
<td>00:00:14</td>
<td>01:36:23</td>
</tr>
<tr>
<td>T2</td>
<td>175</td>
<td>00:34:28</td>
<td>00:17:22</td>
<td>00:00:10</td>
<td>01:19:02</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies
A one-way ANOVA was used to compare reading times across the three conditions.

Results from the ANOVA are presented in Table 60.

Table 60. ANOVA Results: Reading Time

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>1.290E8</td>
<td>2</td>
<td>6.448E7</td>
<td>74.74</td>
<td>.000*</td>
</tr>
<tr>
<td>Within groups</td>
<td>5.125E8</td>
<td>594</td>
<td>862721.65</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

p < 0.1

The omnibus test indicated statistically significant differences in reading times (p = .000).

Fischer’s least significant difference (LSD) test was used to make pairwise comparisons (see Table 61).

Table 61. Reading Time: Results from Fisher’s LSD Post-Hoc Test

<table>
<thead>
<tr>
<th>(I) condition</th>
<th>(J) condition</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>T1</td>
<td>.000*</td>
</tr>
<tr>
<td>Control</td>
<td>T2</td>
<td>.000*</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>.079*</td>
</tr>
</tbody>
</table>

* p < 0.1

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

There was a statistically significant difference in reading times between participants in the two Web-based learning environment conditions and participants in the control group (p = .000 and p = .000 respectively). The difference in reading time between participants in the two Web-based learning environment conditions was also statistically significant (p = .079).

Participants in both Web-based learning environment conditions spent nearly twice as much time reading the instructional unit on the human heart when compared with participants in
the control condition who read the instructional unit on the human heart on a regular Web page (see Figure 47).

![Figure 47. Reading times by condition.](image)

At the end of the study, participants were asked to respond to a feedback survey. One question in this survey asked participants’ about the time they spent reading in the Web-based learning environment, “Do you think you spent more time reading the human heart text in the learning environment when compared with the time you would have spent reading the same text on a regular Web page or on paper? If yes, by how much? Do you think this extra time spent was beneficial?” Analysis of responses to this question indicated that most participants in the Web-based learning environment conditions thought that they spent longer reading in the Web-based
learning environment as compared to the time they would have spent reading the same text on a regular Web page. Many of these participants thought that this extra time was beneficial. Representative responses from participants are discussed in a later section in this Chapter.

During the lab sessions in this study the researcher observed that female participants spent more time reading in the Web-based learning environment than their male counterparts. On the basis of this observation, a comparison between reading times was made across gender. These differences were statistically significant for all three experimental conditions. Female participants spent more time reading the instructional unit on the human heart in the Web-based learning environment (see Table 62).

Table 62. Reading Time by Gender: Descriptive Statistics and Results from T-Tests

<table>
<thead>
<tr>
<th>Condition</th>
<th>Female</th>
<th>Male</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>00:17:59</td>
<td>00:15:58</td>
<td>0.000*</td>
</tr>
<tr>
<td>T1</td>
<td>00:37:20</td>
<td>00:26:42</td>
<td>0.000*</td>
</tr>
<tr>
<td>T2</td>
<td>00:40:08</td>
<td>00:29:15</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

* p < 0.1

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies.
Time Spent Responding to the Web-based Human Heart Tests

Research Question 4: Did participants in the three experimental conditions take equal amount of time to respond to the Web-based human heart tests?

The time spent by participants on the Web-based human heart tests was compared across the three experimental conditions (see Table 63).

Table 63. Descriptive Statistics for Time on Tests in the Three Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>N</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>210</td>
<td>00:27:22</td>
<td>00:07:11</td>
<td>00:15:20</td>
<td>01:01:19</td>
</tr>
<tr>
<td>T1</td>
<td>211</td>
<td>00:24:56</td>
<td>00:07:28</td>
<td>00:07:13</td>
<td>00:52:56</td>
</tr>
<tr>
<td>T2</td>
<td>175</td>
<td>00:27:40</td>
<td>00:08:24</td>
<td>00:10:52</td>
<td>01:09:12</td>
</tr>
<tr>
<td>Total</td>
<td>596</td>
<td>00:26:36</td>
<td>00:07:45</td>
<td>00:07:13</td>
<td>01:09:12</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

A one-way ANOVA was used to compare reading times across the three conditions.

Results from the ANOVA are presented in Table 64.

Table 64. ANOVA results: Time on Tests

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df.</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>3272026.43</td>
<td>2</td>
<td>1636013.22</td>
<td>7.73</td>
<td>.000*</td>
</tr>
<tr>
<td>Within groups</td>
<td>1.255E8</td>
<td>593</td>
<td>211673.65</td>
<td>7.73</td>
<td>.000*</td>
</tr>
</tbody>
</table>

p < 0.1
The omnibus test indicated statistically significant differences in reading times ($p = .000$). Fischer’s least significant difference (LSD) test was used to make pairwise comparisons (see Table 65).

Table 65. Pairwise Comparisons: Time on Tests Across the Three Conditions

<table>
<thead>
<tr>
<th>(I) condition</th>
<th>(J) condition</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>T1</td>
<td>.001*</td>
</tr>
<tr>
<td>Control</td>
<td>T2</td>
<td>.702</td>
</tr>
<tr>
<td>T1</td>
<td>T2</td>
<td>.001*</td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

$p < 0.1$

There was a statistically significant difference in time spent on tests between participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) and participants in the other two conditions—control and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) ($p = .001$ and $p = .001$ respectively). Participants in T1 spent significantly less time responding to test questions when compared with participants in the control group and participants in T2. The difference in reading time between participants in the control condition and participants in T2 was not statistically significant ($p = .702$) (see Figure 48).
Effect of Time on Task on Test Scores

The effect of time on task—time spent reading the instructional unit on the human heart and the time spent responding to the heart tests—on the total scores was estimated separately for each of the three conditions.

Control Group

Correlations between the time spent reading the instructional unit on the human heart, the time spent responding to the heart tests and the total score on the Web-based human heart tests were computed. The three variables were positively correlated and the correlations were statistically significant (see Table 66).
Table 66. Correlations Among Reading Time, Time on Test and Total Score for the Control Group

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (n = 211)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Reading time</td>
<td>—</td>
<td>.522**</td>
<td>.419**</td>
</tr>
<tr>
<td>2. Time on tests</td>
<td>—</td>
<td>—</td>
<td>.381**</td>
</tr>
<tr>
<td>3. Total score</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).

A regression model, with reading time and time spent on the human hearts tests as the predictor variables and the total scores as the dependent variable, was computed (see Table 67).

Table 67. Regression Model for Control Group: Reading Time, Time on Test, and Total Score

<table>
<thead>
<tr>
<th>R</th>
<th>R square</th>
<th>Adjusted R square</th>
<th>Std. error of the estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>.460</td>
<td>.212</td>
<td>.204</td>
<td>16.542</td>
</tr>
</tbody>
</table>

Two separate scatterplots with total score on the Web-based human heart tests as the dependent variable, and the reading time and time spent on the human hearts tests as the independent variables are shown in Figure 49 and Figure 50.
**Figure 49.** Scatterplot for Control Condition: Reading time (predictor) and total score on the Web-based human heart tests (dependent variable)

**Figure 50.** Scatterplot for Control Condition: Time on tests (predictor) and total score on the Web-based human heart tests (dependent variable)
Treatment Condition 1 (T1)

Correlations between the time spent reading the instructional unit on the human heart, the time spent responding to the heart tests and the total score on the Web-based human heart tests were computed. The three variables were positively correlated; the correlation between reading time and time spent on tests was not statistically significant, the other two correlations were statistically significant (see Table 68).

Table 68. Correlations Among Reading Time, Time on Test and Total Score for the Treatment Group 1 (T1)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants ((n = 211))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Reading time</td>
<td>—</td>
<td>.063</td>
<td>.257**</td>
</tr>
<tr>
<td>2. Time on tests</td>
<td>—</td>
<td>—</td>
<td>.407**</td>
</tr>
<tr>
<td>3. Total score</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (2-tailed).

A regression model, with reading time and time spent on the human hearts tests as the predictor variables and the total scores as the dependent variable, was computed (see Table 69).

Table 69. Regression Model for Treatment Group 1 (T1): Reading Time, Time on Test and Total Score

<table>
<thead>
<tr>
<th>R</th>
<th>R square</th>
<th>Adjusted R square</th>
<th>Std. error of the estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>.468</td>
<td>.219</td>
<td>.212</td>
<td>18.023</td>
</tr>
</tbody>
</table>

Two separate scatterplots with total score on the Web-based human heart tests as the dependent variable, and the reading time and time spent on the human hearts tests as the predictor variables are shown in Figure 51 and Figure 52.
Figure 51. Scatterplot for Treatment 1 (T1): Reading time (predictor) and total score on the Web-based human heart tests (dependent variable)

Figure 52. Scatterplot for Treatment 1 (T1): Time on tests (predictor) and total score on the Web-based human heart tests (dependent variable)
**Treatment Condition 2 (T2)**

Correlations between the time spent reading the instructional unit on the human heart, the time spent responding to the heart tests and the total score on the Web-based human heart tests were computed. The three variables were positively correlated and the correlations were statistically significant (see Table 70).

Table 70. Correlations Among Reading Time, Time on Test and Total Score for Treatment Group 1 (T2)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants (n = 175)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Reading time</td>
<td></td>
<td>.261**</td>
<td>.338**</td>
</tr>
<tr>
<td>2. Time on tests</td>
<td></td>
<td></td>
<td>.400**</td>
</tr>
<tr>
<td>3. Total score</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.01 level (2-tailed).

A regression model, with reading time and time spent on the human hearts tests as the predictor variables and the total scores as the dependent variable, was computed (see Table 71).

Table 71. Regression Model for Treatment Group 2 (T2): Reading Time, Time on Test and Total Score

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>R square</th>
<th>Adjusted R square</th>
<th>Std. error of the estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.468</td>
<td>.219</td>
<td>.210</td>
<td>16.267</td>
</tr>
</tbody>
</table>

Two separate scatterplots with total score on the Web-based human heart tests as the dependent variable, and the reading time and time spent on the human hearts tests as the predictor variables are shown in Figure 53 and Figure 54.
Figure 53. Scatterplot for Treatment 1 (T1): Reading time (predictor) and total score on the Web-based human heart tests (dependent variable)

Figure 54. Scatterplot for Treatment 2 (T2): Time on tests (predictor) and total score on the Web-based human heart tests (dependent variable)
For each of the three experimental conditions the reading time and time spent responding to the human heart tests explained a considerable portion (over 20%) of the variance in the total score obtained by participants in that condition.
Participant’s Use of the Five Reading Strategies in the Web-Based Learning Environment

Research Question 5a: How did participants use the reading strategies in the Web-based learning environment?

At the end of the Phase IV study participants were asked to respond to a feedback survey. A section of this feedback survey included questions regarding participants’ use of the reading strategies and their experience in the Web-based learning environment. Participants’ responses to the following questions from this section of the feedback survey were analyzed.

Q. What features did you like in the Learning Environment?
Q. What did you not like about the Learning Environment? What would you like changed?
Q. Do you think you benefited from reading the Human Heart text in the Learning Environment?
Q. Do you think you spent more time reading the Human Heart text in the Learning Environment when compared with the time you would have spent reading the same text on a regular Web page or on paper? If yes, by how much? Do you think this extra time spent was beneficial?

Responses to these questions indicated that many participants thought they benefited from using the five reading strategies in the Web-based learning environment. Participants’ also provided feedback regarding ways in which they thought the reading strategies helped them learn from the instructional unit on the human heart. Data regarding each of the five reading strategies are discussed.

Quantitative data related to the use of the five strategies in the Web-based learning environment—number of sections (tabs) participants created, the length (number of words) of summaries and notes, and the comfort-meter levels participants set for each section, are also presented.
A question in the feedback survey asked participants to rate on a 9-point Likert-type scale how useful they found each of the five reading strategies in the Web-based learning environment. Participants’ responses to this question are discussed at the end of this section.

**Text-Macrostructure (Chunking) Strategy**

The average number of sections created by a given participant was computed for all the participants in the two Web-based learning environment conditions. The descriptive statistics for this variable are provide in Table 72.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Participant created at least one section</th>
<th>Participant did not create any sections</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>151</td>
<td>60</td>
<td>6.68</td>
<td>4.12</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>T2</td>
<td>121</td>
<td>54</td>
<td>5.13</td>
<td>2.87</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>272</td>
<td>114</td>
<td>5.99</td>
<td>3.69</td>
<td>1</td>
<td>25</td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies*

ANOVA was used to compare the average number of sections created by participants in the two Web-based learning environment conditions (T1 and T2) (see Table 73). On average participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) chunked the instructional unit on the human heart into more sections (mean = 6.68) than participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) (mean = 5.13). This difference was statistically significant ($p = .001$). It is worth noting that
participants in T1 scored lower than participants in T2 even though participants in T1 created more sections in the Web-based learning environment.

Table 73. ANOVA Results: Use of the Text-Macrostructure Strategy

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>1</td>
<td>159.98</td>
<td>12.21</td>
<td>.001*</td>
</tr>
<tr>
<td>Within groups</td>
<td>270</td>
<td>13.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* p &lt; 0.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Several participants said that they found it easier to engage with the text because it was “broken up” into smaller pieces (elements). Participants liked being able to read and focus on one element at a time, and move these elements to sections that they created. Being able to “manipulate” elements in the instructional text in this way made the reading task “less daunting” for them (see Table 74).

Table 74. Feedback from Participants: Benefits of Division of the Instructional Unit Into 25 Elements

**Treatment Condition 1 (T1)**

_I liked how there were 25 different sections of text with pictures. It was easier to read and understand in that format instead of just a solid paragraph form essay._

_I liked the original format where the essay was broken up into 25 parts. It made it easy to focus and was a nice transition instead of it all jumbled together._

... _I liked how it was all broken up. It made reading it not so scary._

**Treatment Condition 2 (T2)**

_I liked that the text was separated into small readings, instead of long paragraphs._

_I liked that ...and the text was not overwhelming. The breakup of text was great._
I liked how the text was broken into smaller, more readable segments.

I liked how it was broke up in too many small portions. Reading large portions can get me lost and confused.

I liked that the text was already broken up into “elements.”

It was good that the text was already broken up into parts, I just took out the main points and wrote notes.

Only one participant in the Web-based learning environment condition that did not include explicit instruction on reading strategies (T1) noted that he did not like the text being broken up into elements, “The breaking up of the text was fairly useless because it was already broken up.”

Several participants in both Web-based learning environment conditions noted that they liked using the text-macrostructure strategy (see Table 75).

Table 75. Feedback from Participants: Liked Using the Text-Macrostructure Strategy

**Treatment Condition 1 (T1)**

I liked being able to divide information into categories ...

[I liked] the divided reading sections

[I liked] breaking up a large text into smaller texts

[I liked] breaking up the story in to smaller pieces.

[I liked] That I could break up the text...

[I liked] Making tabs and being able to move chunks of text.

I Really liked the break up into smaller sections. I thought it was useful.

**Treatment Condition 2 (T2)**

The best part was the chunking in to elements.

I liked how we could divide the elements on our own.

[I liked] how it was set up with breaking down the text
Several participants in both Web-based learning environment conditions noted that they benefited from the text-macrostructure strategy because it allowed them to reorganize the instructional unit on the human heart into a form they were comfortable with. Participants in both Web-based learning environment conditions felt that this strategy made the reading task less overwhelming because they were able to focus on smaller portions of the instructional unit at a time. Being able to customize the text motivated some participants. Representative feedback from participants is included in Table 76.

Table 76. Feedback from Participants: Benefits of Using the Text-Macrostructure Strategy

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The ability to reorganize the text was extremely useful because I knew everything I was reading after I put things under new headings was of one common group, and therefore it was more difficult to become confused since all the sections had similar information.</strong></td>
</tr>
<tr>
<td><strong>I liked being able to divide information into categories and to take notes accordingly.</strong></td>
</tr>
<tr>
<td><strong>I liked how you could break up the material into different sections. I think that by doing this it allowed the reader to take a little break in between the sections to let the material sink in.</strong></td>
</tr>
<tr>
<td><strong>I liked that I was to set up the text how I wanted it to be.</strong></td>
</tr>
<tr>
<td><strong>I liked splitting up the text into smaller pieces, but found that it took a lot of time since I didn’t know the material prior to reading it. It’s easier to break up the text into smaller pieces if you read it straight through then organize it.</strong></td>
</tr>
<tr>
<td><strong>I liked that I could organize the reading however I wanted and could create my own summaries.</strong></td>
</tr>
</tbody>
</table>
I enjoyed how you could manipulate the text to make it easier to understand

breaking the text into pieces made it much easier to digest and comprehend

I liked how I could break up the individual sections into the sections I wanted them to be in. I could then name them so I could go back and know exactly what was there. I also liked the note taking aspect of this program.

[ I liked ] Separating the individual elements up, as if into an outline.

Breaking down the text and adding notes to smaller sections is much more efficient than simply taking notes or highlighting a textbook. You can group everything too, so all related info can be put together away from different topics.

I liked how you could separate the essay into different parts which helped me organize my thoughts

I liked the organization it allowed. The sections allowed you to categorize, then by the end of reading, you could ask yourself “Did I learn what this section was trying to get across?”

...Breaking the text up also helped reading not as daunting.

The features I liked in the learning environment, were being able to create tabs to group things according to how I wanted to and adding pictures.

The best part for me was being able to separate long texts because it was much easier to comprehend the meaning of the essay.

I liked the tab format. That made it much easier for me to divide it into sections and be able to understand and learn one section at a time.

I liked the easy function of breaking up the text, it allowed me to not only break down a huge supply of information, but it also aided me in highlighting and review the information I was not clear or satisfied with...

it was beneficial because it forces you to break apart the text and understand it better.

it really made me read the text closer in order to break into smaller parts, and think of what needed to go where.

I really did benefit from the learning environment, because being able to organize the information helped me to really understand what the text was trying to teach me.

it probably made the text a little easier to read, and a little less intimidating the way it was divided up.

Breaking up the information made it less boring and easier to reread. I’d probably read about 10 minutes more.

I definitely spent more time reading this text because it was easier to follow than trying to read all of it combined into one giant essay. It was definitely more beneficial.

...I would have not been as interested to read it thoroughly or organize it.

Yes I think I spent more time reading the text in the learning environment because I had to reorder everything; however it was incredibly easy to retain the information that I was taking in.
Treatment Condition 2 (T2)

I really liked that I could manipulate the material and put it where I wanted and organize it in a way that made sense to me.

[1 liked] organizing material by topic

broken up text=easier to read and made it seem shorter

...separating the text into smaller pieces eliminated intimidation of the text

I enjoyed having the ability to compartmentalize the material and to take notes on them individually.

I liked the ability to organize the sections of the text that made sense specifically to me...

I liked how you could split up the text and actually put them into different categories, that you got to name and decide for yourself.

I liked the ability to group similar objects together and take notes on them

Breaking up the text and labeling each part was very useful.

I liked the ability to put sections into sections than summarize them

Breaking up the text helped A LOT in remembering the information later on down the line.

I liked being able to create my own sections, or chunks, and then being able to write a summary for each chunk. It really lets you categorize content easily and allows better comprehension.

I was forced to break it up which probably added another 10 minutes to my reading, but it was beneficial.

I liked the tabs that allowed me to break up the text. It made it more manageable.

I liked the feature of separating sections into tabs. This made it easier to divide up the text into different topics that were covered within the larger scope. I also liked being able to make summaries of each tab.

Separating the text into sections really helps. The text is less dense and mingles. I can remember sections at a time.

The ability to split of the text into smaller sections was a very beneficial feature. Overall the strategies proved to be effective and efficient in attaining the most out of the text.

Splitting it up into small sections was very beneficial

...I organized the material I was reading into smaller, more related sections

I think it would be easier to reread it though because you can break it down clearly by topics

Yes, on the web page I would have skimmed through the material. The learning environment made me break down what each section was about, and write a short note on it. I thought it was more beneficial than if I had just skimmed through the material.

[1 liked] The ability to grab parts of the text and place it in Labels that I related to better.
It is possible that by using the text-macrostructure strategy to externalize their macro-
level organization of the instructional text, these participants were able to offload some of the
cognitive load that is intrinsic to reading an expository text such as the instructional unit on the
human heart.

One participant in the Web-based learning environment group with demonstration that
did not include explicit instruction on reading strategies (T1) did not like using the text-
macrostructure strategy, “I did not like the breaking up into pieces tool. I think it’s unnecessary.
How many people read with scissors anyway?” One other participant in Treatment 2 (T2)
suggested that the content should be organized into tabs ahead of time, “The content should be
organized ahead of time into tabs, I shouldn’t have to do it myself. It’s a waste of time.”

Interestingly, two participants in control group suggested that it would be beneficial to
chunk the instructional unit on the human heart into smaller pieces (see Table 77).

Table 77. Feedback from Participants: Suggestions for Chunking Strategy from Participants in
the Control Group

<table>
<thead>
<tr>
<th>Control Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make each part of the reading its own slide so students don’t get discouraged about reading the whole thing about the heart.</td>
</tr>
<tr>
<td>I found that the tests towards the end were very difficult because if I had just memorized the facts from the essay as opposed to actually learning them I would have been unable to answer the questions. If the essay were broken up into shorter lessons I might have been able to learn the information better.</td>
</tr>
</tbody>
</table>
Summarization Strategy

The total number of words in summaries and the average number of words per summary were computed for each participant in the two Web-based learning environment conditions. Descriptive statistics for these variables are provided in Table 78.

Table 78. Descriptive Statistics: Use of the Summarization Strategy

<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition</th>
<th>n</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of words</td>
<td>T1</td>
<td>149</td>
<td>170.50</td>
<td>210.18</td>
<td>2</td>
<td>1353</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>115</td>
<td>158.43</td>
<td>248.57</td>
<td>1</td>
<td>1946</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>264</td>
<td>165.24</td>
<td>227.32</td>
<td>1</td>
<td>1946</td>
</tr>
<tr>
<td>Words per summary</td>
<td>T1</td>
<td>149</td>
<td>26.11</td>
<td>32.95</td>
<td>1.00</td>
<td>265.50</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>115</td>
<td>31.03</td>
<td>35.44</td>
<td>.67</td>
<td>176.91</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>264</td>
<td>28.26</td>
<td>34.08</td>
<td>.67</td>
<td>265.50</td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies.*

On average, participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) used more words per summary than participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1). ANOVA was used to compare the total number of words in summaries and the average number of words per summary across the two Web-based learning environment conditions. The differences in these variables across the two conditions were not statistically significant (see Table 79).
Table 79. ANOVA Results: Use of the Summarization Strategy

<table>
<thead>
<tr>
<th></th>
<th>df.</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of words</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>in summaries</td>
<td>Between groups</td>
<td>1</td>
<td>9442.98</td>
<td>.18</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>262</td>
<td>51837.81</td>
<td></td>
</tr>
<tr>
<td>Words per summary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Between groups</td>
<td>1</td>
<td>1569.74</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>Within groups</td>
<td>262</td>
<td>1159.98</td>
<td></td>
</tr>
</tbody>
</table>

Several participants in both Web-based learning environment conditions noted that they liked using the summarization strategy (see Table 80).

Table 80. Feedback from Participants: Liked Using the Summarization Strategy

Treatment Condition 1 (T1)

*I liked that I could create my own summaries.*

*writing your own summaries is a cool idea, although I did not use it.*

Treatment Condition 2 (T2)

*[I liked] Preparing summaries online while reading*

*I liked the fact that you could summarize, that was probably my favorite aspect of the whole environment.*

Several participants in both Web-based learning environment conditions noted that they benefited from the summarization strategy because it not only made them review their macro-level organization of the instructional unit, it also gave them an opportunity to test their memory and understanding of the instructional unit. One participant noted that this strategy helped him “tie up” his understanding of the instructional unit. Another participant said, “making summaries forced me to think harder” (see Table 81).
Table 81. Feedback from Participants: Benefits of Using the Summarization Strategy

Treatment Condition 1 (T1)

typing the summary made me remember what I read a little easier to store it in my brain.
the summary feature helped the most because it allowed me to put the text into my own words
The summaries helped me to quickly review what I just read.
Making summaries forced me to think harder about the material, at least at the time I was doing it. I think it helped me remember a little more of it than just reading.
...I also liked putting the summaries for the groups of units, because it made it easier to remember what each group was about (in general).
Being able to write summaries allowed for me to understand or tie up the meanings behind certain sections.
I liked that we were able to break the material into segments and write our thoughts and be able to review the material. This would help in preparation for an exam.

Treatment Condition 2 (T2)

...retyping what I had taken from each section
Yes, writing the summary about the chunk dealing with blood flow really helped me digest all of it.
yes, requiring to create a summary and group makes for more careful reading

Some participants noted their dissatisfaction with the summarization strategy. In particular, participants who took a lot of notes, found the summaries they were asked to write to be redundant. For these students, the note-taking strategy could have prevented the induction of the summarization strategy. It is also possible that some of these participants used the note-taking strategy to summarize (see Table 82).

Table 82. Feedback from Participants: Summarization Strategy vs. Note-Taking Strategy

Treatment Condition 1 (T1)

I did not like having to write a summary- I felt that was doing the same thing as putting them into mini groups
I did not see the benefit of the summary, as I would put key words, or label the sections with their major themes. The summary and title of each tab seem to be very similar it seems a little unnecessary also the note taking was my summary so the summaries seemed redundant.

I liked being able to write notes on the sections I was reading. Also, writing your own summaries is a cool idea, although I did not use it.

**Treatment Condition 2 (T2)**

I didn’t really think the summaries were as helpful as the notes.

I felt like the notes were pretty much the same thing as the summary. One or the other may be just fine. The summaries and note taking seemed to be pretty much the same thing so I would only do one of them in the future.

I didn’t see the point of the summary. if you take good notes you don’t really need it

The summary feature could simply be a grouping of the notes that were taken on the section.

The summary could be the notes for each section combined.

the summaries of the tabs were not helpful because I basically summarized the text through my note taking

I did not like the need to write a summary, since if your put notes on the section shouldn’t need to summarize your already made notes. Also, didn’t like that you needed to use a summary/picture/comfort in order to continue

I think it should be either summary or notes. both aren’t necessary

Summaries were not really necessary when you already have the note-taking function.

Interestingly, three participants in the Web-based learning environment group with demonstration that did not include explicit instruction on reading strategies (T1) found the summarization strategy to be redundant with the text-macrostructure strategy, in particular the task of choosing labels for sections that they created (see Table 83).
Table 83. Feedback from Participants: Summarization Strategy vs. Text-Macrosstructure Strategy

Treatment Condition 1 (T1)

I did not like having to write a summary- I felt that was doing the same thing as putting them into mini groups

I did not see the benefit of the summary, as I would put key words, or label the sections with their major themes.

The summary and title of each tab seem to be very similar it seems a little unnecessary

Imagery Strategy

Several participants in both Web-based learning environment conditions said they liked using the imagery strategy. Participants noted that this strategy helped them “visualize” the instructional unit and complement their understanding (see Table 84).

Table 84. Feedback from Participants: Benefits of Using the Imagery Strategy

Treatment Condition 1 (T1)

I also liked the images that can be attached so that we have a clear picture of what we are studying.

...images were great tools in that I am a visual learner, and when I see something I have a much easier time retaining the information if it is visually in my memory.

I liked the pictures because it helps me visualize the text. Breaking the text up also helped reading not as daunting.

Treatment Condition 2 (T2)

I liked that I was able to attach images to further my understanding of the human heart.

Although many participants liked the idea of attaching images to sections they created, they did not like the way in which the strategy was implemented in the Web-based learning
environment. Participants found the images that were available in the library to be inadequate, both in quality and in quantity. Some of them said that they would have liked to be able to upload images from external sources. Some participants also found it limiting that they could attach only one image, they wanted to be able to attach more than one image to the sections that they created (see Table 85).

Table 85. Feedback from Participants: Limitations of the Imagery Strategy

---

**Treatment Condition 1 (T1)**

*I really didn’t enjoy the images too much because it didn’t help as much as other aspects.*

*Attaching images to sections is useless, only those next to the elements were necessary.*

*Attaching Images; I found that unnecessary because there were already images in the text.*

*...I would like to change the image portion to be more detailed.*

*... although pictures while reading were helpful to understand the concept, just not when classifying in broader terms.*

*I would add the ability to attach more than one image to the different sections*

*I liked the whole thing although the picture section was not necessarily useful.*

*I didn’t think affiliating a picture with different sections was very useful because each element came with a picture, and multiple elements were added to each section. Also, it did seem a little lengthy towards the end.*

*I thought the image was frivolous and not needed*

*I didn’t like that I had to go back and assign a picture because none really applied to my sections overall*

*The pictures were limited so I did not find it useful.*

*The part I liked the least about the learning environment was the images and the comfort meter. ... I wasn’t sure about the images, because I feel there are times when none of the preselected images would fit the group of units you had.*

**Treatment Condition 2 (T2)**

*I would have liked to have access to my own pictures, say if I wanted to download a more personally-helpful image from google or other web browser.*

*I didn’t really like the options of the images that we were given to attach to our topics. I thought they were*
somewhat vaguely confusing and time consuming, and the comfort-meter didn’t seem to do anything.

I thought it would be helpful to be able to attach more than just one image.

forcing to use a picture, even when a definitive picture may not exist

The pictures could help a lot if they were more descriptive and showed the overall processes in more detail. Basically, better images would help more.

Reading Self-Assessment (Comfort-Meter) Strategy

The average comfort-meter level across all the sections created by a given participant was computed for participants in the two Web-based learning environment conditions. The descriptive statistics for this variable are provide in Table 86.

Table 86. Descriptive Statistics: Use of the Comfort-meter Strategy

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>151</td>
<td>3.33</td>
<td>.64</td>
<td>1.80</td>
<td>5.00</td>
</tr>
<tr>
<td>T2</td>
<td>121</td>
<td>3.53</td>
<td>.65</td>
<td>2.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Total</td>
<td>272</td>
<td>3.43</td>
<td>.65</td>
<td>1.80</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

On average, participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) indicated a higher level of comfort with the sections that they created (mean = 3.53) as compared to participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) (mean = 3.33). ANOVA was used to compare the average comfort-meter level set by participants in the two Web-based learning environment conditions (see Table 87). These differences were statistically significant ($p = .012$). Participants
in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) found the instructional unit on the human heart to be more difficult. It is worth noting here that these participants also scored lower on the post-tests.

Table 87. ANOVA Results: Use of the Comfort-meter Strategy

<table>
<thead>
<tr>
<th></th>
<th>Sum of squares</th>
<th>df.</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between groups</td>
<td>2.62</td>
<td>1</td>
<td>2.62</td>
<td>6.35</td>
<td>.012*</td>
</tr>
<tr>
<td>Within groups</td>
<td>111.57</td>
<td>270</td>
<td>.41</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although participants in the current study were not expected to revisit the instructional unit, some participants were able to foresee this benefit of the comfort-meter strategy. Several participants in both Web-based learning environment conditions liked being able to set their level of comfort with their understanding of the sections that they created. One participant noted that the comfort-meter make it “harder to overlook and forget about things you have trouble with.” Another participant noted that this strategy would be useful as long as she “came back” to the instructional unit. Feedback from some participants related to the comfort-meter strategy is provided in Table 88.

Table 88. Feedback from Participants: Benefits of Using the Comfort-meter Strategy

**Treatment Condition 1 (T1)**

*it was good to be able to set the comfortmeter so that you could return to the topics you didn’t feel comfortable with the comfort meter allows you to set a focus to the studying.*

*[I liked] The comfort-meter. This tool, which flags when you’re not comfortable with something, makes it harder to overlook and forget about things you have trouble with.*
Also it was nice being able to have a comfort level so we knew what to re-read and what was unnecessary to go over.

The comfort meter would also be very useful in a class because as long as you could come back to it, it would be very effective.

I like the comfort meter idea.

Treatment Condition 2 (T2)

I like the chunking idea and the comfort-meter so I know what I need to study more.

It was so detailed and the comfortmeter was cool.

... I only liked the comfort level indicator.

Several participants said they did not find the comfort-meter strategy to be useful.

Interestingly more people in the Web-based learning environment group with demonstration that did not include explicit instruction on reading strategies (T1) gave such feedback. Clearly, these participants were not able to foresee how they could benefit from this strategy (see Table 89).

Table 89. Feedback from Participants: Dissatisfaction with the Comfort-meter Strategy

Treatment Condition 1 (T1)

There is no point in having a comfort meter.

The comfort-meter isn’t really that useful. I wouldn’t go back to see what I have written before. I would be more inclined to just read the summaries.

The comfort meter seemed kind of pointless to me.

The comfort meter seemed kind of worthless but then again it helps to gauge would I think I might need to study on more before I take a test about it.

I didn’t like setting a comfort level, because I know what I know and don’t know.

Setting my comfort-level did not help me remember the reading at all.

I didn’t think the comfort level was applicable. Putting a rating on how you knew the material and how comfortable you felt didn’t affect your preparation for the test questions.

The part I liked the least about the learning environment was the images and the comfort meter. I saw the comfort meter as a slight waste of time. I think you should know whether or not you know the material in the text, and not...
need a meter for you to actually put it on a scale…

**Treatment Condition 2 (T2)**

*I did not like the comfort meter I felt like it did nothing.*

*I did not like the comfort-meter setting; it had no significance. I think it should be eliminated from the learning environment*

*I don’t think the comfort meter really had any impact on my learning. Other than that, I thought everything else helped a lot in learning the material.*

---

**Note-Taking Strategy**

The number of notes, total number of words in notes, and the average number of words per notes were computed for each participant in the two Web-based learning environment conditions. Descriptive statistics for these variables are provided in Table 90.

**Table 90. Descriptive Statistics: Use of the Note-taking Strategy**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Condition</th>
<th>n</th>
<th>Mean</th>
<th>Std. deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Notes</td>
<td>T1</td>
<td>125</td>
<td>14.77</td>
<td>9.53</td>
<td>1</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>128</td>
<td>14.02</td>
<td>8.31</td>
<td>1</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>253</td>
<td>14.39</td>
<td>8.92</td>
<td>1</td>
<td>49</td>
</tr>
<tr>
<td>Total Number of Words in Notes</td>
<td>T1</td>
<td>125</td>
<td>363.41</td>
<td>353.43</td>
<td>2</td>
<td>2068</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>128</td>
<td>323.06</td>
<td>313.57</td>
<td>2</td>
<td>1914</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>253</td>
<td>343.00</td>
<td>333.81</td>
<td>2</td>
<td>2068</td>
</tr>
<tr>
<td>Words Per Note</td>
<td>T1</td>
<td>125</td>
<td>22.16</td>
<td>13.52</td>
<td>2.00</td>
<td>82.72</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>128</td>
<td>23.31</td>
<td>37.49</td>
<td>2.00</td>
<td>419.00</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>253</td>
<td>22.74</td>
<td>28.26</td>
<td>2.00</td>
<td>419.00</td>
</tr>
</tbody>
</table>

*Note:* T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies
ANOVA results for the number of notes, total number of words in notes, and the average number of words per notes were computed for each participant in the two Web-based learning environment conditions. There was no significant difference in any of the variables (see Table 91).

<table>
<thead>
<tr>
<th>Variable</th>
<th>df.</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Notes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>1</td>
<td>35.06</td>
<td>.44</td>
<td>.508</td>
</tr>
<tr>
<td>Within groups</td>
<td>251</td>
<td>79.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number of Words in Notes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>1</td>
<td>102941.30</td>
<td>.92</td>
<td>.337</td>
</tr>
<tr>
<td>Within groups</td>
<td>251</td>
<td>111460.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Words Per Note</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between groups</td>
<td>1</td>
<td>84.40</td>
<td>.10</td>
<td>.746</td>
</tr>
<tr>
<td>Within groups</td>
<td>251</td>
<td>801.68</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Several participants said they liked being able to take notes “right next to the elements.” Participants in both the Web-based learning environment conditions said that note-taking helped them remember the information better. Several participants said they liked using the note-taking strategy in conjunction with the text-macrostructure strategy. Some participants liked how their notes relocated with the elements when they moved to elements to new sections. One participant compared taking notes in textbooks with taking notes in the Web-based learning environment. One other participant noted that the design of the note-taking strategy encouraged him to take notes for every “block of reading” (see Table 92).
Table 92. Feedback from Participants: Benefits of Using the Note-taking Strategy

Treatment Condition 1 (T1)

I liked being able to break the text up into sections and then being able to see my notes I took on the info.

I liked being able to divide information into categories and to take notes accordingly.

I enjoyed using the note-taking portion, because it enabled it to be right beside the information, while still allowing me to paraphrase. If this was in relation to one of my classes, I would have enjoyed it a lot.

The breaking the text into smaller pieces and note taking forced me to learn some of the material by repetition of reading and typing it.

The ability to take notes helped me remember many of the facts

I liked that it encouraged me to take notes after each block of reading. The notes really helped me to focus on the text and learn the material as I was reading.

I thought the notes part was really good, it makes you retype what you learned which helps you remember it better.

It is cool because usually I hate reading on the computer due to the fact that it is harder to note take and focus. I like that you could take notes on certain sections. Taking notes allows me to remember better.

I liked the innovative way of note taking.

I liked how I could type notes and read the information at the same time. Because it was on the same screen, I quickly absorbed the information and was able to type it while I was reading it. I was also more motivated to take notes while reading the text because I didn’t have to go through the trouble of opening a new screen or taking out a notebook.

Treatment Condition 2 (T2)

I liked the ability to put notes right in there. writing in textbooks is def. worse

[1 liked] How you could take notes on the pages that you were reading it was very convenient.

The note taking...was extremely useful

[1 liked] The ability to put notes right on the proper sections.

I enjoyed the note-taking features because it made it easier for me to remember the information

[1 liked] The ability to easily write down typed notes on the spot...

The only feature I used was the note-taking. I found that extremely helpful.

because I was forced to take notes that in the end I spend more time on trying to learn the material rather than just read it and be done with it

Yes, I spent more time because I was forced to take notes and to sit and actually go through everything.

...I think by slowing down and taking notes, I understood the information better.
Interestingly, none of the participants in the study gave negative feedback for the note-taking strategy.

Participants Perceived Usefulness of the Five Reading Strategies

Participants in the two Web-based learning environment conditions were asked to indicate on a 9-point Likert-type scale how useful they found each of the five reading strategies in the Web-based learning environment (see Figure 55).

<table>
<thead>
<tr>
<th>The following strategies are designed in the Learning Environment. Please tell us how useful you found each of these strategies.</th>
<th>No Response</th>
<th>Not at all Useful</th>
<th>Extremely Useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Breaking-up the text into smaller pieces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Note-taking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Preparing Summaries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Attaching Images</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Setting the Comfort-meter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 55. Feedback survey: How useful did participants find each of the five reading strategies in the Web-based learning environment.*

Responses from participants in the two Web-based learning environment conditions were ranked, the mean ranks are provided in Table 93.
Table 93. Descriptive Statistics: Perceived Usefulness of Reading Strategies

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Condition</th>
<th>N</th>
<th>Mean Rank</th>
<th>Mean Rank</th>
<th>Mean Rank</th>
<th>Mean Rank</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chunking</td>
<td>T1</td>
<td>202</td>
<td>164.10</td>
<td>5.90</td>
<td>2.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>137</td>
<td>178.70</td>
<td>6.23</td>
<td>2.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Note-taking</td>
<td>T1</td>
<td>202</td>
<td>157.10</td>
<td>5.17</td>
<td>2.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>141</td>
<td>193.34</td>
<td>6.12</td>
<td>2.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summarization</td>
<td>T1</td>
<td>200</td>
<td>164.56</td>
<td>4.06</td>
<td>2.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>137</td>
<td>175.49</td>
<td>4.34</td>
<td>2.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imagery</td>
<td>T1</td>
<td>203</td>
<td>174.88</td>
<td>4.48</td>
<td>2.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>137</td>
<td>164.01</td>
<td>4.15</td>
<td>2.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comfort-meter</td>
<td>T1</td>
<td>198</td>
<td>167.14</td>
<td>3.04</td>
<td>2.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>136</td>
<td>168.02</td>
<td>3.04</td>
<td>2.15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Kruskal Wallis test was performed to investigate differences in these ranks across the two Web-based learning environment conditions (see Table 94).

Table 94. Chi-square for the Perceived Usefulness of Reading Strategies

<table>
<thead>
<tr>
<th></th>
<th>Chunking</th>
<th>Note-taking</th>
<th>Summarization</th>
<th>Imagery</th>
<th>Comfort-meter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>1.850</td>
<td>11.266</td>
<td>1.042</td>
<td>1.017</td>
<td>.007</td>
</tr>
<tr>
<td>df.</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>.174</td>
<td>.001</td>
<td>.307</td>
<td>.313</td>
<td>.934</td>
</tr>
</tbody>
</table>

On average, responses from participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) indicate that they found the chunking, note-taking and summarization strategies less useful than participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2). The only strategy that this group found more useful was the imagery strategy.
In particular, the difference in perceived usefulness for the note-taking strategy was significant \((p = .001)\). Participants in T2 found this strategy much more useful than participants in T1.

A summary of participants’ feedback for the five reading strategies in the Web-based learning environment is provided in Table 95. This table shows how participants thought they benefited from the five reading strategies and what they did not like about the strategies.

Table 95. Summary of Feedback for the Five Reading Strategies in the Web-Base Learning Environment

<table>
<thead>
<tr>
<th>Reading strategy</th>
<th>Positive feedback</th>
<th>Negative feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text-macrostructure (chunking) strategy</td>
<td>Allowed participants to read and focus on one element at a time</td>
<td>“The breaking up of the text was fairly useless because it was already broken up.” (T1)</td>
</tr>
<tr>
<td></td>
<td>Being able to “manipulate” elements in the instructional unit allowed participants to reorganize it into a form that they were comfortable with. This made the reading task “less daunting.” It also helped participants focus and concentrate on the reading.</td>
<td>“I did not like the breaking up into pieces tool. I think it’s unnecessary. How many people read with scissors anyway?” (T1)</td>
</tr>
<tr>
<td></td>
<td>Ability to “customize” the instructional unit was motivating.</td>
<td>“The content should be organized ahead of time into tabs, I shouldn’t have to do it myself. It’s a waste of time.” (T2)</td>
</tr>
<tr>
<td>Summarization strategy</td>
<td>Forced participants to review their memory and understanding of the instructional unit: “Being able to write summaries allowed for me to understand or tie up the meanings behind certain sections.” (T1)</td>
<td>Several participants found summarization strategy to be redundant with the note-taking strategy: “I didn’t see the point of the summary. if you take good notes you don’t really need it.” (T1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A few participants found the summarization strategy to be redundant with the task of</td>
</tr>
</tbody>
</table>
choosing labels (text-macrostructure strategy): “I did not like having to right a summary—I felt that was doing the same thing as putting them into mini groups.” (T1)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Description</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imagery strategy</td>
<td>Allowed participants to “visualize” the instructional unit and complement their understanding</td>
<td>Many participants did not like the implementation of the imagery strategy in the Web-based learning environment:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• participants found image library to be inadequate, both in quality and in quantity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• participants wanted to upload their own images</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• participants wanted to upload more than one image</td>
</tr>
<tr>
<td>Comfort-meter (reading self-assessment) strategy</td>
<td>It helped some participants to identify which sections of the instructional unit they should focus more. “I like ... the comfort-meter so I know what I need to study more” (T1)</td>
<td>Several participants, mostly from Treatment 1 (T1), did not see the point of using the comfort-meter: “The comfort meter seemed kind of pointless to me.” (T1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some participants noted that the comfort-meter strategy would be helpful if they revisited the instructional unit to reread it</td>
</tr>
<tr>
<td>Note-taking strategy</td>
<td>Helped participants remember the information better.</td>
<td>None of the participants gave negative feedback for this strategy.</td>
</tr>
<tr>
<td></td>
<td>Participants liked how their notes relocated with the elements when they moved to elements to new sections.</td>
<td></td>
</tr>
</tbody>
</table>
Participants’ Experiences in the Web-Based Learning Environment

Research Question 5b: What was participants’ experience in the Web-based learning environment?

At the end of the study participants were asked to respond to a feedback survey. A section of this feedback survey included questions regarding participants’ use of the reading strategies and their experience in the Web-based learning environment. Participants’ responses to the following questions from this section of the feedback survey were analyzed.

Q. What features did you like in the Learning Environment?
Q. What did you not like about the Learning Environment? What would you like changed?
Q. Do you think you benefited from reading the Human Heart text in the Learning Environment?
Q. Do you think you spent more time reading the Human Heart text in the Learning Environment when compared with the time you would have spent reading the same text on a regular Web page or on paper? If yes, by how much? Do you think this extra time spent was beneficial?

Responses related to participants experience in the Web-based learning environment indicated that many participants enjoyed reading in the Web-based learning environment. Their responses also indicated that they realized they spent longer reading in the Web-based learning environment as compared to the time they would have spent reading the same text on a regular Web page or on paper; participants found this extra time to be beneficial.

Participants’ responses to the four feedback questions mentioned above are discussed under the following headers:

1. What did participants like in the Web-based learning environment?
2. What did participants not like in the Web-based learning environment?
3. Updates to the Web-based learning environment suggested by participants.
4. Did participants think they benefited from the Web-based learning environment and how?
5. What did participants think about the time they spent reading in the Web-based learning environment?

6. What was participants’ overall experience in the Web-based learning environment?

**What did Participants Like in the Web-Based Learning Environment?**

Overall participants seemed to have liked reading in the Web-based learning environment. Participants seemed to engage deeply with instructional unit on the human heart in the Web-based learning environment and they seemed to enjoy their reading experience. On average participants spent twice as much time reading the instructional unit on the human heart in the Web-based learning environment as compared to participants who read the same text on a regular Web page. Responses to the question “*What features did you like in the learning environment?*” that provide support for these findings are listed in Table 96.

Table 96. Feedback from Participants: Features of the Web-Based Learning Environment Liked by Participants

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The ability to be involved with the text.</td>
</tr>
<tr>
<td>Everything</td>
</tr>
<tr>
<td><em>I liked that we were able to break the material into segments and write our thoughts and be able to review the material. This would help in preparation for an exam.</em></td>
</tr>
<tr>
<td><em>I liked the easy function of breaking up the text, it allowed me to not only break down a huge supply of information, but it also aided me in highlighting and review the information I was not clear or satisfied with. The comfort meter, and images were great tools in that I am a visual learner, and when I see something I have a much easier time retaining the information if it is visually in my memory.</em></td>
</tr>
<tr>
<td><em>The involvement and entertainment to use such user-friendly items to read a long essay with the help of summarizing and setting the comfort meter. Moreover, I could also use the pictures to help me understand the concept of every detail about the heart movements.</em></td>
</tr>
</tbody>
</table>
new

I liked the different ways that it allowed you to learn the information and process it. It also gave everyone an opportunity to learn in their own way.

**Treatment Condition 2 (T2)**

Many options for all types of learners.

It was extremely helpful in guiding me in the direction that would best set me up for success.

The ability to learn in different ways

I liked the reading strategies.

I liked how you can customize the environment to the way you are comfortable learning.

I liked the strategies that were given and the technology provided to break up the texts into smaller pieces and taking notes and summaries on the important information.

5 strategies

Learning Environment was a very innovative tool to use.

I like how you do not have to use separate paper or word documents to take your notes and write your summaries. I feel like it keeps everything much more neat and organized.

pictures, being able to take notes on each section, color (etc.) could be added to the text when making notes, separating the information into easier to understand sections, splitting up the information and attaching a respective image to each section

quick and easy freedom to create own personal study plan

It can be fitted for many learning styles.

It was easy to use. I liked note taking. I liked how the notes you took were displayed under the actual text so I didn’t have to click anything to bring them up. I like the summary feature for the tabs I created. I liked that there were lots of images.

Some participants noted that they benefited from the Web-based learning environment because it let them customize the reading. This gave them a sense of control (see Table 97).
Table 97. Feedback from Participants: Ability to Customize the Text

**Treatment Condition 1 (T1)**

*I liked that you could choose how you wanted to read the essay.*

**Treatment Condition 2 (T2)**

*I think I comprehended the material a lot more by being able to change it.*

*It was much more interesting. The way the page was set up, I was in control of what material went where and in what order.*

*I think I spent less time because information was organized more and I was the one who controlled the organization so I knew right where to look.*

*I think I comprehended the material a lot more by being able to change it.*

*quick and easy freedom to create own personal study plan*

Several participants said that they liked how the Web-based learning environment could accommodate different learning styles (see Table 98).

Table 98. Feedback from Participants: Flexibility to Accommodate Different Learning Styles

**Treatment Condition 2 (T2)**

[I liked] *Many options for all types of learners*

[I liked] *The ability to learn in different ways*

[I liked] *It can be fitted for many learning styles*

[I liked] *I liked how you can customize the environment to the way you are comfortable learning*

Many participants found the experience of reading in the Web-based learning environment to be engaging. They felt that they were able to learn more because they were more
focused and engaged more deeply with the instructional unit. Many participants noted that they enjoyed this experience (see Table 99).

Table 99. Feedback from Participants: Participants Felt More Engaged and Focused More

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think reading in the learning environment, compared to a regular website, was very beneficial. It helped me focus on what I was reading and really think about it. I would have otherwise read it through but not really digested what was being said.</td>
</tr>
<tr>
<td>yes, with the learning environment I probably spent twice as much time because I read over each part I made a separate folder for more than once</td>
</tr>
<tr>
<td>Yes. I probably would have just skimmed the text or read it lazily, not really grasping what I said. Any time spent studying in a way that is better for me to learn is beneficial</td>
</tr>
<tr>
<td>I actually read the whole thing as opposed to “breezing” through it.</td>
</tr>
<tr>
<td>I would have had little motivation to read about the human heart before this study. I probably spent an hour more time reading about the human heart than I would have.</td>
</tr>
<tr>
<td>I think it was [time] well spent, and time I would not have devoted had I not had to do all the extra work involved.</td>
</tr>
<tr>
<td>[I liked] The ability to be involved with the text.</td>
</tr>
<tr>
<td>[I liked] The involvement and entertainment to use such user-friendly items to read a long essay with the help of summarizing and setting the comfort meter. Moreover, I could also use the pictures to help me understand the concept of every detail about the heart movements.</td>
</tr>
<tr>
<td>No. I would have gotten bored and gave up reading straight from the web. Also- the learning environment helped me retain more information, easier and faster.</td>
</tr>
<tr>
<td>I spent more time, only because I was really digesting the information, through breaking it down, and associating comfort, and making images and mental notes in my head. If I had to read this straight, I would probably have been checking my email and doing home work at the same time.</td>
</tr>
<tr>
<td>yes...it kept me involved by organizing so I had to read the entire text to see which category the element fit into</td>
</tr>
<tr>
<td>it made me focus more on what I was reading</td>
</tr>
<tr>
<td>I probably would have just skimmed the text or read it lazily, not really grasping what I said. Any time spent studying in a way that is better for me to learn is beneficial</td>
</tr>
<tr>
<td>...I took my time and focused more than I would have.</td>
</tr>
</tbody>
</table>
### Treatment Condition 2 (T2)

The same text on a regular web page or paper makes me not focus and not interact with the material, however with such fun applications I was able to understand the entire concept and learn a lot about the Human Heart.

Yes; with the enhanced features of the article (sections & tabular capability) I felt as though I had to complete a task along with the reading which motivated me to read further in depth with each section in order to properly categorize each section.

I would have normally speed through the reading on a normal web page and not understand half of what I was able to understand. The extra time was beneficial.

...if I hadn’t had the learning environment tool to break everything up and help me understand it in my own way, I would have spent extra time rereading the text to understand it or find something in the text.

I wasn’t overwhelmed and when I see huge pieces of text... most of the time I skip everything.

I frequently become bored by reading on a computer, but this kept me engaged into the reading.

I felt I spent more time because I made an effort to take extra notes and other study strategies like the picture and summaries that I normally do not.

Yes, because it was easier to focus and not just skim the information.

kept me more focused

I found that breaking it up into smaller sections made it much easier to concentrate of the material in front of me.

---

Several participants said they benefited from the Web-based learning environment because it forced them to reread and review their work (see Table 100).

### Table 100. Feedback from Participants: Rereading and Review

### Treatment Condition 1 (T1)

Working with the material through use of the notes and images made me reread the text and gain a better understanding.

It is less intimidating in the learning environment, and that probably prompted me to go back and reread more than I usually do.

Yes it is beneficial, made me look over the text over and over again so got more information memorized in my head.
Treatment Condition 2 (T2)

yes, the breaking down of the information took about 15-20 minutes longer than I would normally spend. However, I think it was worth it as my retention was much better than if I had simply read the text over once.

I reviewed the information more before moving on to the next part.

This was a survey that you could finish at your own pace. I liked that you could read about it and go over it about as many times as you felt needed.

A participant in Treatment 1 (T1) noted that even though there was a lot of information in the instructional unit, the Web-based learning environment helped him recall it when he needed to during the test, “although I was in over my head with the information regarding the Human Heart, I could use the learning environment to attempt to stimulate memories as I went through the test.”

Several participants appreciated the overall design of the Web-based learning environment. They found the interface to be user-friendly and intuitive (see Table 101).

Table 101. Feedback from Participants: Satisfaction with the User interface

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>involvement and entertainment to use such user-friendly items to read a long essay...</td>
</tr>
<tr>
<td>how things were easily organized</td>
</tr>
<tr>
<td>Everything was very easy to use</td>
</tr>
<tr>
<td>Well organized</td>
</tr>
<tr>
<td>easy program</td>
</tr>
<tr>
<td>easy to use</td>
</tr>
<tr>
<td>The ease of its use and how you could go back and look at what you had done to every section.</td>
</tr>
<tr>
<td>[I liked] How interactive it was.</td>
</tr>
<tr>
<td>[I liked] ... the way it is set up.</td>
</tr>
</tbody>
</table>
Treatment Condition 2 (T2)

I liked that you could take notes right on the information given. There was no need to open another tab to take notes.

I liked that it was very organized and easy to use.

Easy to use.

It was very straight-forward.

Some participants said that found the Web-based learning environment convenient and satisfying to use (see Table 102).

Table 102. Feedback from Participants: Satisfying Experience

Treatment Condition 1 (T1)

I think this learning environment made the reading a lot easier, quicker, and better organized.

I was more organized with this approach

Treatment Condition 2 (T2)

I liked how it was very interactive and you could customize your own way of studying.

...quick and easy freedom to create own personal study plan

I like how you do not have to use separate paper or word documents to take your notes and write your summaries. I feel like it keeps everything much more neat and organized.

What did Participants Not Like in the Web-Based Learning Environment?

Several participants noted features and experience in the Web-based learning environment that they did not like. Responses to the question “What did you not like about the learning environment? What would you like changed?” are summarized in Table 103.
Table 103. Feedback from Participants: Features of the Web-Based Learning Environment Not Liked by Participants

**Treatment Condition 1 (T1)**

I thought it was a lot of work like looking for the right picture and making tabs but I think it will help to learn more things on your own.

The summary basically consisted on me repeating my notes.

The summaries were a tedious part in addition to note-taking. Note-taking is more efficient.

It seemed like a lot of work when I could just read and remember things.

I didn’t like how much information was thrown at you at once, and I think this should be narrowed down to a more sizeable amount.

I would like to be able to access it after the study. I did not know you could not reference the text and I rushed through it and did not know any answers.

It is a lot of information to gather even reading and seeing everything, I still cannot remember all of the intricate details. It would take me days to understand that information and be able to perform well on it. Maybe have an interactive quiz before doing the test so we can test ourselves to see if we are ready for the test because come the test I mostly forgot most of the material.

There were some options I didn’t even feel like using because I felt it would just be more work to use the things then it will really help me.

I didn’t really see much of a point to the image attachment feature.

**Treatment Condition 2 (T2)**

I would change the requirement to attach summaries and other things to the study.

There was nothing that I didn’t like, but I don’t see myself using its features on an average day of studying. I think that the learning environment could be very beneficial, but I don’t think that people would take the time to complete all the tasks. If it were me, I would only break the text into the smaller features. People are generally too lazy because the readings take much longer when done this way. I also think that writing things out by hand, versus on a computer screen helps you to remember more.

I don’t think the image feature was very helpful or the comfort meter. I would have liked to have an idea of what kinds of questions I would be answering before I read the text to help me focus. I concentrated on definitions and the text more than the actual pictures and diagrams.

too structured

I’m terrible at summarizing so that was not useful to me at all, but I’m sure it helps others.
A participant in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) said that she found the tasks in the Web-based learning environment to be distracting and that she would prefer to read the instructional unit on paper “I have a hard time reading essays off the computer, and having to worry about side tasks that did not help me just added to distraction. I would prefer to have just done this via hard copy.”

Interestingly, several participants from both Web-based learning environment conditions gave a positive response to the negative question, “What did you not like about the learning environment? What would you like changed?” Many participants said they didn’t want anything changed in the Web-based learning environment, they liked it as is (see Table 104).

Table 104. Feedback from Participants: Positive Response to a Negative Question

**Treatment Condition 1 (T1)**

*There is nothing that needs to be changed.*

*Nothing that I can think of as of now.*

*I wouldn’t want anything changed*

*It was more than expected. I cannot think of ways to change it*

*I would not change anything about the learning environment.*

*There was not anything wrong with it, people can choose to use the tools or not, and that is good.*

*I think if I used it for a real class I might use it.*

*Nothing I wish classes were arranged like this to take notes.*

*I liked the learning environment, I think it is a great way to help people learn.*

*Honestly, there wasn’t much I didn’t like*

*I think that the learning environment is good as it is. I wouldn’t change anything about the learning environment.*

*I thought it was a useful Learning Environment which could really work.*
Treatment Condition 2 (T2)

I found nothing wrong with it.

I enjoyed everything

There was nothing in particular that I didn’t enjoy about the learning environment.

There was nothing that I didn’t like

I would not have changed anything.

There was not too much that you couldn’t like about the environment, except for the hot computer room we were in. There was nothing I didn’t like. It’s a great way to learn online.

it was perfect

Nothing really, enjoyed the environment in general.

I believe everything is good.

I actually enjoyed this a lot, and I have no complaints

I think everything was useful so there is nothing I would like to change.

A requirement to use the summarization, imagery and comfort-meter strategies for all the sections that participants created was added to the design of the Web-based learning environment at the end of Study 1 in Phase III (see discussion for Study 1 in Phase III). Several participants complained about this requirement; participants found the requirement to be unrealistic and overly restrictive (see Table 105).

Table 105. Feedback from Participants: Frustration with the Requirement that All Strategies be Used

Treatment Condition 1 (T1)

I didn’t like how I had to write a summary and rate my comfort level for each section in order to complete it. I had already taken notes and did not need to write another summary about the sections.

I did not like how you were required to write a summary, include an image, and select your comfort level with each set of texts.
I had to do every part (summary, image, and comfort meter)- Even for the tabs I created that had very little material in it. There should be a choice

That you had to make a summary and attach a picture before being “finished”

It wouldn’t let me leave an image or comfort level blank, I didn’t necessarily need those all the time.

summaries, pictures, and rating shouldn’t be mandatory

The fact that you had to complete a summary, add a picture, and do a comfort level in order to continue.

I didn’t necessarily feel the need to attach an image to the tab, but I had to in order to move on.

I didn’t like the fact that I had to worry the whole time about completing a comfort level, breaking up the sections into tabs, writing about it, and then picking an image from a database that didn’t allow me to visualize anything close to what I wrote about in the tabs.

The summary and comfort-meter features seem like over-kill. I’m not sure there is any need for them to be there and their presence is distracting since they are required. Perhaps it would be better if the environment didn’t prevent you from moving on until you’ve completed those.

I didn’t like the fact that I had to pick a picture for each tab I created. I felt that was unnecessary. Also, I felt the summaries were unnecessary for my purposes. Maybe the pictures and summaries should be optional. The comfort level indicator was also unnecessary. I can see how it would be helpful for the purposes of this study, but if this program were to be used for a class, the student should be cognizant of how much he/she knows from each section without having to rate his/her comfort level. On the other hand, if there was some way of tracking which sections of a text a given student had trouble with, it would be helpful for reviewing and studying purposes.

**Treatment Condition 2 (T2)**

You should not be REQUIRED to include a picture and comfort rating in order to move on.

Having to do each strategy was annoying. It would have been nice to have the option to do them all without having to do them all

I didn’t like that you were forced to write a summary, set a picture, and set a comfort level.

mandating that you pick a picture, make a summary, etc

I thought that having to complete the image, and comfort level before moving on was pointless

I did not like how we were required to attach a summary, image, and comfort meter to every tab that we created. I found this to be unnecessary, as I did not think back to any of these three items during any segment of the test. I think that it may have been helpful to have them as an option, but definitely not a requirement

I didn’t like that I had to assign a summary, image and comfort meter for each before going further in the task.

That you HAD to use all three parts (comfort level, image, and summary) if you made a section for the reading

I don’t like how it is mandatory to set the comfort level, write a summary, and attach an image. Sometimes you just don’t need all of that extra reinforcement.

I don’t like that I couldn’t continue without using all of the tools. Images don’t really help me learn and so picking them out to me was a waste of time.
I did not like how we had to have an image, summary and comfort level for each tab we had. I think it should be optional and I find it unnecessary unless you want it.

The purpose of the images didn’t seem that useful. I didn’t like that I had to select an image before finishing.

I didn’t like the fact that you had to complete all of the aspects (including a picture, writing a summary, etc.) because I would have just liked to do the note taking. If I hadn’t done the rest it would have been okay for me.

I didn’t like the fact that we were forced to use each individual aspect of the program before we could continue.

You HAD to do all of the learning styles to complete the assignment. If you don’t like summarizing, you shouldn’t have to, for example.

I think you should only use what features are best for you instead of not being able to continue until the summaries, images, and comfort meter were completed for each tab.

All five strategies being mandatory

the requirement for images is pretty pointless for me, as well as a comfort meter.

I also did not like having to complete a summary, choose an image, and select my comfort level for ALL chunks I created. Some chunks might not require these actions so users should be able to opt out of these items.

Updates to the Web-Based Learning Environment Suggested by Participants

Several participants suggested specific design changes to the Web-based learning environment (see Table 106).

Table 106. Feedback from Participants: Updates to the Web-Based Learning Environment Suggested by Participants

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would like to be able to cut and paste things better, in order to be able to use notes to make summaries. I think it would also be good to have a place to make a glossary.</td>
</tr>
<tr>
<td>I would like to have more interaction with checking on a word if unsure of the meaning</td>
</tr>
<tr>
<td>I would add the ability to attach more than one image to the different sections</td>
</tr>
<tr>
<td>...I would also like to see the tabs for the sections I created located on the left side, vertically down the page instead of at the top. It would also be nice to have a hover effect where if you were to put your mouse over the created section, you could see what you wrote as a summary.</td>
</tr>
</tbody>
</table>
I would like if at the end, it would create an outline with our sections, the summaries, pictures, and our notes in order, so we could review our reading all at once instead of going back to each section individually.

The ability to group “elements” should be customizable. Elements should be able to appear in more than one tab.

I didn’t know where to find my summary right away.

I didn’t like that after I divided the original text into different pieces I was unable to see the text in its original format.

Treatment Condition 2 (T2)

I would add a Hi-light feature where you could just select certain words and make them a different color to stand out more.

I would have liked to be able to move tabs within a tab.

...I might have added a highlighter tool.

I could not change the tab order.

I think the note taking should be easier. You should be able to highlight things and have it transfer to a “notesheet” below the text as opposed to having to open a new note and such. It would be really nice to be able to highlight something and have it stay highlighted in the text. not sure if that is even possible though.

That there wasn’t one overall summary.

I would have liked to be able to label each “element.”...sometimes I just needed a heading (besides element #) on it rather than putting it into a completely different section on another part of the program

I would have added a way to outline and highlight the material

I would like it to cater more to essays that are not as organized as the instructional unit on the human heart. It would be useful if you could import your own notes into the program and organize them and then if the program was able to make quizzes or flashcards based on the information you entered....Add a color coded highlighting feature.

I didn’t like how the bolding, bulleting or underlining of my notes never showed up after I finished writing the note.

---

Did Participants Think They Benefited from Reading in the Web-Based Learning Environment and How?

Participants in both Web-based learning environment conditions noted feedback which indicated that they felt they benefited from reading in the Web-based learning environment.
Responses to the question, “Do you think you benefited from reading the human heart text in the learning environment?” provide evidence (see Table 107).

Table 107. Feedback from Participants: Did Participants Think They Benefited from Reading in the Web-Based Learning Environment and How?

**Treatment Condition 1 (T1)**

*absolutely... I don't test well or remember information very well and I found this very easy to understand and remember.*

Yes, if I did not have to or read it here, I would not have read it what so ever, especially if it was just pages in a book.

*most definitely*

Yes, because although I was in over my head with the information regarding the Human Heart, I could use the learning environment to attempt to stimulate memories as I went through the test.

Yes, I actually know every function of the heart and its parts really well. I was not intending to actually retain so much information.

yes, It is my best experiences.

*Absolutely*

I definitely feel that I have benefited from this reading even though I may not have scored that well I feel I retained most of the information.

Yes definitely, glad I came!

I believe after taking these tests that if I made several tabs and read those, I would have done better. I didn’t trust the learning environment at first but then after failing this miserably, I wish I would of went back and made tabs and read the material over again.

*I feel like a smarter woman!*

I really did benefit from the learning environment, because being able to organize the information helped me to really understand what the text was trying to teach me.

I feel like I easily learned a lot about the heart, and had I tried to read this from a text, I would have gotten bored and stopped

Yes. It would have been easier to get distracted if reading in a text book.

Yes I do. I'm not good with the short term memory of titles and such so I wasn’t good at remembering them but I definitely learned about the process.

Yes, it was perfectly suited to the quizzes following the reading.
Yes, it probably made the text a little easier to read, and a little less intimidating the way it was divided up.

I developed an overall better sense of how my heart works. However, much of the detail I forgot as soon as I left the reading.

I think reading in the learning environment, compared to a regular website, was very beneficial. It helped me focus on what I was reading and really think about it. I would have otherwise read it through but not really digested what was being said.

Yes, I really enjoyed the learning environment.

I don’t think I liked it because it was a reading that took more than one sitting to understand it.

Technically, No. But I feel that this could possibly be a very good way to study and take notes. Obviously I didn’t score very well but if this was a legitimate class and this is how we would take notes I think kids would like this very much.

Yes, I actually learned a lot more than expected.

Treatment Condition 2 (T2)

Yes, I actually learned a lot more than expected.

Yeah, I learned more about the heart than I ever have before, I enjoyed the whole experience.

I now know more about the heart then I thought I would ever learn

yes, but for other classes I feel like it could be used a lot better

Yes, definitely. I would like all of my online classes to have this option.

Yes, I learned a lot more than I thought I could in such a short amount of time.

I probably wouldn’t have learned half of what I did if it was in another form.

Yes, if I had to read that from just a book I would of got bored and shut my brain off

The learning environment was good, but I have absolutely no interest in big words about the human heart

I think I comprehended the material a lot more by being able to change it.

Yes extremely

yes of course

Yes, greatly.

yes, easy to develop own plan

Yes, because it was easier to focus and not just skim the information.

Yes definitely kept me more focused

Yes although I was not very motivated to learn.
Yes because on a regular web page I would not have read as thoroughly and carefully as I did in the learning environment. I would have just skimmed a regular website or paper. I think the extra time is probably about a half hour to an hour but I think the time is beneficial because I understood what I was reading in the learning environment. It was easy to comprehend.

What did Participants Think About the Time They Spent Reading in the Web-Based Learning Environment?

Most participants thought that they spent much longer reading in the Web-based learning environment as compared to the time they would have spent reading same text on a regular Web page. They thought that this extra time was beneficial. Participants responses to the question, “Do you think you spent more time reading the human heart text in the learning environment when compared with the time you would have spent reading the same text on a regular Web page or on paper? If yes, by how much? Do you think this extra time spent was beneficial?” are summarized in Table 108. The primary reason cited for spending the extra time was that reading in the Web-based learning environment was a more engaging experience. Participants said that this extra time they spent helped them learn more.

Table 108. Feedback from Participants: Extra Time Spent Reading in the Web-Based Learning Environment was Beneficial

Treatment Condition 1 (T1)

I spent more time reading this than on a regular webpage or paper since I was trying to break all the paragraphs up into categories. I think this time spent was beneficial. Even if I didn’t ‘ace’ the test, I definitely did better than I would have if I were reading a website or paper.

Overall, Yes. The same text on a regular web page or paper makes me not focus and not interact with the material, however with such fun applications I was able to understand the entire concept and learn a lot about the Human Heart.

It took me a few more minutes to read the text in the learning environment, but I feel as though the extra time was very well spent. It helped me break down the text into smaller sections and allowed me to take notes on each section.
which helped me remember much more than I would have if I were just reading the text on paper.

Yes, I would never spend an hour reading a text book. (If I can sit down and read for half an hour it is quite an accomplishment). The interaction with the information and the extra time would definitely be helpful in a wide variety of subjects.

I spent about 30 minutes longer reading this text than I normally would read another text, which I think was definitely beneficial. I became interested in the text and retained a lot of information that I normally wouldn’t by reading a long text online.

I definitely spent more time learning about it. I would say 10x as much. This extra time was extremely beneficial.

Yes, probably twenty minutes more. I think this extra time was beneficial because it really made you look in-depth at the text.

Yes. Double. Yes, it was beneficial because it forces to you break apart the text and understand it better.

Yes, but it was beneficial time in that it really made me read the text closer in order to break into smaller parts, and think of what needed to go where.

Yes, by a long shot -- perhaps twenty minutes or more. This extra time along with note taking ability really helped me to understand the material.

Yes I did spend more time. Breaking up the information made it less boring and easier to reread. I’d probably read about 10 minutes more.

I spent more time, only because I was really digesting the information, through breaking it down, and associating comfort, and making images and mental notes in my head. if I had to read this straight, I would probably have been checking my email and doing home work at the same time.

Yes. By about 30 minutes more. Very beneficial

yes but the extra time spent categorizing it forced me to have a better understanding the subject material, whereas just reading it from paper I would have just kept going without reviewing the material

Yes, a lot of extra time, dividing everything and taking notes. It was beneficial.

Yes, probably by about half an hour. I wouldn’t want to spend that much extra time normally but it definitely helped me understand the material better.

Yes definitely, I was able to edit the text so it only featured the most important information. Therefore I did not get bored with an overwhelming amount of text. I do think the extra time was beneficial.

yes, I probably doubled or tripled the time but it was extremely beneficial

If I read text about the human heart on a regular web page it would have took me 15-20mins. In the learning environment, I read the text for about an hour.

yes, by about 20 minutes. it made me focus more on what I was reading

I definitely spent more time learning about it. I would say 10x as much. This extra time was extremely beneficial.

Yes. I would have had little motivation to read about the human heart before this study. I probably spent an hour more time reading about the human heart than I would have.

yes definitely, I probably spent an extra half an hour working with and reading over the material. Working with the
material through use of the notes and images made me reread the text and gain a better understanding

Definitely more time. The extra time helped me learn it better, I believe.

Yes, by about 20 minutes or so. Yes, this extra time was beneficial because I understood the text much better.

Yes. I actually read the whole thing as opposed to “breezing” through it.

I spent more time, more efficiently.

Yes, by at least 100% and yes I do think it was beneficial

I think I spend extra time in the learning environment compared to a webpage easily an hour more.

Treatment Condition 2 (T2)

Yes, probably by about 15 minutes. It took longer because I wasn’t just scanning the text. I was analyzing the text and taking it apart. I digested the material better that way.

I did take more time reading it, but it was very helpful and helped me understand it more.

I learned more during my time reading. It probably took the same amount of time, but I learned and retained more information.

Yes I would say 30 minutes more and it was extremely beneficial.

Yes definitely. If the text were just on a web page or paper I would have read through it pretty quickly then taken the text to get it over with. Doing the learning environment tools forced me to read the text carefully and actually absorb what I was reading.

I would have spent more time reading from a paper. The layout made it easier.

I spent about four times more on the instructional unit on the human heart, and the extra time spent was beneficial.

yes, possibly twice the time, but it was extremely beneficial

Yes, by a lot of time. I do think this extra time spent was beneficial because it helped me understand the text better.

Yes, by a significant amount. I would have normally speed through the reading on a normal web page and not understand half of what I was able to understand. The extra time was beneficial.

Yes because on a regular web page I would not have read as thoroughly and carefully as I did in the learning environment. I would have just skimmed a regular website or paper. I think the extra time is probably about a half hour to an hour but I think the time is beneficial because I understood what I was reading in the learning environment. It was easy to comprehend.

Yes, double the time. Yes the time spent to learn it was beneficial. This knowledge will stay with me for a long time.

Yes, but I think by slowing down and taking notes, I understood the information better. I’m not sure how much extra time I spent, but I believe it was very beneficial.

Yes by a lot and I do think it was beneficial.

Yes by probably twice as long, but again it was to ensure you knew the information.
Yes I do, and by a lot. I wouldn’t have concentrated as much on something that was on a regular webpage or on paper. I think that the extra time was beneficial.

Yes, I hate reading websites. They are so boring. The extra time was beneficial.

Absolutely. I would have briefly skimmed the web page, spending maybe 15 minutes doing so. The extra time was definitely beneficial.

I think I did spend more time reading the instructional unit on the human heart compared to other regular web page context, because it was set up/broken up to easily configure and obtain the information, whereas in the textbooks, it’s just paragraphs after paragraphs which can be boring and easily distractive. I can’t tell if the extra time spent was beneficial, considering the topic itself was very hard to understand, but it definitely did catch my full attention to actually read the information thoroughly.

Yes, by a significant amount. I would have normally speed through the reading on a normal web page and not understand half of what I was able to understand. The extra time was beneficial.

Yep, I don’t think I would’ve spent any time reading it online. I would’ve skimmed through and not absorbed anything. The learning environment required me to focus.

I think I spent about 8 minutes more reading in the learning environment, but this extra time was beneficial. I was able to retain the information much better than a regular article.

Interestingly, several participants noted that the Web-based learning environment actually made them learn more but in a shorter time (Table 109).

Table 109. Feedback from Participants: Spent Less Time Reading in the Web-Based Learning Environment, But Still Beneficial

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No, but it gave me better understanding in a shorter amount of time.</td>
</tr>
<tr>
<td>No, I would have gotten bored and gave up reading straight from the web. Also- the learning environment helped me retain more information, easier and faster.</td>
</tr>
<tr>
<td>No, I think this learning environment made the reading a lot easier, quicker, and better organized.</td>
</tr>
<tr>
<td>no I felt like I retained the information a lot quicker and easier</td>
</tr>
<tr>
<td>Less time, but more beneficial time, because I understood more.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Condition 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I learned more during my time reading. It probably took the same amount of time, but I learned and retained more</td>
</tr>
</tbody>
</table>
I would have spent more time reading from a paper. The layout made it easier.

No I felt the content was smaller than it would have been.

No I feel as if it would have been similar time but I understood it better.

No, I felt that I was able to better retain the information in this than I would have with any other text.

Participants’ Overall Experience in the Web-Based Learning Environment

Participants in the two Web-based learning environment conditions were asked to respond to the following question, “How would you rate your overall experience in the learning environment?” The Web-based learning environment condition * experience in the Web-based learning environment cross tabulation is shown in Table 110.

Table 110. Web-Based Learning Environment Condition * Experience in the Web-Based Learning Environment Cross Tabulation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Experience in the Web-based Learning Environment</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>T1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>174</td>
<td>37</td>
</tr>
<tr>
<td>Expected Count</td>
<td>182.9</td>
<td>28.1</td>
</tr>
<tr>
<td>% within condition</td>
<td>82.5%</td>
<td>17.5%</td>
</tr>
<tr>
<td><strong>T2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>132</td>
<td>10</td>
</tr>
<tr>
<td>Expected Count</td>
<td>123.1</td>
<td>18.9</td>
</tr>
<tr>
<td>% within condition</td>
<td>93.0%</td>
<td>7.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>306</td>
<td>47</td>
</tr>
<tr>
<td>Expected Count</td>
<td>306.0</td>
<td>47.0</td>
</tr>
<tr>
<td>% within condition</td>
<td>86.7%</td>
<td>13.3%</td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies*
Histograms for the distribution of responses for the two Web-based learning environment groups are presented in Figure 56.

*Figure 56. Experience in the Web-based learning environment: Distribution of responses for the two Web-based learning environment groups (T1 and T2).*

Overall 87% of the participants had a favorable experience of the Web-based learning environment. There was a significant difference between participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) and participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2). While 93% of the participants in T2 voted favorably, only 83% of the participants in T1 did so. These differences in distribution across the two conditions Web-based learning environment conditions were
statistically significant \[\chi^2 (1, N = 353) = 8.097, p = .004\]. This data indicates that the seemingly subtle difference in the two Web-based learning environment conditions led to significant difference in the participants’ experience in the Web-based learning environment.

Participants in the two Web-based learning environment conditions were also asked to respond to the following question, “Would you like to use this Learning Environment to read papers for courses that you will be taking next semester?” The cross tabulation of responses for the two Web-based learning environment groups is presented in Table 111.

### Table 111. Web-Based Learning Environment Condition * Would You Like to Use the Web-Based Learning Environment Next Semester? Cross Tabulation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Would you like to use the Web-based learning environment next semester?</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>T1</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>157</td>
<td>53</td>
</tr>
<tr>
<td>Expected Count</td>
<td>169.3</td>
<td>40.7</td>
</tr>
<tr>
<td>% within condition</td>
<td>74.8%</td>
<td>25.2%</td>
</tr>
<tr>
<td><strong>T2</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>126</td>
<td>15</td>
</tr>
<tr>
<td>Expected Count</td>
<td>113.7</td>
<td>27.3</td>
</tr>
<tr>
<td>% within condition</td>
<td>89.4%</td>
<td>10.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Count</td>
<td>283</td>
<td>68</td>
</tr>
<tr>
<td>Expected Count</td>
<td>283.0</td>
<td>68.0</td>
</tr>
<tr>
<td>% of Total</td>
<td>80.6%</td>
<td>19.4%</td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies*

Histograms for the distribution of responses for the two Web-based learning environment groups are presented in Figure 57.
Overall 81% of the participants said that they would like to read papers for courses that they would be taking the following semester in the Web-based learning environment. There was a significant difference between participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) and participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2). While 89% of the participants T2 voted favorably, only 75% of the participants in T1 did so. These differences in distribution across the two conditions Web-based learning environment conditions were statistically significant $[\chi^2 (1, N = 351) = 13.880, p = .000]$. This data once again indicates that the seemingly subtle difference in
the two Web-based learning environment conditions lead to significant difference in the participants’ experience of the Web-based learning environment.

Many participants from both Web-based learning environment groups were enthusiastic about the prospect of using the Web-based learning environment in future. Representative responses are presented in Table 112.

Table 112. Feedback from Participants: Positive Experience in the Web-Based Learning Environment

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This would be helpful in one of my courses.</td>
</tr>
<tr>
<td>I believe that this was a worthwhile study and will help online classes.</td>
</tr>
<tr>
<td>It was organized well. I like seeing the new learning environment. This is something that could definitely help me reading in the future.</td>
</tr>
<tr>
<td>I found this to be very helpful and I hope to see this learning environment in some of my classes in the future.</td>
</tr>
<tr>
<td>I really feel that I learned a lot about the human heart, and I hope that the university starts using this system as soon as possible.</td>
</tr>
<tr>
<td>I think that this is a very innovative way of learning and I would like to use it one day.</td>
</tr>
<tr>
<td>I think that this program should be used as an option for every student to use if they would like, but should not be required for students to use.</td>
</tr>
<tr>
<td>I think the learning environment can be influential.</td>
</tr>
<tr>
<td>I think this program is great. I hope I will have the opportunity to use it in my future classes.</td>
</tr>
<tr>
<td>I would enjoy taking a course that incorporated the elements present in the research study.</td>
</tr>
<tr>
<td>It was a good experience and I think reading texts in this format may be helpful for some students who may struggle learning just by reading a textbook.</td>
</tr>
<tr>
<td>This is a very good idea and I would really like to see it put into use in my future classes.</td>
</tr>
<tr>
<td>enjoying using a new system of education</td>
</tr>
<tr>
<td>I liked the experience, first time, so it was difficult to figure out how to do the summaries and rating the material. I have problems reading from the computer, I really think that this would be a great tool to use for classes. I tend to write the notes over and it would be great to type them on the computer and have them as a study guide.</td>
</tr>
<tr>
<td>thank you</td>
</tr>
</tbody>
</table>
I think this form of note taking could become a pretty good thing.

good stuff. excellent way of reading. I wish they would incorporate this sooner for my classes

the breaking down the text is a good idea, especially for classes at school. I feel that it would be a great tool in learning the material for tests and easy reference to go back to. Also I think that students are lazy and wouldn’t want to do that either. but overall I feel that the breaking down text is a great idea for the future.

Treatment Condition 2 (T2)

I actually did like the learning environment and would appreciate the use of it in future classes. I have taken MATSE 081 as well as the EGEE class that I am currently in, and both have a great amount of reading. The learning environment would surely assist me in the hardships of studying.

I really like the learning environment that was used to read the text. I would love to be able to chuck the sections, take notes, writes summaries, and add pictures to text that I have to read online with my classes because this helped me understand the information better.

I enjoyed the learning environment study, and would hope this is implemented in the classes soon

I learned a lot about this technology and I want to have it for some of my other classes. Although it makes me worry that professors will try to use this program in place of teaching....I think that this should be a learning tool, but NOT a teaching tool. Then again I don’t think it would have to be limited for use with only online classes.

I like this method of studying and hope it gets put in for online assignments or classes.

I think this is a very helpful way of critically reading texts and I would definitely like to use this method in the future.

I thought this was an interesting way to approach learning. I think that this program would definitely be a benefit to students who have numerous amounts of online reading to do. I would rather be able to read like this than to read an actual book that I can highlight.

I was able to learn new things that I would not have previously taken the time to study, and I am happy that I was able to become acquainted with, as well as help refine a tool that maybe used in future classes.

I would like to see this application for some of my classes I am taking now. I would definitely use this in the future.

It is alright. I hope to see more teachers using this learning environment because I think it could help me in the future with my classes.

interesting in the sense that this may be the future of education

I would like all of my online classes to have this option.

I think I did benefit somewhat, though I’m not very intrigued with the topic and it’s not something that I find interesting in, however if there was a course with a more interesting subject matter, I think this Learning Environment design could be very helpful

although it took a really long time to complete and was extremely dense information, I can definitely see myself benefiting from this in one of my classes...not even necessarily a science class.
Participants’ Experience with the Web-Based Human Heart Tests

Research Question 5: What was participants’ experience with the Web-based human heart tests?

Participants in all three experimental conditions were asked to respond to the following question, “Rate your overall experience of the tests that you just completed.” The condition by experience in the Web-based learning environment cross tabulation is presented in Table 113.

Table 113. Web-Based Learning Environment Condition * Experience with the Web-Based Human Heart Tests Cross Tabulation

<table>
<thead>
<tr>
<th>Condition</th>
<th>Experience with the Web-based human heart tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
</tr>
<tr>
<td>Control</td>
<td>179</td>
</tr>
<tr>
<td>Expected</td>
<td>165.7</td>
</tr>
<tr>
<td>% within condition</td>
<td>88.6%</td>
</tr>
<tr>
<td>T1</td>
<td>139</td>
</tr>
<tr>
<td>Expected</td>
<td>155.8</td>
</tr>
<tr>
<td>% within condition</td>
<td>73.2%</td>
</tr>
<tr>
<td>T2</td>
<td>129</td>
</tr>
<tr>
<td>Expected</td>
<td>125.5</td>
</tr>
<tr>
<td>% within condition</td>
<td>84.3%</td>
</tr>
<tr>
<td>Total</td>
<td>447</td>
</tr>
<tr>
<td>Expected</td>
<td>447.0</td>
</tr>
<tr>
<td>% of Total</td>
<td>82.0%</td>
</tr>
</tbody>
</table>

Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies

Histograms for the distribution of responses for the three experimental conditions are presented in Figure 58.
Overall, 82% of the participants found the overall experience of responding to the human heart tests to be favorable. Furthermore, there was a significant difference in the overall experience of the heart tests. Participants in the control group and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) rated their experience to be more positive (88.6%, 84.3% respectively) than participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) (73.2%). This might be because participants in T1 felt that the time that they spent reading in the Web-based learning environment did not prepare them
for the post-tests. These differences in distribution across the three experimental conditions were statistically significant \( \chi^2 (2, N = 545) = 16.619, p = .000 \).

**Overall Experience with the Web-Based Human Heart Tests**

Participants in the Phase IV study were also asked to respond to the following open-ended question, “Briefly note down any comments that you may have regarding your experience with the tests. For example, what you liked and did not like about them.” On the whole participants seemed to have a positive experience of the Web-based human heart tests. Several participants noted that the tests were comprehensive and they thoroughly tested their understanding of the instructional text. Many participants commented positively about the interactivity and variety of the questions in the tests. Participants found many of the question types to be different from questions that they commonly responded to in their courses. In fact, one participant found the questions to be too unusual “I don’t think the questions were realistic of actual course questions that would be asked on an exam.” Responses representative of participants overall experience with the human heart tests are listed in Table 114.

Table 114. Feedback from Participants: Overall Experience of the Web-Based Human Heart Tests

<table>
<thead>
<tr>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tests were very straightforward and I liked that we were asked questions in a variety of ways as opposed to just multiple choice or essay. There was a mix of everything and I very much liked that because it made the test more enjoyable and easier to focus on since it was broken down into smaller sections rather than just one big 50 minute test.</td>
</tr>
<tr>
<td>I hope the study helps to create tests that are fair for other subjects.</td>
</tr>
<tr>
<td>Creative way to test students.</td>
</tr>
</tbody>
</table>
I really liked how this test was set up. I had the reading. I had the opportunity to take notes on what I thought was important, then take the test...I also give kudos to the quiz/test maker. The questions were not extremely hard or easy. They made you think about what you read, and tested you to see if you knew the material inside and out.

The test really helped me in an interactive way learn about the human heart in a way I never have before. Coming into this I had little education about the heart and its many functions and now I can say I learned something. The tests were helpful, clear, and fun to participate in.

Treatment Condition 1 (T1)

I thought the tests were set up very well, and they fairly gauged the knowledge I gained from reading the text. I didn’t spend as much time reading the text as I would have if it were for a class, but I still gained a lot from it and the tests made me realize this.

I thought they were excellent tests. The first few were simple, quick identifications. But the last few really took some thought. For a class I would much prefer all easy questions, but this test made me think.

It was hard information but it really tested your knowledge.

I enjoyed the interactive nature of the tests. It was a nice change to all of the typical exam questions I am used to completing.

I really liked how everything was broken down, and I liked the different sorts of testing methods. most tests are only one, and I enjoyed that this had various types, because I know some people are better at answering certain types of questions in different formats. I like that this mixed it up and gave me a chance to test myself in other methods than multiple choice like standard tests.

I liked the tests because not only were they much more interactive than a multiple choice test, but they also tested different kinds of learning methods. I liked how there were many visuals and pictures which are rarely, if ever used on exams administered at PSU.

I hope this type of course review is available for online courses in the future.

I liked the different styles of questions. Most of them were not just the standard multiple choice questions. I liked the questions with diagrams and the automatic word finishing on the first diagram helped a lot.

It was a good way to test all around skills and comprehension of the reading instead of the generic multiple choice and short answer questions.

Treatment Condition 2 (T2)

I liked everything. It gave me a full test on everything I had read.

I liked how it was broken down into different types of questions and included interactive questions (dragging, ordering, pictures).

I think that this activity was a very good way to test our knowledge of the human heart. Being able to dissect the instructional unit on the human heart using the learning environment tools enabled me to pull key facts and ideas out of the text that I would remember easily. The tests were fairly simple if you read the text carefully and paid attention to the different functions and parts of the heart. Overall, it was very effective and I don’t think that you would need to change anything. It was very informative and presented in an understandable manner.
I liked the variety in the structure of the questions.
I also liked that it was not just one test form and we were asked questions in many different ways.
I liked the vast variety of questions, it was fun to answer questions when it was interactive.
I thought it was a very useful test that tested your knowledge fairly.

Feedback from several participants indicated that they enjoyed the overall experience of responding to the test questions (see Table 115).

Table 115. Feedback from Participants: Overall Experience of Responding to Questions in the Web-Based Human Heart Tests was Enjoyable

**Control Group**

The first part was enjoyable albeit a bit of a time crunch. It was a good brain teaser and this essay was intriguing in that it clearly measured information retention in different ways. It was a good run of surveys and enjoyable not only because of the ending extra-credit bonus.

Enjoyed it very much. I enjoy thinking outside the box and testing my memory skills.

I loved it. Awesome!

**Treatment Condition 2 (T2)**

I really enjoyed all of the tests. Although a lot of the material was the same and a few questions were difficult to understand (not necessarily the way they were worded, but just the material presented. For example, about the contractions) I really enjoyed the questions and the interactivity of the entire experience.

The test were not as bad as I thought, they were actually fun and interesting.

I liked the fact that there were different kinds of tests, they were fun...like putting the 20 words into bins, ordering the sentences, and the drop down boxes.

One participant from Treatment 1 (T1) appreciated the use of “new” technology in the design of the tests “I enjoyed the tests because it showed me a new technology while teaching me about something I didn’t know too much about.”
Web-Based Human Heart Tests Reinforced Memory and Understanding of the Instructional Unit on the Human Heart

Some participants suggested that the tests reinforced their memory and understanding of the instructional unit. Many participants found the “repetitive” nature of the tests to be helpful (see Table 116).

Table 116. Feedback from Participants: Web-Based Human Heart Tests Reinforced Learning

<table>
<thead>
<tr>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>I liked the repetitive testing because I felt that I more solidly learned the information this way.</td>
</tr>
<tr>
<td>I liked it, I feel like you could gain a lot of information about how different testing styles affect people’s answers. I do, however, think that as I went on I reinforced the knowledge in my head.</td>
</tr>
<tr>
<td>The test really helped me to understand and visualize everything that was mentioned in the essay. The tests went along with it extremely well...</td>
</tr>
<tr>
<td>I liked how the questions were repetitive to help drill it in your brain. With the essay I liked the picture next to the text so I could relate it visually instead of just seeing a bunch of words. Overall very effective.</td>
</tr>
<tr>
<td>I thought the test questions were relevant, but they also helped reinforce the knowledge. I feel pretty good about my performance and look forward to seeing how I did. The labeling was interesting and I liked the auto-fill, but that only encourages people to memorize initials and not the whole name.</td>
</tr>
<tr>
<td>I liked the repetitive testing because I felt that I more solidly learned the information this way.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I liked how you were tested on the material after reading, it helped to re-iterate major points and to help remember key topics and points...</td>
</tr>
<tr>
<td>The test really helped me to understand and visualize everything that was mentioned in the essay</td>
</tr>
<tr>
<td>I enjoyed it and it helped stick info in my head.</td>
</tr>
<tr>
<td>The questions were challenging at some parts but it also helped me very much to retain the information that I learned.</td>
</tr>
<tr>
<td>The tests were nice and thorough, and they made me feel I really knew what I was talking about. Sometimes it felt like I was being asked the same questions quite a few times, but I guess that is alright.</td>
</tr>
</tbody>
</table>
Treatment Condition 2 (T2)

The tests were an excellent way of reinforcing the information I read about. I strongly believe that reciting information is a key part of learning it.

Interestingly, some participants did not like the repetitiveness of the questions because it made them “second guess” their learning. One participant noted “but I did not like how the questions were repeated, it made me second guess what I knew as true.” Another participant said she got confused by the repetitiveness in the tests “I learned a lot just by reading the text, but I started to get myself confused after seeing the same questions over and over again. I could almost feel my memory fading as I was taking the different tests.”

Feedback Related to Specific Types of Questions in the Web-Based Human Heart Tests

1. Implementation of the autocomplete design pattern used in the micro-textbase test.

Participants provided feedback on specific types of questions. Some of them commented on the implementation of the autocomplete design pattern as an alternative to multiple choice questions. Several participants said that this helped them respond to questions for which they “knew” the answer “but didn’t quite remember it.” Several participants noted that this was a fairer way of testing knowledge of content that they were learning for the first time and for which they had no prior-knowledge. Many participants seemed to enjoy responding to these questions (see Table 117).
Table 117. Feedback from Participants: Implementation of the Autocomplete Design Pattern

**Control Group**

I liked how when you started to type a word it showed the possible answers this really helped for when I knew what it was but couldn’t quite remember the name.

I liked the fill in feature, because even if I knew roughly what the word was, I wouldn’t have been able to write it correctly without that, especially by just cramming information like these tests were making you do.

I liked the different types of tests. I feel that the word generator [autocomplete] was helpful for the fill-in-the-blank questions because without having the text in front of you, it is difficult to remember how to spell the entire word correctly. There was a lot of text so it was hard to remember every little specific detail, especially when having no prior-knowledge about the function and regulation of the human heart. Overall, this was a positive learning experience.

I like how the test had a drop down on the fill in the blanks. Students get frustrated when there is a blank space and they are forced to fill in a word. This gave the learner options without giving the answer away to test their knowledge.

I liked how in the one section, if you had an idea of the answer, there were several answers to choose from. When remembering information for a brief section of time, it is difficult to remember exact details. With that feature, it really measures how well one remembers the information.

**Treatment Condition 1 (T1)**

I really liked the “suggested answer” section more than a traditional fill-in-the-blank question.

Some of the answers I knew right away, but for those I did not, the questions where you had to type out an answer were not helpful. Granted, the system filled in a word for you, but if you had no idea, there was no real way to make an educated guess. I would have preferred all the questions to be multiple choice.

I liked the multiple choice. Being required to know the first letter ensures knowledge of the material, and at the same time makes it easier for the student to answer questions without misspelling.

I liked how when you started to type a word it showed the possible answers this really helped for when I knew what it was but couldn’t quite remember the name.

I didn’t like how some of them were fill in the blank instead of multiple choice. It was hard to think of the answers on the spot, since there were so many terms.

They were pretty good, there wasn’t really anything I didn’t like about them. I really liked the “suggested answer” section more than a traditional fill-in-the-blank question.

I liked that it brought the responses into the window- with such difficult material, the exact spelling of terms can be difficult...

...I also liked that once you started typing in an answer, the computer filled in the rest for you. I thought this was good because some people are not good at spelling or others at typing, and I don’t think it’s necessarily fair for them to get the answer wrong because of one of those two issues.
Treatment Condition 2 (T2)

I really liked the auto complete option and the way the questions were asked. I also liked that it was not just one test form and we were asked questions in many different ways.

I liked how when I started typing something it came up. This makes it like a smarter version of multiple choice.

I like the open answers how when you started typing it gave you a list of the words used that started with that letter. I didn’t have to memorize how to spell it in order to get it right.

The fill in the blanks are always much harder than the multiple choice, however I did like that when you typed in the first letter it gave only correct possible responses instead of a bunch of words that could be incorrect.

I liked that fact that words would pop up in the blanks. Being a bad speller, I often know the answer but am unable to spell it to get the answer correct.

I liked the auto fill feature, particularly while the spellings of the words would be a bit challenging after the first read.

I like that when you began to type a word, it would pop up below... fun stuff

One participant in T1 noted that he preferred the multiple-choice format over the autocomplete format, “Prefer multiple choice. Find recognition easier than recall.”

2. Dissatisfaction with questions on the macro-textbase test.

Several participants noted their dissatisfaction with questions in the macro-textbase instrument (see Table 118).

Table 118. Feedback from Participants: Dissatisfaction With Questions in the Macro-Textbase Test

Control Group

However, I don’t think that putting the sentences in order or knowing exactly which sentences were in the text really tested the knowledge of the heart we go from the text.

I did not like the rearrange the sentence portion of the tests. I found that I got confused and flustered and could not complete them with any confidence.

I feel that the rearranging tests didn’t test knowledge of material, simply recollection.
... but I did not like the test where you had to place the sentences in order because it was tricky and somewhat confusing.

...What I didn’t like was the drag and drop system, I don’t see why it is important as to which sentence came first in the essay and what-not.

...However, I don’t think that putting the sentences in order or knowing exactly which sentences were in the text really tested the knowledge of the heart we go from the text.

Overall the tests were difficult. I liked the variety of ways that the tests tested you on for example the bin exercise and the organizing of phrases exercise.

Treatment Condition 1 (T1)

...I didn’t think the questions where you put the sentences in order really tested competence of the subject though.

Some of the questions were pointless (order how you saw these statements)

I have never been able to regurgitate phrases word for word, so the section on whether the sentence had appeared before or the when did not adequately represent the knowledge I had acquired.

I didn’t like having to place the sentences in order as I learned them in the text because I didn’t feel that was needed to accurately determine how much I learned. What I learned was not necessarily placed in specific order of which order they were in the text.

I think they were pretty good, except I feel that making us list the order in which certain phrases appear is pretty irrelevant.

Treatment Condition 2 (T2)

The order that the sentences came in was a joke of a question. You shouldn’t grade someone off of the order that they read information, only the subject matter.

I didn’t like the part where you had to remember the order it was written in the text.

I didn’t like the test that made you say if the sentence was in the text or not.

...I didn’t like the idea that you had to know the exact location of a certain phrase in relation to all the others though.

Interestingly one participant from Treatment 2 (T2) noted that she found these questions beneficial, “...I also liked re-organizing sentences to match the progress of the text. It made me revisit the text in my head.” One participant from Treatment 1 (T1) noted, “I liked putting the sentences in order in which they were shown.”
3. *Sort-in-bins question from the macro-situation model test.*

Some participants liked the “sort-in-bins” question in the macro-situation model instrument. They found this question to be a “creative” way of testing their knowledge (see Table 119).

**Table 119. Feedback from Participants: Sort-in-Bins Question in the Macro-Situation Model Test**

**Control Group**

...Specifically, I really enjoyed the section where you had to label the bins. That was a different yet creative approach to test the understanding of material.

**Treatment Condition 1 (T1)**

*I did not like the trash can one.*

Overall the tests were difficult. I liked the variety of ways that the tests tested you on for example the bin exercise and the organizing of phrases exercise.

**Treatment Condition 2 (T2)**

*I liked the trash bin idea...*

...I did not like the bin exercise because I felt that since all of the words were a portion of a process, they didn’t fall well into separate categories. It didn’t feel like sorting them was increasing my understanding, I was just trying to make a trivial ordering of them.

Some of the questions were a little confusing. The format of some of the questions were a little weird; the bins and the drag and drop ones, for example.

One participant did not like this question specifically, “*I thought the only bad part about the tests was the question about putting the words into ‘bins,’ which I found a bit too open ended.*” One other participant suggested an interesting modification to the question, “*The classifying of heart parts into bins was busy work. It would be better to have the bin titles given and to sort the words.*”
4. “Submarine” question from the macro-situation model test.

A few participants provided feedback regarding the “submarine” question in the macro-situation model instrument (see Table 120).

Table 120. Feedback from Participants: “Submarine” Question in the Macro-Situation Model Test

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tests themselves, while difficult, were meant to test how much someone has learned. I very much thought that putting the steps of the human heart in order was very beneficial.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Condition 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I liked ...as well as putting myself inside the body and ordering the sentences to show what parts of the heart I would be going through.</td>
</tr>
</tbody>
</table>

Effectiveness of the Web-Based Human Heart Tests in Measuring Knowledge of the Instructional Unit on the Human Heart

Participants in all three experimental conditions in the Phase IV study were asked to respond to a 9-point Likert-type question about the effectiveness of the Web-based human heart tests in measuring knowledge about the instructional text on the human heart (see Figure 59).

Figure 59. Feedback question regarding the effectiveness of the Web-based human heart tests in measuring knowledge of the instructional text on the human heart.
Responses from participants were ranked. The mean ranks (by condition) are shown in Table 121.

Table 121. Effectiveness of Web-Based Human Heart Tests: Rankings Across the Three Experimental Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>N</th>
<th>Mean Rank</th>
<th>Mean</th>
<th>Std. deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>210</td>
<td>295.65</td>
<td>6.17</td>
<td>2.08</td>
</tr>
<tr>
<td>T1</td>
<td>211</td>
<td>292.85</td>
<td>6.10</td>
<td>2.18</td>
</tr>
<tr>
<td>T2</td>
<td>172</td>
<td>303.74</td>
<td>6.32</td>
<td>1.86</td>
</tr>
</tbody>
</table>

*Note: T1: Web-based learning environment + demonstration without explicit instruction on reading strategies; T2: Web-based learning environment + demonstration with explicit instruction on reading strategies*

The Kruskal Wallis test was performed to determine any differences across the three conditions. The difference in distribution across the three conditions were not statistically significant \[\chi^2 (2, N = 593) = 0.414, p = .813\], yet it is interesting to note that the trend in the perceived effectiveness rankings mirror the trend in performance on the Web-based human heart tests.

Most of the participants found the tests to be effective. Several students noted that the tests were appropriate and aligned well with the instructional unit on the human heart (see Table 122).

Table 122. Feedback from Participants: Alignment of Questions in the Web-Based Human Heart Tests with the Human Heart Instructional Unit

Control Group

*I felt this test was very effective in telling someone how much they know about the heart and it was also very beneficial with the information one gains from participating in this, overall it was a very good test.*

*I thought that I learned a great deal about the heart through the texts and complimentary images. The tests were a good way of testing my knowledge of the information that I had just read.*
The text was very thorough and emphasized the main points throughout. The questions reflected the text very well.

I felt it was effective in teaching me about the heart and then testing the knowledge I learned.

Extremely well down tests for the essay we were given.

I enjoyed this reading thoroughly. Even though this is not a topic which would necessarily interest me, I found the reading and testing to correlate nicely and I learned an abundance of new information as well.

I wish for identifying the heart there was a box with choices because it was hard to think of the names of the heart after just reading such a large amount of text. But I think the test accurately tested my knowledge, even though I am not very knowledgeable on this topic.

I believed that this did a very good job of accurately explaining what we were supposed to know, and then measuring how well we knew it.

I know I didn’t do very well on the tests, but I still think they were an accurate measure of my knowledge.

I felt that this was a fair test after reading all the information. The test was taken directly from the lesson and the lessons were delivered in a manner that was easily understandable.

Treatment Condition 1 (T1)

Yes, it was perfectly suited to the quizzes following the reading.

I thought the tests were set up very well, and they fairly gauged the knowledge I gained from reading the text. I didn’t spend as much time reading the text as I would have if it were for a class, but I still gained a lot from it and the tests made me realize this.

Treatment Condition 2 (T2)

I thought labeling the heart was very tough, but other than that the text covered pretty much all of the questions.

Did the Web-Based Human Heart Tests Measure Different Types of Knowledge? What were Participants’ Perceptions?

One of the goals of this study was to develop measurement instruments that measured reader’s memory and understanding of instructional unit on the human heart at four levels—micro-textbase, macro-textbase, micro-situation model, macro-situation model. Feedback
indicating that participants, in fact, perceived that the tests measured different constructs is noted in Table 123.

Table 123. Feedback from Participants: Differences in the Four Human Heart Tests

**Control Group**

I liked that the easier questions were asked before the more difficult questions because that was a true test as to whether I was able to retain the more complex details.

I found that the tests towards the end were very difficult because if I had just memorized the facts from the essay as opposed to actually learning them I would have been unable to answer the questions. If the essay were broken up into shorter lessons I might have been able to learn the information better.

I did not like the first couple of tests about the terms. The terms of the heart were very difficult to memorize as I was reading. Instead of memorizing the terms, I basically created a mental image in my head about what was going on throughout the steps and phases and parts of the heart.

I felt the tests were very fair in trying to gauge the amount of knowledge gained through the reading. I liked the fact that it asked the same questions in different ways, instead of the same boring multiple choice format. Overall I felt they were great.

Very interesting way to get excited about the parts and functions of the human heart. Kept me very interested with the different quizzing methods, my favorite being the place the sentences in order section. Kept me thinking outside of the box and utilizing multiple memory skills. I feel I know a lot about the heart now and will never forget this information, which is very good to know. Glad I did this study!

**Treatment Condition 1 (T1)**

They were divided well.

I liked how some were on facts and how some made you think

I thought they were excellent tests. The first few were simple, quick identifications. But the last few really took some thought. For a class I would much prefer all easy questions, but this test made me think.

I liked the variation in examination methods (matching, multiple choice, short answer, etc) However, the material got quite repetitive.

I liked how it was broken into sections, so it didn’t seem like I was just answering a lot of questions at once

**Treatment Condition 2 (T2)**

The first test was rather difficult to start off with. Other than that they were very good in testing one’s knowledge.

All of them were great tests that measured different ways of retaining information. The order of the statements, the individual pieces, the pictorial arrangement, and then the overall process as it pertained to both words as well as pictures. It was a great test of information retention, I had a decent time doing it. Thank you.
Summary of Results

Results for the Phase IV study presented in this chapter are summarized in Table 124. These results are organized by research question.

Table 124. Summary of Results from the Phase IV Study

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Did the Web-based learning environment help participants develop better memory (micro-textbase and macro-textbase) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?</td>
<td>Participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) performed significantly better than participants in the control group on three out of the four measurement instruments.</td>
</tr>
<tr>
<td>2. Did the Web-based learning environment help participants develop better understanding (micro-situation and macro-situation) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?</td>
<td>Test</td>
</tr>
<tr>
<td></td>
<td>Memory</td>
</tr>
<tr>
<td>Micro-textbase</td>
<td>$p = .274$</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>$p = .076^*$</td>
</tr>
<tr>
<td>Understanding</td>
<td></td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>$p = .079^*$</td>
</tr>
<tr>
<td>Macro-situation model</td>
<td>$p = .012^*$</td>
</tr>
<tr>
<td>* $p &lt; .10$</td>
<td></td>
</tr>
<tr>
<td>Performance of participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) was unexpected; their scores on all the tests were lower than scores obtained by participants in the control group.</td>
<td></td>
</tr>
<tr>
<td>3. Did participants take equal amount of time to read the instructional unit on the human heart in the three conditions?</td>
<td>Participants in the two Web-based learning environment conditions took nearly twice as much time reading the instructional unit on the</td>
</tr>
</tbody>
</table>
human heart in the Web-based learning environment when compared with participants in the control group ($p = .000^*$ and $p = .000^*$ respectively).

Most participants in the two Web-based learning environment conditions were aware of the extra time they spent reading. Many of them thought that they benefited from this extra time.

Time spent reading the instructional text on the human heart positively correlated ($p < .01$) with total scores on the Web-based human heart tests.

| 4. Did participants take equal amount of time to respond to the post tests in the three conditions? | Participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) spent significantly less time responding to questions on the Web-based human heart tests when compared with participants in the control group and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) ($p = .001^*$ and $p = .001^*$ respectively).

Time spent responding to the Web-based human heart tests positively correlated ($p < .01$) with total scores on the Web-based human heart tests. |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5a. How did participants use five reading strategies in the Web-based learning environment?</td>
<td>Feedback from participants in the Web-based learning environment groups indicated that many of the participants were able to use the five reading strategies in the Web-based learning environment effectively. Participants engaged deeply with the instructional text, and thought that they benefited from using the reading strategies.</td>
</tr>
<tr>
<td>5b. What was participants’ experience in the Web-based learning environment?</td>
<td>Overall 87% of the participants had a favorable experience of the Web-based learning environment. There was a significant difference between the Web-based learning environment group with demonstration that did not include explicit instruction on the reading</td>
</tr>
</tbody>
</table>
strategies (T1) and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2). While 93% of the participants in T2 voted favorably, only 83% of the participants in T1 did so. These differences were statistically significant [$\chi^2 (1, N = 353) = 8.097, p = .004$].

Overall, 81% of the participants wanted to use the Web-based learning environment in the following semester. 89% of the participants in the Web-based learning environment group with demonstration that included explicit instruction on strategies (T2) noted that they would have liked to use the Web-based learning environment in the following semester. In comparison, this percentage was only 75% for the Web-based learning environment group with demonstration that did not include explicit instruction on strategies (T1). This difference was statistically significant [$\chi^2 (1, N = 351) = 13.88, p = .000$].

6. What was participants’ experience with the Web-based human heart tests?

Overall, 82% of the participants found the overall experience of responding to the human heart tests to be favorable. Furthermore, there was a significant difference in the overall experience of the heart tests. Participants in the control group and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) rated their experience to be much more positive (88.6%, 84.3% respectively) than participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) (73.2%). These differences were statistically significant [$\chi^2 (2, N = 545) = 16.619, p = .000$].
CHAPTER 05
DISCUSSION AND CONCLUSIONS

Overall Research Purposes and Goals

This research study had two purposes, (a) to design and develop a Web-based learning environment that supports the use of a set of reading strategies, and (b) to investigate the impact of this Web-based learning environment on readers’ memory and understanding of an instructional unit on the human heart (Dwyer & Lamberski, 1977). These purposes led to four major research goals:

1. Guide the design of a Web-based learning environment that supports the use of a set of five reading strategies: (a) Text-macrostructure or chunking strategy: Readers can chunk the instructional unit on the human heart into smaller sections by moving elements (one or more paragraphs of text and an image) that make up the instructional unit into tabs that they create in the Web-based learning environment. (b) Summarization strategy: Readers can write a summary for each section that they create. (c) Imagery strategy: Readers can select an image from a library of images that is most representative of the contents of a given section. (d) Reading self-assessment or comfort-meter strategy: Readers can mark on a scale of 1-5 how comfortable they feel with their understanding of each section of the instructional unit. (e) Note-taking strategy: Readers can take notes on an element-by-element basis—these notes are attached to the elements that make up the instructional unit.

2. Establish validity and reliability of Web-based measurement instruments that were designed to measure memory and understanding of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model and macro-situation model.
3. On the basis of these measurement instruments, determine whether participants who read the instructional unit on the human heart in the Web-based learning environment developed better memory and understanding of the instructional unit when compared with participants who read the same text on a regular Web page.

4. Develop an understanding of participants’ use of the five reading strategies in the Web-based learning environment and their experience in the Web-based learning environment.

A design-based research methodology was used to inform the design of the Web-based learning environment and the measurement instruments. Updates to both the Web-based learning environment and the Web-based measurement instruments were made based on data collected at various stages of the design-based research investigation. These updates were part of the iterative cycle of finding-out and revising. These design iterations also helped the researcher develop a better understanding of the cognitive and motivational processes that readers engaged in while reading in the Web-based learning environment.

The design-based research framework guided the design of a series of studies that addressed the research goals in this study: (a) Phase I: Exploratory study related to the design of the Web-based learning environment; (b) Phase II: Design, validate and revise the Web-based measurement instruments; (c) Phase III: Design, develop, and update the Web-based learning environment; develop a feedback survey to gauge readers’ use of the five reading strategies in the Web-based learning environment, their experience in the Web-based learning environment, and their experience with the Web-based human heart tests; and (d) Phase IV: Large-scale quasi-experimental study designed to estimate the learning benefits and to develop an understanding of readers’ experience in the Web-based learning environment. Findings from each of the first three phases of the investigation were used to update the design of the Web-based learning environment.
environment, the Web-based measurement instruments, and the research design of the subsequent phase.

Summary of Overall Findings

In the Phase I study, participants’ use of the text-macrostructure or chunking strategy was investigated with the help of an early-stage paper prototype of the Web-based learning environment. Participants’ organization of the individual elements that made up the instructional unit on the human heart into sections, and the labels that participants gave these sections were markedly different across the six participants who completed this study. This evidence indicated that participants in the study made use of the text-macrostructure strategy to develop unique macro-level representations of the instructional unit on the human heart. Findings from this study provided support for incorporating the text-macrostructure strategy in the Web-based learning environment. This strategy played a key role in the overall design of the Web-based learning environment.

In the Phase II study, Web-based measurement instruments that measured participants’ knowledge of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model, and macro-situation model—were designed and validated. Cronbach’s alpha for scores on the multiple-choice items on all four Web-based human heart tests was greater than .75. Knowledge of human anatomy and spatial ability were treated as possible covariates. The Cronbach’s alpha for scores on the knowledge of human anatomy test was .713. On the basis of item-total statistics and the discrimination index data, two items were identified as being most problematic; one item was updated, the other item was replaced. Reliability for scores on the spatial ability tests could not
be calculated because of insufficient data. An implementation of the Damerau-Levenshtein distance (DLD) algorithm was found to be suitable for scoring the “rearranging-type” questions in the macro-textbase and macro-situation model tests. Correlations among the scores on all four human heart tests were statistically significant.

Given these correlations, it was determined that there would be an advantage to using multivariate analysis of variance procedures over separate ANOVAs in phases of the study that followed. Given the high correlations between scores on the Web-based human heart tests, the knowledge of the human anatomy test, and the paper-folding test, it was determined that there would be an advantage to using scores on the knowledge of human anatomy and paper-folding tests as covariates in studies in the subsequent phases.

Technology used to develop the measurement instruments (implementation of the autocomplete design-pattern, drag-and-drop, and AJAX) and online delivery of measurement instruments was tested; bugs that were identified were fixed. The Web-based measurement instruments developed in this study were used in the subsequent phases of the investigation.

Participants in the Phase III study read the instructional unit on the human heart inside the Web-based learning environment. Participants engaged deeply with the reading task in the Web-based learning environment spending nearly twice as much time reading when compared with participants in the Phase II study who read the instructional unit on the human heart on a regular Web page. An animated demonstration that provided participants an overview of the user interface of the Web-based learning environment was prepared and tested. Feedback questions related to participants’ experiences with the Web-based learning environment and the Web-based measurement instruments were prepared and tested. On the basis of data collected from
interviews with participants, responses to the feedback survey, think-aloud and video data, numerous updates were made to the user interface and the design of the reading strategies in the Web-based learning environment.

On the basis of observations in the Phase III studies, a decision was made to develop two variants of the animated demonstration for the Web-based learning environment. The first demonstration was similar to the demonstration used in the Phase III studies. The objective of this demonstration was to provide participants an orientation of the interface of the Web-based learning environment. In addition to providing participants an orientation of the interface of the Web-based learning environment, the second demonstration provided *explicit instruction* on the five reading strategies.

The Phase IV study investigated the impact of the Web-based learning environment on readers’ memory and understanding of an instructional unit on the human heart. Two levels of the independent variable—the Web-based learning environment—were set up: (a) Web-based learning environment with demonstration that did not include explicit instruction on the reading strategies (T1); and (b) Web-based learning environment with demonstration that included explicit instruction on the reading strategies (T2). In the control condition participants read the instructional unit on the human heart on a regular Web page. The six dependent variables in the study included scores on four tests that measured participants’ memory and understanding of the instructional unit on the human heart (micro-textbase, macro-textbase, micro-situation model, and macro-situation model), time spent reading the instructional unit on the human heart, and the time spent responding to test questions. Six research questions were pursued: (a) Did the Web-based learning environment help participants develop better *memory* (micro-textbase and macro-textbase tests) of the instructional unit on the human heart, and was there an effect of the explicit
instruction on reading strategies? (b) Did the Web-based learning environment help participants develop better understanding (micro-situation model and macro-situation model tests) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies? (c) Did participants in the three experimental conditions spend the same time reading the instructional unit on the human heart? (d) Did participants in the three experimental conditions spend the same time responding to the post-tests? (e) How did participants use the five reading strategies in the Web-based learning environment and what were their experiences in the Web-based learning environment? (f) What were participants’ experiences with the Web-based human heart tests? Results from the Phase IV study are summarized in Table 125.

Table 125. Summary of Results from the Phase IV Study

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Did the Web-based learning environment help participants develop better memory (micro-textbase and macro-textbase) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?</td>
<td>Participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) performed significantly better than participants in the control group on three out of the four measurement instruments.</td>
</tr>
<tr>
<td>2. Did the Web-based learning environment help participants develop better understanding (micro-situation and macro-situation) of the instructional unit on the human heart, and was there an effect of the explicit instruction on reading strategies?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td></td>
</tr>
<tr>
<td>Micro-textbase</td>
<td>$p = .274$</td>
</tr>
<tr>
<td>Macro-textbase</td>
<td>$p = .076^*$</td>
</tr>
<tr>
<td>Understanding</td>
<td></td>
</tr>
<tr>
<td>Micro-situation model</td>
<td>$p = .079^*$</td>
</tr>
<tr>
<td>Macro-situation model</td>
<td>$p = .012^*$</td>
</tr>
</tbody>
</table>

* $p < .10$
Performance of participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) was unexpected; their scores on all the tests were lower than scores obtained by participants in the control group.

3. Did participants take equal amount of time to read the instructional unit on the human heart in the three conditions?

Participants in the two Web-based learning environment conditions took nearly twice as much time reading the instructional unit on the human heart in the Web-based learning environment when compared with participants in the control group ($p = .000^*$ and $p = .000^*$ respectively).

Most participants in the two Web-based learning environment conditions were aware of the extra time they spent reading. Many of them thought that they benefited from this extra time.

Time spent reading the instructional text on the human heart positively correlated ($p < .01$) with total scores on the Web-based human heart tests.

4. Did participants take equal amount of time to respond to the post tests in the three conditions?

Participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) spent significantly less time responding to questions on the Web-based human heart tests when compared with participants in the control group and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) ($p = .001^*$ and $p = .001^*$ respectively).

Time spent responding to the Web-based human heart tests positively correlated ($p < .01$) with total scores on the Web-based human heart tests.

5a. How did participants use five reading strategies in the Web-based learning environment?

Feedback from participants in the Web-based learning environment groups indicated that many of the participants were able to use the five reading strategies in the Web-based...
### 5b. What was participants’ experience in the Web-based learning environment?

Overall 87% of the participants had a favorable experience of the Web-based learning environment. There was a significant difference between the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2). While 93% of the participants in T2 voted favorably, only 83% of the participants in T1 did so. These differences were statistically significant $[\chi^2 (1, N = 353) = 8.097, p = .004]$.

Overall, 81% of the participants wanted to use the Web-based learning environment in the following semester. 89% of the participants in the Web-based learning environment group with demonstration that included explicit instruction on strategies (T2) noted that they would have liked to use the Web-based learning environment in the following semester. In comparison, this percentage was only 75% for the Web-based learning environment group with demonstration that did not include explicit instruction on strategies (T1). This difference was statistically significant $[\chi^2 (1, N = 351) = 13.88, p = .000]$.

### 6. What was participants’ experience with the Web-based human heart tests?

Overall, 82% of the participants found the overall experience of responding to the human heart tests to be favorable. Furthermore, there was a significant difference in the overall experience of the heart tests. Participants in the control group and the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) rated their experience to be much more positive (88.6%, 84.3% respectively) than participants in the Web-
Findings from Phase I, Phase II and Phase III were discussed in Chapter 3. This chapter discusses findings from the Phase IV study. The discussion is organized by the six research questions in Table 125.

Discussion of Findings from the Phase IV Study

Performance Differences on Human Heart Tests

Reading in the Web-based learning environment, as long as participants were provided explicit instruction on the reading strategies, had a positive effect on participants’ performance on the Web-based human heart tests. Participants in Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) scored significantly higher ($p < .10$) than participants in the control group on macro-textbase ($p = .076$), micro-situation model ($p = .079$) and macro-situation model tests ($p = .012$). There was no significant difference in scores on the micro-textbase test ($p = .274$).

The performance of participants in the Web-based learning environment condition that did not include explicit instruction on the reading strategies (T1) was unexpected. Their scores on all the dependent measures were lower than scores obtained by participants in the other two
groups (control and T2). The V-shaped pattern of performance (see Figure 43, Figure 44, Figure 45, Figure 46 in Chapter 4) raised three questions:

(1) Why did participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) perform worse than participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2)?

(2) Why did participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) perform worse than participants in the control group?

(3) Why did participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) perform better than participants in the control group?

Explanations to the first and the third question are somewhat obvious. The first question points to a positive effect of explicit instruction on the reading strategies. The third question points to a positive effect of reading in the Web-based learning environment, as long as participants were provided explicit instruction on the reading strategies. The second question is indeed perplexing—what caused the performance of participants in the Web-based learning environment condition that watched a demonstration that did not include explicit instruction on the reading strategies to be worse than participants in the control condition? Each of these questions is discussed on the basis of the data collected in the Phase IV study.

Furthermore, data from the Phase IV study demonstrated that participants in Treatment 2 (T2) performed significantly better than participants in the other two conditions ($p < .10$) on three out of the four human heart tests. This finding is also discussed.
(4) Why did participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) perform significantly better than participants in the control group on the macro-textbase, micro-situation model, and macro-situation model but not on the micro-textbase test?

A discussion of these four questions based on the data collected in the Phase IV study follows.

(1) Why did Participants in T2 Perform Significantly Better on the Human Hearts Tests than Participants in T1?

The only difference between the two Web-based learning environment groups was whether they did or did not receive explicit instruction on the reading strategies as part of the demonstration that they watched before they engaged with the instructional unit on the human heart in the Web-based learning environment. Given this, the above question can be reframed as such, Why did explicit instruction on reading strategies impact the performance on the Web-based human heart tests?

Possible explanations of this effect can be found in the reading research literature. Research on reading strategy instruction has demonstrated that reading strategies, like any other strategies, become internalized only with prolonged use (Ogle, 1986; Palincsar & Brown, 1984; Raphael & Au, 2005; Williams, 2007). A limitation of the design of the Phase IV study was that it gave participants only a single opportunity with the Web-based learning environment. With only a one-time exposure to the Web-based learning environment, participants in the study clearly did not have enough time with the reading strategies in the Web-based learning environment to internalize them.
In these circumstances, it is not surprising that participants who were given explicit instruction on the reading strategies performed better on the Web-based human heart tests. These findings are consistent with literature on cognitive load theory (Brünken, Plass, & Leutner, 2003; Gerjets & Scheiter, 2003; Mayer & Moreno, 2003; Paas, Renkl, & Sweller, 2003; Paas, Tuovinen, Tabbers, & van Gerven, 2003). Not only did participants in the Web-based learning environment condition that did not include explicit instruction on the reading strategies (T1) have to grapple with the complexity of the instructional unit on the human heart, they also had to devote cognitive resources to make sense of the reading strategies and learn to use them. Quite possibly these readers were left wondering how the manipulations (the reading strategies were called manipulations in the demonstration for participants in T1) that they were carrying out in the Web-based learning environment would help them learn the instructional unit on the human heart. The demonstration that included explicit instructions on the reading strategies directly addressed this question. Because of the explicit instruction on the reading strategies, participants in the Treatment 2 (T2) had a better idea of how they could benefit from using the reading strategies in the Web-based learning environment even though they were using the Web-based learning environment for the first time.

(2) Why did Participants in T1 Perform Worse on the Web-based Human Heart Tests than Participants in the Control Group?

Lack of orientation to the reading strategies for participants in the Web-based learning environment with demonstration that did not include explicit instruction on the reading strategies and the cognitive load that this entailed may explain this outcome (as discussed above). Given that multiple strategies were available in the Web-based learning environment and the fact that
readers had no prior experience with the Web-based learning environment, many participants could have failed to effectively use the reading strategies. Some participants in Treatment 1 (T1) noted that they were not so familiar with the features in the Web-based learning environment and therefore they did not use it as effectively as they could have (see Table 126).

Table 126. Feedback from Participants in Treatment 1 (T1): Lack of Familiarity with Features in the Web-Based Learning Environment

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>More description as to what exact features we should be utilizing.</strong></td>
</tr>
<tr>
<td><strong>Even after watching the instructions, I couldn’t figure out how to use some of the strategies.</strong></td>
</tr>
<tr>
<td><strong>I did not have a clear understanding of everything available to me in the learning environment.</strong></td>
</tr>
</tbody>
</table>

Given the lack of familiarity with the features in the Web-based learning environment, some participants felt overwhelmed by the options available to them. Several participants in T1 complained of information overload. These participants found the complexity of the text, along with the demands of the Web-based learning environment to be overwhelming (see Table 127). It is worth noting that participants in Treatment 2 (T2) did not provide such feedback.

Table 127. Feedback from Participants in Treatment 1 (T1): Cognitive Overload

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I have a hard time reading essays off the computer, and having to worry about side tasks that did not help me just added to distraction. I would prefer to have just done this via hard copy.</strong></td>
</tr>
<tr>
<td><strong>I didn’t like how much information was thrown at you at once, and I think this should be narrowed down to a more sizeable amount.</strong></td>
</tr>
<tr>
<td><strong>It is a lot of information to gather even reading and seeing everything, I still cannot remember all of the intricate details. It would take me days to understand that information and be able to perform well on it. Maybe have an interactive quiz before doing the test so we can test ourselves to see if we are ready for the test because come the</strong></td>
</tr>
</tbody>
</table>
This lack of familiarity with the features in the Web-based learning environment was also evident in comments from several participants in T1 who realized that they did not do well on the tests. Participants in T2 did not provide such feedback. Some participants in T1 noted that given another opportunity to read the instructional unit on the human heart in the Web-based learning environment they could perhaps have done better (see Table 128).

Table 128. Feedback from Participants in Treatment 1 (T1): Awareness of Poor Performance on the Web-Based Human Heart Tests

Treatment Condition 1 (T1)

*The research study seems very interesting, while I do not feel like I did particularly well on the test questions I am glad I was able to participate in the study*

*I definitely feel that I have benefited from this reading even though I may not have scored that well I feel I retained most of the information.*

*I believe after taking these tests that if I made several tabs and read those, I would have done better. I didn’t trust the learning environment at first but then after failing this miserably, I wish I would have gone back and made tabs and read the material over again.*

*yes, but for other classes I feel like it could be used a lot better*

*The learning environment was good, but I have absolutely no interest in big words about the human heart*

*I know I benefited from reading it but for me to really understand it I would need to reread it, take notes on it, study it a lot and really work at it, and learn it in small groups like anyone would.*

*I spent more time reading this than on a regular webpage or paper since I was trying to break all the paragraphs up into categories. I think this time spent was beneficial. Even if I didn’t ‘ace’ the test, I definitely did better than I would have if I were reading a website or paper.*

*I feel that this could possibly be a very good way to study and take notes. Obviously I didn’t score very well but if this was a legitimate class and this is how we would take notes it think kids would like this very much.*

In summary, the novelty of the features in the Web-based learning environment combined with a lack of explicit instruction on the reading strategies in the Web-based learning
environment could explain why participants in treatment group 1 (T1) performed worse than participants in the control group and participants in Treatment 2 (T2). Responses to the questions in the feedback survey corroborate these trends in scores.

Participants in all three experimental conditions were asked to respond to the following questions using a 9-point Likert-type scale (see Figure 60).

![Survey Questions](image)

**Figure 60.** Feedback survey: Participants rated their knowledge of the human heart, their motivation, and how difficult they found reading the instructional unit on the human heart.

Responses from participants to each of these four items were ranked. The mean ranks for responses to each of the four questions were calculated for the three conditions (see Table 129). Means and standard deviations are also noted.
Table 129. Responses to Demographic Questions

<table>
<thead>
<tr>
<th></th>
<th>Condition</th>
<th>N</th>
<th>Mean Rank</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of the human heart</td>
<td>Control</td>
<td>209</td>
<td>287.35</td>
<td>2.51</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>T1</td>
<td>211</td>
<td>290.73</td>
<td>2.51</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>174</td>
<td>317.91</td>
<td>2.67</td>
<td>1.52</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>594</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge of the human heart</td>
<td>Control</td>
<td>211</td>
<td>283.13</td>
<td>5.47</td>
<td>2.01</td>
</tr>
<tr>
<td>after the study</td>
<td>T1</td>
<td>211</td>
<td>294.68</td>
<td>5.59</td>
<td>2.04</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>175</td>
<td>323.34</td>
<td>5.94</td>
<td>1.83</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>597</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivation to participate in</td>
<td>Control</td>
<td>211</td>
<td>310.62</td>
<td>5.57</td>
<td>2.03</td>
</tr>
<tr>
<td>the study</td>
<td>T1</td>
<td>209</td>
<td>283.11</td>
<td>5.29</td>
<td>1.86</td>
</tr>
<tr>
<td></td>
<td>T2</td>
<td>175</td>
<td>300.57</td>
<td>5.46</td>
<td>1.85</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>595</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty reading the</td>
<td>Control</td>
<td>210</td>
<td>280.85</td>
<td>4.08</td>
<td>2.38</td>
</tr>
<tr>
<td>instructional unit on the</td>
<td>T1</td>
<td>211</td>
<td>330.43</td>
<td>4.76</td>
<td>2.37</td>
</tr>
<tr>
<td>human heart</td>
<td>T2</td>
<td>175</td>
<td>281.18</td>
<td>4.05</td>
<td>2.16</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>596</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On average, participants in Web-based learning environment condition that did not include explicit instruction on strategies (T1) were the least motivated to participate in the study and found the reading to be most difficult. Furthermore, responses from participants in Web-based learning environment group with demonstration that included explicit instruction on strategies (T2) indicated that they believed they had more knowledge about the human heart before participating in the study as well as after they had read the instructional unit on the human heart in the study. The Kruskal Wallis test was performed to test the significance of these differences (see Table 130).
Table 130. Results of Kruskal Wallis Test

<table>
<thead>
<tr>
<th>Question</th>
<th>Chi-square</th>
<th>df.</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of the human heart before the study</td>
<td>3.75</td>
<td>2</td>
<td>.153</td>
</tr>
<tr>
<td>Knowledge of the human heart after the study</td>
<td>5.53</td>
<td>2</td>
<td>.063*</td>
</tr>
<tr>
<td>Motivation to participate in the study</td>
<td>2.82</td>
<td>2</td>
<td>.244</td>
</tr>
<tr>
<td>Difficulty reading the instructional unit on the human heart</td>
<td>11.42</td>
<td>2</td>
<td>.003*</td>
</tr>
</tbody>
</table>

* $p < 0.10$

The difference in responses was statistically significant ($p = 0.063$) for the question that asked participants to rate their knowledge of the human heart after they had read the instructional unit on the human heart. Participants in the Web-based learning environment group with demonstration that included explicit instruction on strategies (T2) rated their knowledge of the instructional unit on the human heart to be the highest while participants in control group rated it the lowest. It is worth noting that ratings of participants in control group were lower than from participants in the Web-based learning environment condition that did not include explicit instruction on strategies (T1), even though participants in the control group scored higher than participants in T1 on the post-tests.

The difference in responses was statistically significant ($p = 0.003$) for the item that asked participants to rate how difficult they found reading the instructional unit on the human heart. Participants in the Web-based learning environment condition that did not include explicit instruction on strategies (T1) found reading the instructional unit on the human heart to be the most difficult, while participants in control group and participants in the Web-based learning environment group with demonstration that included explicit instruction on strategies (T2) found it to be equally difficult, but much less so than T1.
Before moving to the third question, two factors—burn out effect and poor use of strategies and conflict among strategies—that could have negatively affected performance of participants in both Web-based learning environment conditions (T1 and T2) are discussed.

1. Burn out effect: Participants in the Web-based learning environment conditions (T1 and T2) spent twice as much time reading the instructional unit on the human heart as compared to participants who read the instructional unit on a regular Web page. During this time, participants in the Web-based learning environment conditions expended considerable cognitive effort. The researcher maintained a research journal for every session in the Phase III and Phase IV studies. In these journals, the researcher noted participants’ involvement and the energy that they appeared to spend reading the instructional unit on the human heart in the Web-based learning environment. Several participants appeared visibly exhausted at the end of the session. Could the extra time and energy that participants spent reading in the Web-based learning environment have had an adverse impact on performance on the Web-based human heart tests, especially for those participants who were not motivated to do well in the study? There is some evidence of this phenomenon in the feedback from participants (see Table 131).

Table 131. Feedback from Participants: Burn Out Effect

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>It was rough! The learning environment is a fantastic idea, however.</em></td>
</tr>
<tr>
<td>The time factor plays a role and if that could be limited I’m sure people would want to be more involved and the word of this learning environment could spread.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment Condition 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>I was really tired and so I probably did badly on the quiz. I hope you can make use of my comments on the learning environment however, as I am conscious enough to comprehend and appreciate the benefits of it.</em></td>
</tr>
<tr>
<td><em>It was extremely long, but being able to write a summary, our own personal notes, include a picture, and write</em></td>
</tr>
</tbody>
</table>
how we felt about the portion of the reading was good. It allowed us to break down the reading and remember the passages a lot better instead of just a bunch of information all at once.

yes, 1/2 hour, in the beginning it was beneficial, then I began to burn out and lost concentration. I think I would have done better if it would have been maybe 2 essays, one learning about the parts of the heart and the other the functioning of the heart.

I spent probably more than double the time, but it was beneficial. I am also extremely tired right now, so I don’t know if the amount of extra time is even accurate.

The extra time may or may not have been beneficial, I am not sure. I did not spend too much extra time but that was because I got mad at myself for taking so much longer that I just rushed through the last part of it. I kept looking at the time and thinking I do not have much time left and I need to use the time on the actual test part of it, so the amount of time I spent reading got greatly reduced by the second half of it and my concentration, among other things, suffered.

One participant said that she got too involved with the strategies in the Web-based learning environment, so much so that it adversely affected her performance on the Web-based human heart tests, “I got too caught up in trying to write note and section everything that by the time I took the quiz I forgot a lot of the material.”

2. Poor use of strategies and conflict among strategies: It was likely that at least three strategies in the Web-based learning environment—note-taking, summarization and imagery—were not new to many of the participants in the study. Some of these participants, however, might have had poor conceptions of these strategies. For example, many participants in the study used the note-taking strategies ineffectively—they simply copied and pasted text from the instructional unit to create notes without reflecting or paraphrasing. In effect, the Web-based learning environment might have given some participants an opportunity to practice strategies that were poorly conceived. This could have negatively impacted their performance.

Data in the study indicates that many of those participants who prepared lengthy notes did so at the expense of other strategies. For example, the number of words used in summaries created by such participants was disproportionately small. In effect, in some cases, the note-
taking strategy prevented other strategies (in this case the summarization strategy) from getting induced. In their feedback, several participants who used the note-taking strategy said that they found the summarization strategy to be redundant (see Table 132).

Table 132. Feedback from Participants: Note-Taking Strategy vs. Summarization Strategy

**Treatment Condition 1 (T1)**

I did not like having to write a summary- I felt that was doing the same thing as putting them into mini groups

I did not see the benefit of the summary, as I would put key words, or label the sections with their major themes.

the summary and title of each tab seem to be very similar it seems a little unnecessary

...also the note taking was my summary so the summaries seemed redundant.

I think the summary and the note taking is too redundant.

...Also the summary basically consisted in me repeating my notes.

The summaries were a tedious part in addition to note-taking. Note-taking is more efficient.

I didn’t find any usefulness for preparing summaries, attaching images, or setting the comfort meter. I feel that these may be more useful when studying for a major exam when the text will be revisited multiple times.

**Treatment Condition 2 (T2)**

I didn’t really think the summaries were as helpful as the notes.

I felt like the notes were pretty much the same thing as the summary. One or the other may be just fine.

The summaries and note taking seemed to be pretty much the same thing so I would only do one of them in the future.

I didn’t see the point of the summary…if you take good notes you don’t really need it

The summary feature could simply be a grouping of the notes that were taken on the section.

The summary could be the notes for each section combined.

the summaries of the tabs were not helpful because I basically summarized the text through my note taking

I did not like the need to write a summary, since if your put notes on the section shouldn’t need to summarize your already made notes. Also, didn’t like that you needed to use a summary/picture/comfort in order to continue

I think it should be either summary or notes. both aren’t necessary

Summaries were not really necessary when you already have the note-taking function.
(3) Why Did Participants in T2 Perform Significantly Better than Participants in the Control Group?

Responses from participants to feedback question related to the use of the reading strategies in the Web-based learning environment provided insights into the cognitive and metacognitive processes that participants who read in the Web-based learning environment could have benefited from. Many participants noted that being able to break up the text into smaller sections made the task of the reading the instructional unit less daunting.

Participants noted that the summarization strategy made them revisit and review the sections that they had created. One of the participants noted that even though she was not good at summarization, the strategy could have helped others, “I’m terrible at summarizing so that was not useful to me at all, but I’m sure it helps others.” Some participants said that they benefited from being able to visualize the text (imagery strategy). Several participants noted that having to write notes forced them to read the text more carefully and this helped them retain the information in the text.

In their feedback participants also mentioned motivational benefits of reading in the Web-based learning environment. Some participants said that they liked reading in the Web-based learning environment because it allowed them to customize the text, which in turn gave them a sense of control. Participants felt that the Web-based learning environment motivated them to spend extra time reading which helped them learn more. Some participants said that the Web-based learning environment helped them concentrate and focus on the reading. Several participants noted that they found the reading experience in the Web-based learning environment to be satisfying. Some others noted that they found the Web-based learning environment design flexible because it could accommodate different learning styles.
In summary, feedback from participants in the Treatment 2 (T2) indicates several ways in which these participants could have benefited from reading in the Web-based learning environment. Participants noted that the reading strategies in the Web-based learning environment forced them to review and revise their understanding of the instructional unit on the human heart. They said that the Web-based learning environment allowed them to customize the text; it made the reading task more engaging which motivated them to spend more time with the text. Participants also noted that the Web-based learning environment was convenient and satisfying to use and they thought that the Web-based learning environment could accommodate different learning styles. These factors, as long as participants were provided explicit instruction on the reading strategies, had a positive effect on participants’ performance on the Web-based human heart tests.

(4) Why did Participants in T2 Perform Significantly Better than Participants in the Control Group on the Macro-Textbase, Micro-Situation Model and Macro-Situation Model Tests but not on the Macro-Textbase Test?

As noted in Chapter 2, four out of the five strategies designed in the Web-based learning environment (text-macrostructure, summarization, imagery and reading self-assessment) were expected to affect the construction of knowledge representations at the macro and situation model levels (macro-textbase, micro-situation model, macro-situation model). Among these four strategies, the text-macrostructure strategy was the primary strategy and the other three strategies complemented it. The note-taking strategy, on the other hand, was considered to be “representation neutral” in that it was expected to affect all levels of representation.

A comparison of scores obtained by participants in the participants in Treatment 2 (T2) and participants in the control group supports this hypothesis. Participants in Treatment 2 (T2)
scored significantly higher ($p < 0.1$) than participants in the control group on macro-textbase, micro-situation model and macro-situation model tests. There was no significant difference in scores on the micro-textbase test. The hypothesis is also supported by participants’ feedback to survey questions. Several participants in the Treatment 2 (T2) used words and phrases such as “learned,” “understand,” “internalize,” “absorb,” “develop and overall better sense,” “in-depth,” “understood the text thoroughly,” “understand rather than just read and forget,” “really grasp the material” to describe how they thought they benefited from reading in the Web-based learning environment. Participants also made a distinction between memory and understanding (see Table 133).

Table 133. Feedback from Participants in Treatment 2 (T2): Levels of Knowledge Representations

<table>
<thead>
<tr>
<th>Treatment Condition 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, I definitely put more thought and time into what I was reading. Usually I would have skimmed the entire thing in about 15 minutes. I definitely believe it was beneficial. I understood the reading very well.</td>
</tr>
<tr>
<td>I did take more time reading it, but it was very helpful and helped me understand it more.</td>
</tr>
<tr>
<td>I think I spent less time reading the text and understood the text more than I would’ve compared to regular web page or on paper.</td>
</tr>
<tr>
<td>…it promotes learning and remembering the information more when it is presented in the learning environment.</td>
</tr>
<tr>
<td>Yes, by using the helpful tools, I was able to grasp a better understanding and definitely spent more time than I would normally. It was beneficial.</td>
</tr>
<tr>
<td>I think the extra time was beneficial; it allowed me to process the information and internalize it better.</td>
</tr>
<tr>
<td>Yes, by a lot of time. I do think this extra time spent was beneficial because it helped me understand the text better.</td>
</tr>
<tr>
<td>Yes, by a significant amount. I would have normally speed through the reading on a normal web page and not understand half of what I was able to understand. The extra time was beneficial.</td>
</tr>
<tr>
<td>Yes, perhaps up to twice as long. The extra time spent allowed for greater comprehension, so yes, it was beneficial.</td>
</tr>
<tr>
<td>Yes because on a regular web page I would not have read as thoroughly and carefully as I did in the learning environment. I would have just skimmed a regular website or paper. I think the extra time is probably about a half</td>
</tr>
</tbody>
</table>
hour to an hour but I think the time is beneficial because I understood what I was reading in the learning environment. It was easy to comprehend.

I probably spent the same amount of time. Only this time I could organize my comprehension to later review.

Yes I spent more time reading this because I was really trying to understand it. I probably spent at least 30 more minutes reading this than I would have normally. I think the extra time spent was very beneficial.

Yep, I don’t think I would’ve spent any time reading it online. I would’ve skimmed through and not absorbed anything. The learning environment required me to focus.

Very beneficial to understanding and retaining the information

Yes by probably twice as long, but again it was to ensure you knew the information

I did spend more time but it was more beneficial because I could break up the reading so that I could understand it easier

No I feel as if it would have been similar time but I understood it better.

Interestingly, similar feedback was provided by many participants in Treatment 1 (T1)

even though, on average, this group scored lower on the tests than the control group (see Table 134).

Table 134. Feedback from Participants in Treatment 1 (T1): Levels of Knowledge Representations

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I’m not good with the short term memory of titles and such so I wasn’t good at remembering them but I definitely learned about the process.</td>
</tr>
<tr>
<td>I developed an overall better sense of how my heart works. However, much of the detail I forgot as soon as I left the reading.</td>
</tr>
<tr>
<td>Except for some of the spellings of the parts of the heart, I’d say I was pretty well prepared.</td>
</tr>
<tr>
<td>it gave me better understanding in a shorter amount of time.</td>
</tr>
<tr>
<td>it really made you look in-depth at the text.</td>
</tr>
<tr>
<td>it forces you to break apart the text and understand it better</td>
</tr>
<tr>
<td>the extra time spent categorizing it forced me to have a better understanding the subject material, whereas just reading it from paper I would have just kept going without reviewing the material</td>
</tr>
</tbody>
</table>
The extra time was beneficial because it forced me to learn more.

Less time, but more beneficial time, because I understood more.

Extra time was beneficial because I understood the text much better.

I spend a lot more time with the text through the learning environment than I would have otherwise. I feel I spent at least twenty-five extra minutes really analyzing the information so that I understood the text thoroughly.

I spent probably double or triple the amount of time I would have normally spent, but the time spent was definitely beneficial because I have retained (almost) everything I read.

The ability to take notes, organize, etc makes the reading take longer but helps the user understand rather than just read and forget

Yes, probably at least 20 minutes more. But, I left with a noticeable understanding.

The extra time spent helped me remember and really grasp the material.

Yes, I spent more time because I took the time to take notes, writes summaries, and break up the text. I felt this time was beneficial because otherwise I probably wouldn’t have done these things and wouldn’t have synthesized the information as well as I did.

Furthermore, many participants in Treatment 2 (T2) struggled with the micro-textbase questions that tested memory. Several participants expressed their frustration with this test and complained that the Web-based learning environment did not prepare them for it (see Table 135).

Table 135. Feedback from Participants: Micro-Textbase Tests

<table>
<thead>
<tr>
<th>Treatment Condition 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>It seemed like a fairly difficult test and while I remembered most of the information on the blood flow. I didn’t remember all of the labels for the heart.</td>
</tr>
<tr>
<td>The tests would have been easier if they were multiple choice, not straight recall of terms. Sometimes if I see a list of terms I can pick the correct one out but I can’t recall it solely from memory. I thought I had taken thorough notes and knew the text well, but the format of the questions did not help me to recall the information.</td>
</tr>
<tr>
<td>The first part about naming each part of the heart was stressful because I could not memorize all of them in such a short time, but the others were better.</td>
</tr>
<tr>
<td>The first test was rather difficult to start off with. Other than that they were very good in testing one’s knowledge.</td>
</tr>
<tr>
<td>The part where there is the picture of the heart with 20 labels for parts was really complicated and I don’t think that was a good reflection of what we read.</td>
</tr>
</tbody>
</table>
I wish I knew the configuration of the test before taking it. For example, if I knew I would need to label the parts of the heart, I would have read the essay in a way where I focused more the visual image of the heart rather than scientific description of how the heart works.

I think that the labeling and identifying the parts of the heart is ridiculous. You can’t expect us to know where every part is located just after reading a long text.

I did not like some of the quiz questions because before I took the quiz, I felt like I had learned something. I felt that the text did not help enough for the quiz.

These responses provide support for the hypothesis that the reading strategies in the Web-based learning environment support creation of knowledge structures at the macro and situation model levels, which in turn led to superior performance on the macro-textbase, micro-situation model and macro-situation model representations, but not on the micro-textbase representation.

*Differences in Time Spent Reading the Instructional Unit on the Human Heart*

During the Phase III studies in which the researcher interacted with the participants on a one-on-one basis he found participants to engage deeply with instructional unit on the human heart in the Web-based learning environment, so much so that many of them seemed to lost track of time.

The same trends were seen in the Phase IV study. Participants in both Web-based learning environment conditions spent nearly twice as much time reading the instructional unit on the human heart when compared with participants in the control condition who read the instructional unit on the human heart on a regular Web page. This extra time spent did not necessarily translate into higher scores on the Web-based human heart tests. In fact, participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) performed worse on the Web-based human heart tests than participants in the control group despite the fact that they spent twice as much time reading.
This anomalous outcome can be attributed to the extrinsic cognitive load associated with reading in the Web-based learning environment when explicit instruction on the reading strategies was not provided. For the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2), the extra time spent reading did translate into gains in performance on the Web-based human heart tests.

Feedback from participants in both Web-based learning environment conditions indicates that participants thought that (a) they spent more time reading in the Web-based learning environment as compared to reading on a regular Web page, and (b) the extra time that they spent was beneficial. One of the challenges faced by reading instructors is that of being able to engage readers in the reading task. The Web-based learning environment was able to respond to this challenge.

Differences in Time Spent Responding to the Web-Based Human Heart Tests

Participants in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) spent significantly less time responding to test questions when compared with participants in the control group and participants in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2). This trend matches the trend in performance of the Web-based human heart tests—participants in T1 performed worse than participants in the control group and participants in T2.

It is quite possible that because of a lack of explicit instruction on the reading strategies at least some participants in T1 did not use the strategies as effectively as participants in T2 because they did not know how they could benefit from the strategies. Perhaps this explains why
responses from participants in T1 indicated that they were the least motivated to participate in the study and found reading the instructional unit on the human heart to be most difficult. This lack of motivation, together with the extrinsic cognitive load associated with reading in the Web-based learning environment when explicit instruction on the reading strategies was not provided, may explain why these participants spent significantly less time on the Web-based human heart tests.

Participants’ Use of the Reading Strategies and their Experiences in the Web-Based Learning Environment

Feedback from participants in the two Web-based learning environment conditions presented in Chapter 4 indicated that many participants thought they benefited from using the reading strategies in the Web-based learning environment. On the whole participants seemed to enjoy reading in the Web-based learning environment. Overall 89% of the participants in the Web-based learning environment group with demonstration that included explicit instruction on reading strategies said that they would like to use the Web-based learning environment to read papers for courses that they would be taking the following semester.

Participants’ use of the reading strategies and their experience in the Web-based learning environment are discussed under the following headers:

1. Participants’ “theories” for the reading strategies in the Web-based learning environment.
2. Reading in the Web-based learning environment was like playing a game.
3. Comparing reading in the Web-based learning environment with reading in other media.
1. Participants’ “theories” for the reading strategies in the Web-based learning environment.

Even after a one-time interaction with the Web-based learning environment, participants, especially those who watched a demonstration that included explicit instructions on strategies (T2), seemed to have internalized the reading strategies to some extent. These participants developed their own theories of how to use these strategies in the Web-based learning environment and how the reading strategies in the Web-based learning environment could benefit them. Several participants were able to identify more with certain strategies than others and seemed to realize why at least a subset of the strategies could be beneficial. Some participants even suggested that they would be able to transfer some of these strategies to reading in other media such as on paper (see Table 136).

Table 136. Feedback From Participants in Treatment 2 (T2): Participants’ “Theories” of How the Web-Based Learning Environment Could be Beneficial

<table>
<thead>
<tr>
<th>Treatment Condition 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>This was a very long study, but I learned a lot about the heart and how to study better.</td>
</tr>
<tr>
<td>I thought the study was good because it helped me see how I comprehend readings.</td>
</tr>
<tr>
<td>I enjoyed learning the importance of note-taking and rereading things.</td>
</tr>
<tr>
<td>I think this is a very helpful way of critically reading texts and I would definitely like to use this method in the future.</td>
</tr>
<tr>
<td>My overall experience in this research study was very beneficial. It helped me improve my learning experience and abilities to effectively attain information.</td>
</tr>
<tr>
<td>It forces you to organize your reading in a way that will make you retain the information much more efficiently</td>
</tr>
<tr>
<td>It helped me learn how to take useful notes.</td>
</tr>
<tr>
<td>I really liked participating in this study, it showed me how much more I can get out of reading a text just by taking the time to categorize and separate, and attach meaning to it.</td>
</tr>
</tbody>
</table>
It helped me understand what I can do to pay more attention while reading.

My overall experience was positive, and even though I don’t have the learning environment tool, I can use some of the strategies on my own when reading papers or texts.

I think this activity helped me learn and realize the different ways you can organize the text to help you retain the information better.

Yes, I know what I need to work on while I’m reading through things.

Yes, I think it not only allowed me to learn a few things about the heart, but it also taught me that I work better when breaking text apart and categorizing the material. It also allows you to actually attach a meaning to the text instead of just reading it.

I learned a lot about the human heart and different studying techniques

Even though I don’t study sciences dealing with the human heart, I feel that I am a lot more knowledgeable than I have ever been about the human heart. It was a great experience to see how different learning tools can help me to understand a text better than just reading and writing down some notes on the text as a whole.

In contrast very few participants in the Treatment 1 (T1) mentioned using the reading strategies in other contexts. One participant noted, “The learning environment has helped me cover this essay and the topic about the Human Heart. Overall, I believe it was worth my time as I have prepared myself to understand and read better when I look at a paper even without the learning environment as I would still use such methods of note-taking.”

One participant in Treatment 2 (T2) seemed to develop his own *meta-strategies*—strategies for the use of the strategies in the Web-based learning environment, “I liked splitting up the text into smaller pieces, but found that it took a lot of time since I didn’t know the material prior to reading it. It’s easier to break up the text into smaller pieces if you read it straight through then organize it.”

2. Reading in the Web-based learning environment was like playing a game.

During the Phase III studies the researcher observed over 40 readers engage with the Web-based learning environment in one-on-one sessions. In the Phase IV study more than 400
participants in over 20 sessions read the instructional unit on the human heart in the Web-based learning environment. Across these sessions, the researcher observed participants engage in an unusual level of concentration as they read the instructional unit on the human heart.

Researcher’s field notes from three different sessions in the Phase IV study provide some evidence of this phenomenon (see Table 137).

Table 137. Researcher’s Field Notes: Engagement with the Reading Task Inside the Web-Based Learning Environment

[40 minutes] I can see some people rolling up their sleeves, taking off their jackets, stretching.

[95 minutes] Mr. x stretches again! Mr. z cracks his fingers...Mr. x stretches his leg and relaxes...now he is at the “bin” question and he moves back into a more alert posture.

[55 minutes] I can see a couple of people stretch. they take deep breaths.

This reminded the researcher of the *trance-like* state that many gamers find themselves in—when they get so involved in the game that they lose sense of time and surroundings (Csikszentmihalyi, 1990). The researcher observed some of the readers in the Web-based learning environment engage in similar behavior. Feedback from some of the participants provides a glimpse into this phenomenon (see Table 138).

Table 138. Feedback from Participants: Reading in the Web-Based Learning Environment was Like Playing a Game

**Treatment Condition 1 (T1)**

*it kept me involved by organizing so I had to read the entire text to see which category the element fit into*

*I liked the organization it allowed. The sections allowed you to categorize, then by the end of reading, you could ask yourself “Did I learn what this section was trying to get across?”*
I like how it was broken up into like 26 [25] different parts. This is a really smart idea because then people can be more or less like in their mind “Okay, I’m going to read 10 passages now and then do the rest later.” It allows people to set goals easier and to see it more of in parts then a huge essay to read.

Treatment Condition 2 (T2)

…it gave me a little game to play I had to organize then right summaries and take notes. If it was just text I would have read and done no note taking.

Many participants noted that they spent much more time reading in the Web-based learning environment because it was fun and engaging (see Table 139).

Table 139. Feedback from Participants: Extra Time Spent Reading in the Web-Based Learning Environment

Treatment Condition 1 (T1)

The involvement and entertainment to use such user-friendly items to read a long essay with the help of summarizing and setting the comfort meter.

I definitely spent more time learning about it. I would say 10x as much. This extra time was extremely beneficial.

I think I spend extra time in the learning environment compared to a webpage easily an hour more.

Yes. I would have had little motivation to read about the human heart before this study. I probably spent an hour more time reading about the human heart than I would have.

Treatment Condition 2 (T2)

I think that I spent more time reading it because it was so interactive. I really liked that about it.

I spent a lot more time. I frequently become bored by reading on a computer, but this kept me engaged into the reading.

Yes; with the enhanced features of the article (sections & tabular capability) I felt as though I had to complete a task along with the reading which motivated me to read further in depth with each section in order to properly categorize each section.

I spent probably more than double the time, but it was beneficial. I am also extremely tired right now, so I don’t know if the amount of extra time is even accurate.
Even though none of the feedback survey questions in the study contained the word “enjoy”, this word and its variants appeared 51 times in feedback from participants in the Web-based learning environment conditions (n = 386), i.e., almost 1 out of every 7 participants used this word in their feedback. In fact, some of the participants said that they got so engaged that they lost track of time, a behavior often exhibited by gamers (Csikszentmihalyi, 1990) (see Table 140).

Table 140. Feedback from Participants: Participants’ Loosing Sense of Time

<table>
<thead>
<tr>
<th>Treatment Condition 1 (T1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I definitely spent more time learning about it. I would say 10x as much. This extra time was extremely beneficial.</td>
</tr>
</tbody>
</table>

Yes I feel like I spent more time on this text than I do on other texts and it was beneficial. I probably spent an extra 10 - 15 minutes on this one however, unlike other article or magazines I did not look at the pictures that closely for some reason. I feel that may have been a result of how entrenched I was with the text itself. If I read most article like I read this one I would probably be a lot better off.

<table>
<thead>
<tr>
<th>Treatment Condition 2 (T2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I did not spend too much extra time but that was because I got mad at myself for taking so much longer that I just rushed through the last part of it. I kept looking at the time and thinking I do not have much time left and I need to use the time on the actual test part of it, so the amount of time I spent reading got greatly reduced by the second half of it and my concentration, among other things, suffered.</td>
</tr>
</tbody>
</table>

I did spend extra time on this, however that was a good thing. The learning environment made the reading more interesting and kept me interested, not only by its presentation, but by being able to interact. If I were to read this on a website or paper I probably would have began to skim read towards the end because I was bored.

Some participants in the Treatment 1 (T1) approached the Web-based learning environment as if they were discovering the rules of a new game or learning to use a new gadget (see Table 141). Interestingly, none of the participants in the Treatment 2 (T2) noted such feedback.
Table 141. Feedback from Participants: Discovering Rules of the Web-Based Learning Environment

Treatment Condition 1 (T1)

[I liked] Learning how to work with the system.

I think it was cool how one could use the tools given in the exercise.

I liked splitting up the text into smaller pieces, but found that it took a lot of time since I didn’t know the material prior to reading it. It's easier to break up the text into smaller pieces if you read it straight through then organize it.

3. Comparing reading in the Web-based learning environment with reading in other media.

Several participants compared reading in the Web-based learning environment with reading in other media, for example, reading on paper and reading on a regular Web page. Participants’ feedback provides insights into some of the reading processes that readers engaged in while reading in the Web-based learning environment. Many of the responses demonstrate a preference towards reading in the Web-based learning environment.

Table 142. Feedback from Participants: Comparing Reading in Learning Environment with Reading in Other Media

Treatment Condition 1 (T1)

if I did not have to or read it here, I would not have read it what so ever, especially if it was just pages in a book.

I feel like I easily learned a lot about the heart, and had I tried to read this from a text, I would have gotten bored and stopped

It would have been easier to get distracted if reading in a text book.

if I had to read that from just a book I would of got bored and shut my brain off

I would have gotten bored and gave up reading straight from the web.
I spent more than an hour reading this, but would not have spent much more than 20-30 minutes reading a webpage or paper.

I definitely think that I spent more time reading it in the learning environment. If I was to read it on a regular webpage I would have probably gotten bored and just skipped over much of the material.

Some other participants made interesting comparisons between multiple media, for example reading in the Web-based learning environment vs. reading online vs. reading from a textbook (see Table 143).

Table 143. Feedback from Participants: Comparisons Across Media

Treatment Condition 1 (T1)

Yes, reading the text in the learning environment was more beneficial than on a regular web page however not more beneficial than reading it on paper. When comparing to a normal web page the learning environment is an easier, more organized read. Comparing the learning environment to paper however I would still prefer to read on paper just because it is what I am used to and have done my entire life.

Treatment Condition 2 (T2)

I think that reading the text through the learning environment was better than reading an online article but comparable to reading something out of a textbook.

One participant said that even though it would be easier to extract the same knowledge from other sources, the Web-based learning environment just ensured that she did so, “Benefited knowledge, I agree it probably would have been harder if just given the text, but I think the knowledge would have been just as easy to interpret, this just ensured you knew it all.” It would be interesting to do a follow up interview with this participant to find out why she thought the Web-based learning environment ensured she “knew it all.”
Participants Experience with the Web-Based Human Heart Tests

More than 82% of the participants found the overall experience of responding to the human heart tests to be favorable. There was a significant difference in the overall experience of the heart tests. Participants in the control group and Treatment 2 (T2) rated their experience to be more positive (88.6%, 84.3% respectively) than participants in Treatment (T1) (73.2%). Once again, this trend can be attributed to the extrinsic cognitive load associated with reading in the Web-based learning environment when explicit instruction on the reading strategies was not provided.

Successful Induction of the Treatment

In the feedback survey at the end of the Phase IV study participants were asked whether they liked reading science texts and biology texts.

Q. Do you like reading SCIENCE texts in general?
Q. Do you like reading BIOLOGY texts in general?

Only 26% of the participants in the study said that they liked reading science texts. The percentage of people who said they liked reading biology texts was even smaller—18%. Also, participants in the study received extra credit for participation alone and not on the basis of scores obtained on the tests. In these circumstances, there was a concern that participants would not be motivated to engage with the reading task in the Web-based learning environment, i.e. the treatment would not be sufficiently induced.

In order to address this concern, several steps were taken to make participation in the study a positive and meaningful experience for the participants. To make participation in the study convenient, a Reservation Website was setup that participants could use to make
reservations for both parts of the study. Participants used this Web site to make a reservation, cancel an existing reservation, update an existing reservation or email themselves their reservation information. Participants appreciated this flexibility. The researcher believes that this flexibility in scheduling was in large part responsible for a high retention rate (students who completed the study/students who made reservations to participate in the study). Out of the 1466 students that were recruited for the study, 834 (57%) visited the Reservation Web site and made reservation for at least one part of the study. Of these 834 participants, 685 students completed both parts of the study—a retention rate of over 82%.

During the four week period that the reservation Website was available, 4716 unique visitors visited the Reservation Web site. I.e., on average, a participant visited the Web site over 5.6 times (4716/834). Out of these 4716 visits, 2998 visits were related to scheduling, rescheduling or cancelling reservations; the remainder being related to checking scheduled time or emailing reservation information. Therefore, on average, participants used over 3.6 (2998/834) attempts to schedule time slots for the two parts of the study. Clearly, participants used the option to reschedule a reservation. Participants appreciated this flexibility of scheduling and the overall organization of the study (see Table 144).

Table 144. Feedback from Participants: Flexibility and Organization of the Study

<table>
<thead>
<tr>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was really well organized! usually these things are a hassle and not worth the stress, but this was comfortable and calm.</td>
</tr>
<tr>
<td>Job well done.</td>
</tr>
<tr>
<td>I have been in many studies and this one was conducted beautifully, other than the time complaint it was perfect.</td>
</tr>
<tr>
<td>It was a fine experience. I did not mind participating in it; however, it was hard to focus as the subject matter was very foreign to me. I think this is a good way of setting up research studies though.</td>
</tr>
</tbody>
</table>
The overall experience was good. The instructions by the administrator and readings were very clear...

Very good environment for learning. Lab was quiet; proctor was very attentive. The study was very structured and organized. It was helpful to know the approximated time for each section and to split the study into many small parts rather than a few longer ones.

It was a positive overall experience in the sense that it was very informative and hands on. It was a good study and seemed that it was well prepared.

Great study. I learned a great amount of information and feel that it was organized sufficiently.

**Treatment Condition 1 (T1)**

I had a great experience. Very organized.

Well done!

**Treatment Condition 2 (T2)**

It was good. Instructions were clearly explained and everything went well. Very helpful!

Great study!

The instructor was very helpful with the study and made it easy for us to understand what was being asked.

the study was very well organized and easy to understand.

It was very easy to do, and everyone was very helpful.

Great idea and great organization.

Overall it was packed with information but only took a short amount of time to complete.

It was a good study because it was effectively organized and easy to be a part of.

very efficient.

I think overall it was good. It was very easy to do because the instructor made it simple to navigate.

Well conducted study overall.

In the feedback survey at the end of the study, participants were asked to respond to the following questions:

*Q. Rate your OVERALL EXPERIENCE in the research study.*

*Q. Was the study WORTH YOUR TIME?*
Over 92% of the participants said that their experience in the research study was positive and over 93% of the participants said that the study was worth their time. In response to the open-ended question that asked participants to comment on their overall experience in the study, several participants said they enjoyed the overall experience (see Table 145).

Table 145. Feedback from Participants: Enjoyed Participating in the Study

**Control Group**

I actually enjoyed this lab, I thought it was interesting to learn about the heart.

This was pretty interesting to do and was definitely worth taking part in.

This was a very interesting and informative experience, I enjoyed it.

I enjoyed this experience. I learned something new and gained valuable information about the human heart...

I enjoyed being in this research study because I like to participate in studies for I think they are very useful to the population and our personal learning experiences here at Penn State.

I really enjoyed this experience, it taught me a lot and was definitely worth my time and effort. I think it got me a lot more interested in the human heart.

I like this experience . . . this was my first time with a big study and it is nice to be a part of something out of the ordinary. Plus, I did learn more about the heart than I knew before.

**Treatment Condition 1 (T1)**

I enjoyed the study and hope to participate more in the future.

Good Study, very worth the time

I enjoyed participating in this study. It will help my grade, my learning experiences, and possibly my appetite.

**Treatment Condition 2 (T2)**

It was a good experience for me and it was challenging.

Worthwhile study that had me motivated to take a human anatomy course.

Thank you. This was a cool experience.

Overall, this experience has been great. I actually enjoyed the second part more than the first.

I thought it was going to be a boring test, but it ended up being beneficial and interesting to take part in a new
This is fun to do especially for me because I have hard time focusing on readings for too long...

Fun, interesting study.

enjoyable learning experience

Many participants appreciated the opportunity to participate in the study because they felt they gained new and useful knowledge (see Table 146).

Table 146. Feedback from Participants: Gaining New Knowledge

**Control Group**

*I know about the heart now. I thank you for this.*

*I learned more about the human heart in this session than I did in biology class in high school.*

*I appreciate learning about the heart simply for purposes of furthering my knowledge; however, I have never enjoyed science or biology. The fact that I had a good experience with this study is rare. I think I enjoyed it because the essay and test was made for someone to read that has never learned anything about the human body (which is me).*

*Overall this was very beneficial to me, not only did I gain extra credit which was the only thing I thought I would gain at first, but I also have much more knowledge on the heart than I did before.*

*very effective. Learned a lot more than I had thought I could in such a small amount of time.*

**Treatment Condition 1 (T1)**

*This was pretty fun to do and made me learn more about the heart.*

*This experience was good because I learned many different things. I would do it over again if given the chance.*

**Treatment Condition 2 (T2)**

*This was a very long study, but I learned a lot about the heart ...*  
*I was able to learn new things that I would not have previously taken the time to study,...*  
*enjoyed it very much. Without this study I probably would’ve never learned these things about the heart.*

*It was very educational. Good research study!*
I actually learned a lot about the heart and it wasn’t that boring.

Evidence presented above suggests that the study successfully engaged a large proportion of participants.

Limitations of the Study

Kitchen-Sink Approach to Investigating the Effects of the Reading Strategies

Given that participants in the Web-based learning environment conditions (T1 and T2) were required to use all five reading strategies, it was difficult to identify which strategies were more effective than others. As discussed in Chapter 2, four out of the five strategies designed in the Web-based learning environment (text-macrostructure, summarization, imagery and reading self-assessment) were expected to affect the construction of knowledge representations at the macro and situation model levels (macro-textbase, micro-situation model, macro-situation model). The note-taking strategy, on the other hand, was considered to be “representation neutral” in that it was expected to affect all four levels of knowledge representation. Given this, one way to address problems related to the “kitchen sink” approach to investigating the effects of the reading strategies would be to investigate one set of strategies at a time.

One-Off Interaction with the Web-Based Learning Environment

Research literature on reading strategy instruction has demonstrated that reading strategies, like other learning strategies, become internalized only with prolonged use (Ogle, 1986; Palincsar & Brown, 1984; Raphael & Au, 2005; Williams, 2007). A limitation of the
design of this study was that participants were provided a single opportunity to experience reading in the Web-based learning environment. Participants clearly did not have sufficient opportunity to become proficient with the strategies in the Web-based learning environment. As noted earlier in this chapter (see Table 126, Table 127), several participants, especially those in the Web-based learning environment condition that did not include explicit instruction on the reading strategies (T1), felt overwhelmed—not only did they have to grapple with the complexity of the instructional unit on the human heart, they also had to devote cognitive resources to make sense of the reading strategies and learn to use them.

This issue can be addressed by engaging participants in multiple reading sessions in the Web-based learning environment, each session with a different instructional unit. After four or five sessions, participants could be asked to read the instructional unit on the human heart and then respond to the Web-based human heart tests. The “metaphor” of a desktop email-client software could be used to extend the design of the Web-based learning environment for this research investigation (Carroll, 2003). This extension of the Web-based learning environment could be conceived as a three window application—(a) “login” window that readers use to log in; (b) “inbox” window in which readers “receive” documents (instructional units); readers can organize these documents into folders; and (c) “document” window in which readers read the instructional units. Screenshots for a prototype for this extension of the Web-based learning environment are included in Appendix U.

A variant of the research investigation described above would be to allow participants multiple sessions with the instructional unit on the human heart before asking them to respond to the human heart tests. In fact several participants in the current study suggested that they would have benefited more from the Web-based learning environment if they were able to engage with
the instructional unit in the Web-based learning environment in more than one sitting. The reading self-assessment (comfort-meter) strategy would become particularly relevant in this case.

**Assignment of Participants to Conditions**

Participants in the Phase IV study used a Reservation Website to book lab slots for Part 2 of the study (see Appendix S). Since participants booked a lab session without knowledge of which treatment was allotted to which lab session, participants may be considered to have been randomly assigned to conditions. There was an important concern with this manner of assignment of participants to conditions—any two participants, for example two friends, could have chosen to participate in the same lab slot as long as there were openings in that slot.

Another limitation with the research design was that conditions were assigned to lab sessions randomly. These issues could be resolved by randomly assigning lab sessions to experimental conditions and then randomly assigning participants to one of these experimental conditions. A given participant would then be able to book from only those sessions that were assigned to the participant’s experimental condition.

**Future Studies**

**Note-Taking Strategy**

Several participants in this study who used the note-taking strategy found the summarization strategy to redundant. The following is a typical response from such participants, “*I felt like the notes were pretty much the same thing as the summary. One or the other may be*
just fine.” With these participants the note-taking strategy may have prevented the summarization strategy from getting induced.

One approach to addressing this problem was discussed in the previous section—disabling the note-taking strategy and then investigating the remaining strategies. An alternative approach could be to retain the note-taking strategy, but constrain its use. This could be achieved, for example, by limiting the total number of words that are allowed per note.

**Order Effects of Tests**

Given that the Web-based learning environment design affected performance on the macro-textbase, micro-situation model, and macro-situation model tests, but not the micro-textbase test, it would be interesting to see if the order in which participants took the tests had an impact of the performance. For example, a participant in the Web-based learning environment group with demonstration that did not include explicit instruction on the reading strategies (T1) noted, “I did not like some of the quiz questions because before I took the quiz, I felt like I had learned something. I felt that the text did not help enough for the quiz.”

Another participant from the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) noted, “I definitely feel that I have benefited from this reading even though I may not have scored that well I feel I retained most of the information.”

Would these participants have had a different experience of the human heart tests, and would they have scored differently on the human hearts tests if they were asked to respond to situation model tests before the textbase tests?
Related to the idea of order effects of tests, is the idea of testing long-term retention. In the current study, participants’ knowledge of the instructional unit on the human heart was tested immediately after they read the instructional unit. It would be interesting to compare the impact of reading in the Web-based learning environment on long-term retention. In fact, this idea was suggested by a participant: “I learned a lot just by reading the text, but I started to get myself confused after seeing the same questions over and over again. I could almost feel my memory fading as I was taking the different tests. That might be an interesting study to see how the memory fades even as you are answering the same questions that you just got correct.”

Another participant noted that, “I feel like I actually learned something that will stick with me instead of just learning something for just the time you need to know it.” It would be interesting to test whether the Web-based learning environment impacted participants’ long-term retention.

Prediction Questions

What would be the impact of asking participants prediction questions before they read the instructional unit on the human heart in the Web-based learning environment (Hegarty, Kriz, & Cate, 2003)? Would participants in the Web-based learning environment condition benefit more than participants in the control group? For example, one participant in the Web-based learning environment group with demonstration that included explicit instruction on the reading strategies (T2) said that she would have benefited more from the reading strategies if she had some idea of the questions that would be asked on the tests, “I would have liked to have an idea of what kinds of questions I would be answering before I read the text to help me focus.”
Moreover, several participants were surprised by some of the questions on the tests. Providing participants representative examples of the questions on the human heart tests before they read the instructional unit on the human heart would be an interesting investigation. For example, one participant said that some knowledge of the type of questions that would be asked on the tests would have helped him prepare better for the tests, “…should let us know the types of questions ahead of time, very difficult to attempt to study an all-encompassing amount of knowledge without any idea what we will be questioned on”

Reader Profiles

On the basis of the four levels of representations used in this study (see Figure 10, Table 1 in Chapter 1), it can be postulated that for any given text, a reader starts at the origin on all four scales. I.e. before reading the text, the reader does not have any knowledge representations of the text. As the reader processes the text, she forms micro-textbase, macro-textbase, micro-situation model and macro-situation model representations of the text. In doing so, the reader continuously “moves” on the four scales. It can be postulated that the movement on these four scales is interdependent and iterative. As the reader processes text she moves outwards on each of these four scales; the movement on one scale sets the stage for the movement on another scale and so on.

The four levels of representations can also be used to construct “reader profiles.” For example in Figure 61 reader R1 is represented by four points (R1a, R1b, R1c, R1d) and another reader R2 is represented by a different set of four points (R2a, R2b, R2c, R2d). It would be interesting to see the long-term effects of reading in the Web-based learning environment on reader profiles. If readers are able to internalize the reading strategies in the Web-based learning
environment and use them effectively they should be able to create superior micro-textbase, macro-textbase, micro-situation model and macro-situation model representations of texts that they read.

![Diagram of text-macrostructure strategy]

Figure 61. Two reader profiles.

*Figure 61. Two reader profiles.*

*Scaffolding Reading in the Web-Based Learning Environment—Simulating Expert Performance*

Participants in the current study had the freedom to chunk the instructional unit on the human heart into as many sections as they wanted. What would happen if participants were provided a pre-determined list of sections (tabs on the interface)? This list could be provided by an expert in the field. In fact, this variant of the text-macrostructure strategy could be used to encourage readers to think like experts. At one level this would make the readers’ task in the
Web-based learning environment simpler by scaffolding the construction of macro-level representations. Another application of this approach could be to address misconceptions that readers may have.

*Strategies for Social Learning*

The Web-based learning environment could be used to investigate the effect of two social learning strategies that have been found to be particularly effective in online settings—online chat and asynchronous discussion. An “online chat” strategy in the Web-based learning environment would allow readers to chat with other readers who are online and reading the same instructional unit in the Web-based learning environment. The “asynchronous discussion” strategy would allow readers to share messages asynchronously. Readers in the online community could provide feedback and vote on posts posted by other members in the community. With more and more feedback from participants, documents in the Web-based learning environment would get richer.

**Conclusions**

This research study had two major goals, (a) to design and develop a Web-based learning environment that supports the use of a set of reading strategies, and (b) to investigate the impact of this Web-based learning environment on readers’ memory and understanding of an instructional unit on the human heart.

A design-based research framework guided a series of studies that addressed these research goals. The design-based research approach allowed the researcher to set up several
studies, most of them with a small number of participants, to determine what worked and what did not work in the Web-based learning environment. The Web-based learning environment, the Web-based measurement instruments, the animated demonstrations of the Web-based learning environment, and the Web-based feedback survey were updated based on data collected at various stages of the design-based research investigation.

Web-based measurement instruments that measured readers’ knowledge of the instructional unit on the human heart at four levels of knowledge representation—micro-textbase, macro-textbase, micro-situation model, and macro-situation model—were designed and validated. Several new Web technologies were used to design these measurement instruments (implementation of the autocomplete design-pattern, drag-and-drop, and AJAX). The measurement instruments were well received—82% of the participants in the study found the overall experience of responding to the human heart tests to be favorable. These measurement instruments demonstrated the use of affordances of current Web technologies in designing assessments that measure multiple levels of knowledge representations.

The Web-based learning environment went through numerous design iterations. Data from Phase III and Phase IV studies demonstrated that participants engaged deeply with the reading task in the Web-based learning environment spending nearly twice as much time reading when compared with participants who read the instructional unit on the human heart on a regular Web page. Feedback from participants indicated that some of them were able to use at least a subset of the five reading strategies effectively; several participants thought that they benefited from using these reading strategies. Overall, 87% of the participants noted that they had a favorable experience in the Web-based learning environment and over 80% wanted to use the
Web-based learning environment to read papers for courses that they would be taking the following semester.

Responses from participants to questions in the feedback survey provided insights into the cognitive and metacognitive processes that participants could have benefited from. Many participants noted that being able to break up the text into smaller sections made the task of reading the instructional unit less daunting. It is possible that by using the text-macrostructure strategy to externalize their macro-level organization of the instructional text, these participants were able to offload some of the cognitive load that is intrinsic to reading an expository text such as the instructional unit on the human heart. Participants noted that the summarization strategy made them revisit and review the sections that they had created. Some participants said that they benefited from being able to visualize the text (imagery strategy). A few participants said that the comfortmeter strategy allowed them to identify sections of the instructional unit they needed to focus more. Several participants noted that having to write notes forced them to read the text more carefully and this helped them retain the information in the text.

Participants also mentioned motivational benefits of reading in the Web-based learning environment. Some participants said that they liked reading in the Web-based learning environment because it allowed them to customize the text, which in turn gave them a sense of control. Participants felt that the Web-based learning environment motivated them to spend extra time reading which helped them learn more. Some participants said that the Web-based learning environment helped them concentrate and focus on the reading. Several participants noted that they found the reading experience in the Web-based learning environment to be satisfying. Some others noted that they found the Web-based learning environment design flexible because it could accommodate different learning styles.
This study attempted to respond to the rhetorical question posed at the beginning of Chapter 1, "Why are some people able to read better, and learn more from what they read, than others? Findings in this study indicate that the Web-based learning environment is a step in the right direction (see Table 107). Responses from two participants provide support for this claim.

It was a good experience and I think reading texts in this format may be helpful for some students who may struggle learning just by reading a textbook.

[Participant in Treatment 1 (T1)]

Yes I feel like I spent more time on this text than I do on other texts and it was beneficial. I probably spent an extra 10 - 15 minutes on this one, however, unlike other articles or magazines, I did not look at the pictures that closely for some reason. I feel that may have been a result of how entrenched I was with the text itself. If I read most articles like I read this one I would probably be a lot better off.

[Participant in Treatment 1 (T1)]

The Web-based learning environment also demonstrated potential for impacting the practice of reading strategies instruction. Several participants in the Web-based learning environment group with demonstration that included explicit instruction on reading strategies (T2) seemed to internalize at least a subset of the reading strategies in the Web-based learning environment. For example one of the participants noted, “I think this activity helped me learn and realize the different ways you can organize the text to help you retain the information better.” Another participant noted, “I know what I need to work on while I’m reading through things.” Another participant suggested, “Yes, I think it not only allowed me to learn a few things about the heart, but it also taught me that I work better when breaking text apart and categorizing the material. It also allows you to actually attach a meaning to the text instead of just reading it.” One participant in Treatment 2 (T2) seemed to develop his own meta-strategies—strategies for the use of the strategies in the Web-based learning environment, “I
liked splitting up the text into smaller pieces, but found that it took a lot of time since I didn’t know the material prior to reading it. It’s easier to break up the text into smaller pieces if you read it straight through then organize it."

A challenge commonly faced by reading instructors is that of engaging readers in the reading task. The Web-based learning environment was able to respond to this challenge (see Table 108). Feedback from one of the participants in Treatment 2 (T2) demonstrates participants’ engagement with the reading task in the Web-based learning environment, “I definitely spent more time learning about it. I would say 10x as much. This extra time was extremely beneficial”.

This research demonstrated the role that design-based research methodology can play in (a) guiding the design of technology-enhanced learning environments, (b) developing an understanding of how learners use these environments, (c) researching learning that occurs in these environments, and (d) guiding the design of technology-enhanced assessments. Findings from this research stand to inform our understanding of comprehension processes, and ways in which affordances of current Web technologies can be used to design compelling reading environments and assessments that measure learning that occurs in these environments.
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Element 1

The human heart is a hollow, bluntly conical, muscular organ. Its pumping action provides the force that circulates blood through the entire body. In the average adult, the heart is about five inches long and about two and one half inches thick. A man’s heart weighs about eleven ounces and a woman’s heart weighs about nine ounces. The heart lies toward the front of the body and is in a slanting position between the lungs, immediately below the breastbone. The wide end points toward the right shoulder while the small end of the heart points to the front of the chest and toward the left. The lower portion of the heart is called the apex and is the part that you feel beating.

In order to follow this instruction you should be able to identify the left and the right side of the heart. Imagine you are looking down at the heart of a person who is laying face-up. In this position the right side of the person’s heart will be on your left and the left side of the heart will be on your right.

Element 2

To understand the functioning of the heart you will need to be able to identify the parts of the heart. These parts are described next.

The human heart is really two pumps combined into a single organ which circulates blood to all parts of the body. The heart is divided longitudinally into halves by the septum. The two halves may be compared to a block of two houses that are independent of each other but have a common wall between them.
Element 3

Each half of the heart is divided into an upper chamber and a lower chamber; the upper chambers are called atria (left and right atrium) and the lower chambers are called ventricles (left and right ventricle). Although there is no direct communication between the right and left sides of the heart, both sides function simultaneously.

Atria act as receiving rooms for the blood while the ventricles act as pumps, moving blood away from the heart. Atria are considerably smaller in size when compared with the ventricles.

Element 4

The heart is enclosed in a thin double-walled sac. The layer which forms the outer wall of the sac is called the pericardium. The pericardium is composed of a tough, transparent, elastic tissue. It protects the heart from rubbing against the lungs and the walls of the chest. The inner portion of the double walled sac is called the epicardium. The epicardium is attached to the heart muscle which is called the myocardium.

The myocardium controls the contraction and relaxation of the heart. The myocardium constitutes by far the greatest volume of the heart and its contraction is responsible for the propulsion of the blood throughout the body. The myocardium varies in thickness. For example, the myocardium forming the atrium walls is thin when compared to the thickness of the myocardium forming the ventricle walls.

The endocardium is the name given to the inside lining of the heart wall.
Element 5

Next, let us consider the flow of blood on the right side of the heart.

Veins carry blood to the heart and arteries carry blood away from the heart. The superior and inferior vena cavae are the two veins which deposit blood in the right atrium. There are NO valves at the openings of these veins into the right atrium.

The superior vena cava brings in blood from all body parts above heart level, for example, the head and the arms. The inferior vena cava brings in blood from all body parts below the heart level, for example, the trunk and legs.

Element 6

As blood from the body fills the right atrium, some of it begins to drip into the right ventricle immediately.
Element 7

The atria and ventricles on both sides of the heart are connected with each other through openings called valves. The valve between the right atrium and right ventricle is called the tricuspid valve. This valve consists of three triangular flaps of thin, strong, fibrous tissue. These flaps permit the flow of blood into the right ventricle, but prevent it from flowing backward into the right atrium because the ends of the flaps are anchored to the floor of the right ventricle by slender tendons.

Element 8

The flaps of the tricuspid valve act like swinging doors which open only in one direction. Thus, blood from the right atrium passes through the tricuspid valve into the right ventricle. As soon as the right ventricle is filled with blood, both right and left ventricles begin to contract.

The immediate effect of the pressure produced in the right ventricle is to force blood behind the flaps of the tricuspid valve. While the blood pressure behind the flaps of the tricuspid valve increases it brings the flaps together closing the tricuspid valve. This prevents the flow of blood back into the right atrium.
Element 9

The contraction of the right ventricle continues until the blood presses hard enough to open the pulmonary valve that is located between the right ventricle and the pulmonary artery. This forces the blood into the pulmonary artery.

Note that the pulmonary valve, like the tricuspid valve, consists of three flaps. Also note that the pulmonary valve opens only when the pressure in the right ventricle is greater than the pressure in the pulmonary artery.

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Blood Leaves the Heart for Oxygenation

Element 10

As soon as the right ventricle begins to relax from its contraction, the pressure exerted on the pulmonary valve from the ventricle side decreases while the pressure from the pulmonary artery side begins to increase as blood that has just passed through the valve begins backing up in the pulmonary artery. This causes the pulmonary valve to slam shut preventing blood in the pulmonary artery from flowing back into the right ventricle.
Element 11

The pulmonary artery carries oxygen-poor blood from the heart to both the left and right lungs where it is cleansed and oxygenated before its return to the heart.

In the illustration at right, the blue indicates oxygen-poor blood on its way to the lungs and the red indicates the oxygen-rich blood returning to the heart from the lungs.

Element 12

Next, let us consider the flow of blood on the left side of the heart.

Returning from the lungs, the blood enters the heart through four pulmonary veins and collects in the left atrium.

Like the right atrium, the left atrium also contracts when it is full, squeezing blood through the mitral valve which is located between the left atrium and the left ventricle. The left ventricle now begins to fill up.
Element 13

As soon as the left ventricle is full, it begins to contract. This contraction forces blood behind the flaps of the mitral valve, thereby closing it and preventing blood from flowing back into the left atrium.

Element 14

When the left ventricle which is filled with blood contracts, the resulting pressure in the ventricles opens the aortic valve that is located between the left ventricle and the aorta. Opening of the aortic valve forces blood into the aorta. The aorta is the large artery which carries blood from the left ventricle and feeds the rest of the body.

Note that it is the contraction of the left ventricle that pumps the blood through the entire body. While all four chambers have important roles, the left ventricle is the true workhorse of the heart. For this reason it is the largest, strongest, and most muscular (thickest) section of the heart.
Element 15

Until now we have followed the blood flow in the heart in a sequential, linear manner. In reality several movements in the heart occur simultaneously and in parallel. We will consider this next.

The directional flow of blood in the heart is determined by valves which allow the blood to flow in only one direction. These sets of valves are the tricuspid and mitral valves, which control the flow of blood from the atria to the ventricles, and the pulmonary and aortic valves which control the flow of blood from the ventricles to the arteries.

Element 16

Both atria receive blood simultaneously through vein openings which have no valves. The right atrium receives its blood through the superior and inferior vena cava, while the left atrium receives its blood from the lungs via the pulmonary veins.
Element 17

A wave of muscular contraction starts at the top of the heart and passes downward, simultaneously, over both sides of the heart; that is, both atria contract at the same time and then relax as the contraction passes down to the ventricles. When the atria contract they become small and pale. Because of the contraction, blood in these chambers is subjected to increased pressure which forces blood through the opened tricuspid and mitral valves into the ventricles.

As the ventricles fill, eddies (swirling motion of blood) float the flaps of the tricuspid and mitral valves back to a partially closed position.

Element 18

As soon as the contraction of the atria is complete they begin to relax and the ventricles are stimulated into contraction. Contraction of the ventricles increases the pressure in the ventricle chambers forcing the tricuspid and mitral valves to completely close, thereby preventing blood from being forced backwards into the atria.

Note that both atria receive a continuous blood flow from the vena cavae and the veins.
Element 19

As the ventricles continue to contract, pressure in these chambers force the pulmonary and aortic valves to open. The pulmonary valve, leading from the right ventricle, guards the entrance to the pulmonary artery. The aortic valve, leading from the left ventricle, guards the entrance to the aorta or aortic artery.

Both these valves have three flaps, and are together known as the semi-lunar valves. Prior to ventricle contraction, the valves are closed by back-pressure provided by blood that is already in the exit arteries. Because of ventricular contraction, the pressure in the ventricles increases and eventually becomes greater than the pressure in the exit arteries. When this occurs the semi-lunar valves open.

Element 20

With the semi-lunar valves open, oxygen-poor blood (blue) flows from the right ventricle into the pulmonary artery which carries it to the lungs for cleaning and oxygenation. Simultaneously, oxygen-rich blood (red) flows from the left ventricle into the aorta for distribution throughout the body.
Element 21

Immediately following the pumping of blood into the arteries, the ventricles begin to relax. This relaxation lowers the pressure within their chambers and the greater back pressure in the arteries closes the semi-lunar valves. Pressure within the ventricles is still sufficient, however, to maintain closure of the tricuspid and mitral valves against the already increasing atrial pressure.

Element 22

As the ventricles relax further, pressure within them rapidly decreases. At the same time blood flowing into the atria from the veins increases the pressure in the atria. As soon as the pressure in the atria becomes greater than the pressure in the ventricles, the tricuspid and mitral valves are forced to open partially.

The circulation of blood through the heart begins again with the next atrial contraction. Increased atrial pressure fully opens the tricuspid and mitral valves resulting in a rapid flow of blood into the ventricles.
Finally let us consider the two distinct phases of blood pressure caused by the contraction and relaxation of the heart.

In the diastolic phase, the heart relaxes between contractions. Blood flows into the heart, filling both atria. During this phase the ventricles are also relaxing. The ventricles are slowly being filled with blood, because of the full atria and partially opened tricuspid and mitral valves.

Although the arteries still maintain part of the pressure developed by a prior ventricular contraction, this is the time of lowest pressure in the arteries, or what is called the diastolic pressure.

The second phase, the systolic or contraction phase, begins when the atria contract. The blood is forced through the tricuspid and mitral valves into the ventricles. The ventricles then contract forcing the blood through the semi-lunar valves into the pulmonary and aortic arteries.

The blood leaves the ventricles under terrific pressure and surges through the arteries with a force so great that it bulges their elastic walls. At this point, arterial blood pressure is greatest; we refer to this pressure as the systolic pressure.
After this, the heart is ready for another cycle of relaxation and contraction—the diastolic phase begins all over again; the heart relaxes. The semi-lunar valves are closed because of back pressure; blood flows into the atria from the veins; and the tricuspid and mitral valves are forced partially open.
Appendix B: Phase I Study—Instructions Sheet and Response Sheet

We have broken the Human Heart text into 25 “elements.” Each element is printed on a separate card. After reading through the text, try to group these cards under different “sections.” For example, upon reading the text I felt that this particular text has four logical parts, and so I organized the cards into four sections - Section $\alpha$, Section $\beta$, Section $\Gamma$ and Section $\delta$.

After you have finished grouping the cards, please note down your organization on the form that follows. Put the title of the sections in the top row. Note the number of the element(s) (you can find this number on the back of the card) that you put in each section under the title for that section. If you do this we will be able to “capture” how you went about organizing these cards into different sections.

Continuing with my example of breaking down the text into four sections…Here’s what my form looked like:

<table>
<thead>
<tr>
<th>Title</th>
<th>Section $\alpha$</th>
<th>Section $\beta$</th>
<th>Section $\Gamma$</th>
<th>Section $\delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element 1</td>
<td>1</td>
<td>8</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>Element 2</td>
<td>9</td>
<td>12</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Element 3</td>
<td>10</td>
<td>13</td>
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<tr>
<td>Element 4</td>
<td>14</td>
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<tr>
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<tr>
<td>Element 6</td>
<td>16</td>
<td>23</td>
<td></td>
<td></td>
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<tr>
<td>Element 7</td>
<td>17</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Element</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Of course, we just make up this example! The names that you choose for your section(s) would be more descriptive than what we have here : )

Thanks and happy chunking!
| Title |
|-------|---|---|---|---|---|---|---|---|---|
| Element |
| Element |
| Element |
| Element |
| Element |
| Element |
| Element |
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| Element |
| Element |
| Element |
| Element |
| Element |

Note: Ask if you need an additional form.
Appendix C: Micro-Textbase Test (Set 1)

Directions: In the questions that follow please enter the term that you feel best identifies the part of the heart indicated by the numbered arrows.

1. Arrow number (1) points to the _____  
AORTA

2. Arrow number (2) points to the _____  
SUPERIOR VENA CAVA

3. Arrow number (3) points to the _____  
RIGHT ATRIUM

4. Arrow number (4) points to the _____  
PULMONARY VALVE

5. Arrow number (5) points to the _____  
INFERIOR VENA CAVA
6. Arrow number (6) points to the _____
   TRICUSPID VALVE

7. Arrow number (7) points to the _____
   RIGHT VENTRICLE

8. Arrow number (8) points to the _____
   PERICARDIUM

9. Arrow number (9) points to the _____
   ENDOCARDIUM

10. Arrow number (10) points to the _____
    SEPTUM

11. Arrow number (11) points to the _____
    EPICARDIUM

12. Arrow number (12) points to the _____
    APEX

13. Arrow number (13) points to the _____
    MYOCARDIUM

14. Arrow number (14) points to the _____
    LEFT VENTRICLE

15. Arrow number (15) points to the _____
    TENDONS

16. Arrow number (16) points to the _____
    MITRAL VALVE

17. Arrow number (17) points to the _____
    AORTIC VALVE

18. Arrow number (18) points to the _____
    LEFT ATRIUM

19. Arrow number (19) points to the _____
    PULMONARY VEINS

20. Arrow number (20) points to the _____
    PULMONARY ARTERY
Appendix D: Micro-Textbase Test (Set 2)

Directions: In the questions that follow please enter the answer you feel best completes the sentences.

1. The phase in which the heart contacts is called the _____.
   SYSTOLIC phase

2. The phase during which blood pressure in the arteries is the lowest is called the _____.
   DIASTOLIC phase

3. The strongest chamber of the heart is the _____.
   LEFT VENTRICLE

4. Vessels that carry blood from the heart to the rest of the body are called _____.
   ARTERIES

5. The heart muscle is called the _____.
   MYOCARDIUM

6. The inside lining of the heart wall is called the _____.
   ENDOCARDIUM

7. The membrane which borders on the inside lining of the pericardium and is connected to the heart muscle is called the _____.
   EPICARDIUM

8. Part(s) of the heart that allow(s) blood to travel in one direction only is (are) called _____.
   VALVES

9. The valve that connects the right atrium and the right ventricle is called the _____.
   TRICUSPID VALVE

10. Vessels that carry blood from the rest of the body to the heart are called _____.
    VEINS

11. The valve that connects the left atrium and the left ventricle is called the _____.
    MITRAL VALVE

12. The outside covering of the heart is called the _____.
    PERICARDIUM
13. The chamber of the heart which pumps oxygenated blood to the rest of the body is called the ______.
LEF T V ENTRICLE

14. The wall that separates the left side and the right side of the heart is called the ______.
SEPTUM

15. The semi-lunar valves are located at the entrance to the ______.
All four combinations are correct:
PULMONARY AND AORTIC ARTERIES
AORTIC AND PULMONARY ARTERIES
AORTA AND PULMONARY ARTERY
PULMONARY ARTERY AND AORTA
Appendix E: Macro-Textbase Test

Question 1

Some of the sentences in the following list APPEAR in the Human Heart text you just read while others DO NOT. Select those sentences that you think belong to the human heart text.

Note that your score on this question will be the number of sentences marked correctly MINUS the number of sentences marked incorrectly.

- In the average adult, the heart is about five inches long and about two and one half inches thick.
- The two halves may be compared to a block of two houses that are independent of each other but have a common wall between them.
- On average, the human heart beats 60 times a minute.
- Although there is no direct communication between the right and left sides of the heart, both sides function simultaneously.
- The atria are about the same size when compared with the ventricles.
- Veins carry blood to the heart and arteries carry blood away from the heart.
- When the atria contract they become small and pale.
- Both these valves have three flaps, and are together known as the semi-lunar valves.

Answer Key (1, 1, 0, 1, 0, 1, 1, 1)

- In the average adult, the heart is about five inches long and about two and one half inches thick.
- The two halves may be compared to a block of two houses that are independent of each other but have a common wall between them.
- (x) On average, the human heart beats 60 times a minute.
- Although there is no direct communication between the right and left sides of the heart, both sides function simultaneously.
- (x) The atria are about the same size when compared with the ventricles.
- Veins carry blood to the heart and arteries carry blood away from the heart.
- When the atria contract they become small and pale.
- Both these valves have three flaps, and are together known as the semi-lunar valves.
Question 2

The following sentences are from the heart instruction that you just read. Based on your memory of the text, re-order the sentences in the order in which they appear in the instruction.

- The blue represents oxygen poor blood on its way to the lungs and the red signifies the oxygen rich blood returning to the heart from the lungs.
- The superior vena cava brings in blood from all body parts above heart level, for example, the head and the arms.
- Both atria receive blood simultaneously through vein openings which have no valves.
- A man’s heart weighs about eleven ounces and a woman’s heart weighs about nine ounces.
- The myocardium varies in thickness. For example, the myocardium forming the atrium walls is thin when compared to the thickness of the myocardium forming the ventricle walls.

Answer Key (4, 5, 2, 1, 3)

- A man’s heart weighs about eleven ounces and a woman’s heart weighs about nine ounces.
- The myocardium varies in thickness. For example, the myocardium forming the atrium walls is thin when compared to the thickness of the myocardium forming the ventricle walls.
- The superior vena cava brings in blood from all body parts above heart level, for example, the head and the arms.
- The blue represents oxygen poor blood on its way to the lungs and the red signifies the oxygen rich blood returning to the heart from the lungs.
- Both atria receive blood simultaneously through vein openings which have no valves.
Question 3

The following sentences introduce “new” sections in the Human Heart text. Your task is to arrange these sentences in the order in which they appear in the text.

- Let us consider the flow of blood on the right side of the heart.
- Let us consider the two distinct phases of blood pressure caused by the contraction and relaxation of the heart.
- You should be able to identify the left and the right side of the heart.
- In reality several movements in the heart occur simultaneously and in parallel.
- Let us consider the flow of blood on the left side of the heart.
- To understand the functioning of the heart you will need to be able to identify the parts of the heart.

Answer Key (3, 6, 1, 5, 4, 2)

- You should be able to identify the left and the right side of the heart.
- To understand the functioning of the heart you will need to be able to identify the parts of the heart.
- Let us consider the flow of blood on the right side of the heart.
- Let us consider the flow of blood on the left side of the heart.
- In reality several movements in the heart occur simultaneously and in parallel.
- Let us consider the two distinct phases of blood pressure caused by the contraction and relaxation of the heart.
Appendix F: Micro-Situation Model Test

Directions: In the questions that follow please select the answer you feel best completes the sentences.

1. Blood from the right ventricle is carried to the lungs by the ______.
   AORTIC ARTERY
   *PULMONARY ARTERY
   PULMONARY VEINS
   SUPERIOR VENA CAVA

2. When blood returns to the heart from the lungs, it enters the _____.
   *LEFT ATRIUM
   RIGHT ATRIUM
   LEFT VENTRICLE
   RIGHT VENTRICLE

3. Blood from the left ventricle is carried to the rest of the body by the _____.
   *AORTIC ARTERY
   PULMONARY VEINS
   PULMONARY ARTERY
   SUPERIOR VENA CAVA

4. Blood from the body enters the heart through the _____.
   AORTIC ARTERY
   PULMONARY VEINS
   *SUPERIOR AND INFERIOR VENA CAVAS
   PULMONARY ARTERY

5. Immediately before entering the aorta, blood must pass through the _____.
   LEFT ATRIUM
   MITRAL VALVE
   RIGHT ATRIUM
   *AORTIC VALVE

6. Which valve on the left side of the heart acts as the counterpart of the tricuspid valve?
   PULMONARY
   AORTIC
   *MITRAL
   SUPERIOR VENA CAVA
7. When blood is being forced out the right atrium, in which position is the tricuspid valve?
   BEGINNING TO OPEN
   BEGINNING TO CLOSE
   *OPEN
   CLOSED

8. When blood is being forced out the aorta, it is also being forced out of the _____.
   PULMONARY VEINS
   *PULMONARY ARTERY
   SUPERIOR VENA CAVA
   LUNGS

9. The contraction impulse in the heart starts in _____.
   THE RIGHT ATRIUM
   BOTH VENTRICLES SIMULTANEOUSLY
   *BOTH ATRIA SIMULTANEOUSLY
   THE LEFT ATRIUM

10. In the diastolic phase the ventricles are _____.
    CONTRACTING, FULL OF BLOOD
    CONTRACTING, PARTIALLY FULL OF BLOOD
    RELAXING, FULL OF BLOOD
    *RELAXING, PARTIALLY FULL OF BLOOD

11. During the first-stage contraction of the systolic phase (atrial contraction), in what position will the mitral valve be?
    *OPEN
    CLOSED

12. During the second-stage contraction of the systolic phase (ventricular contraction), blood is being forced away from the heart via the _____.
    *PULMONARY AND AORTIC ARTERIES
    SUPERIOR AND INFERIOR VENA CAVAS
    TRICUSPID AND MITRAL VALVES
    PULMONARY VEINS

13. When blood is entering the heart through the vena cavas, it is also entering it through the _____.
    MITRAL VALVE
    *PULMONARY VEINS
    PULMONARY ARTERY
    AORTA
14. When heart contracts, the _____.
   ATRIA AND VENTRICLES CONTRACT SIMULTANEOUSLY
   VENTRICLES CONTRACT FIRST, THEN THE ATRIA
   RIGHT SIDE CONTRACTS FIRST, THEN THE LEFT SIDE
   *ATRIA CONTRACT FIRST, THEN THE VENTRICLES

15. When blood leaves the heart through the pulmonary artery, it is also simultaneously leaving
the heart through the _____.
   TRICUSPID VALVE
   PULMONARY VEINS
   *AORTA
   SUPERIOR AND INFERIOR VENA CAVAS

16. When the ventricles contract, blood is forced through the _____.
   SUPERIOR AND INFERIOR VENA CAVAS
   PULMONARY VEINS
   TRICUSPID AND MITRAL VALVES
   *PULMONARY AND AORTIC VALVES

17. If the aortic valve is completely open, the _____.
   *SECOND CONTRACTION OF THE SYSTOLIC PHASE IS OCCURRING
   DIASTOLIC PHASE IS OCCURRING
   TRICUSPID AND MITRAL VALVES ARE COMPLETELY OPEN
   BLOOD IS RUSHING INTO THE RIGHT AND LEFT VENTRICLES
Appendix G: Macro-Situation Model Test

Directions: In the questions that follow please select the answer you feel best completes the sentences.

1. When pressure in the right ventricle is greater than that in the pulmonary artery, in what position is the tricuspid valve?
   * CLOSED
   OPEN
   BEGINNING TO CLOSE
   BEGINNING TO OPEN

2. Blood that is leaving the heart via the aorta had previously left the heart via the __________.
   SUPERIOR VENA CAVA
   PULMONARY VEINS
   * PULMONARY ARTERY
   TRICUSPID AND MITRAL VALVES

3. When pressure in the right ventricle is greater than that in the aorta, in what position is the mitral valve?
   CLOSED
   * OPEN
   BEGINNING TO CLOSE
   BEGINNING TO OPEN

4. When the tricuspid and mitral vales are forced shut, in what position is the pulmonary valve?
   CLOSED
   BEGINNING TO CLOSE
   * OPEN
   SUSPENDED

5. Upon being forced out of the atria, the blood __________.
   ENTERS THE VENA CAVAS
   PASSES THROUGH THE PULMONARY AND AORTIC VALVES
   * PASSES THROUGH THE TRICUSPID AND MITRAL VALVES
   PASSES THROUGH THE PULMONARY ARTERY

6. When the heart relaxes, the __________.
   RIGHT SIDE RELAXES FIRST, THEN THE LEFT SIDE
   LEFT SIDE RELAXES FIRST, THEN THE RIGHT SIDE
   * ATRIA RELAX FIRST, THEN THE VENTRICLES
   VENTRICLES RELAX FIRST, THEN THE ATRIA
7. At the doctor's office the nurse measures your blood pressure and notes two readings—your high blood pressure and your low blood pressure. Let us suppose your readings are 120 and 80.
   a) What are the ventricles doing when your blood pressure is 120?
      RELAXING
      CONTRACTING
   b) What are the ventricles doing when the blood pressure is 80?
      RELAXING
      CONTRACTING

8. As the ventricles contract, what you think happens to the:
   a) tricuspid valve
      OPENS
      CLOSES
   b) mitral valve
      OPENS
      CLOSES
   c) aortic valve
      OPENS
      CLOSES
   d) pulmonary valve
      OPENS
      CLOSES

9. When the atrial pressure becomes greater than the ventricular pressure, what is the position of the:
   a) tricuspid valve
      OPEN
      CLOSED
   b) mitral valve
      OPEN
      CLOSED
10. Below, on the left, you are provided a list of 20 parts of the human heart and on the right are 6 empty bins. In your mind organize the parts of the heart into groups and then drag and drop them from the list on the left into bins on the right. Move as many parts into bins as you like. You do not have to use all six bins but you MUST label the bins that you fill.

Example: Given the list \{Red, Pennsylvania, New Jersey, Yellow, Tree, Blue\} you might drag and drop \{Red, Yellow, Blue\} into a bin and name it “Color” and then drag and drop \{Pennsylvania, New Jersey\} into a bin and name that bin “States.” You might decide to leave Tree unmoved.
11. Imagine you are sitting in a tiny submarine that is about to enter the heart at the location indicated by the arrows in the diagram below. In your mind imagine the path you would take inside the heart and other parts of the body if you were to follow the blood flow. Based on this, rearrange the following sentences so that they represent your path.

- Pass through the tricuspid valve.
- Flow to the rest of the body.
- Enter the right atrium through the superior and inferior vena cava.
- As blood is pumped out of the right ventricle, pass through the pulmonary valve.
- Pass through the mitral valve.
- Travel to the lungs.
- Enter the left atrium via the pulmonary veins that carry oxygenated blood.
- As blood is pumped out of the left ventricle, pass through the aortic valve.

**Answer Key (3, 1, 4, 6, 7, 5, 8, 2)**

- Enter the right atrium through the superior and inferior vena cava.
- Pass through the tricuspid valve.
- As blood is pumped out of the right ventricle, pass through the pulmonary valve.
- Travel to the lungs.
- Enter left atrium via the pulmonary veins that carry oxygenated blood.
- Pass through the mitral valve.
- As blood is pumped out of the left ventricle, pass through the aortic valve.
- Flow to the rest of the body.
12. A library of images is presented below. Your task in this question is to pick ONE image that best represents your “mental image” of the text you just read. Which image would this be?

You can view larger versions of the images displayed in the left panel by hovering-over or clicking on an image. When you are ready to submit your response, select the checkbox below the image in the right panel and click on the next button.
13. Finally, please take a few minutes to write a short summary (50-100 words) of what you learned in the human heart text. Include only what you consider to be the most important information.
Appendix H: Knowledge of Human Anatomy

Directions: In the questions that follow please enter the answer you feel best completes the sentences.

1. The hardest part of the tooth is the _____.
   root
dentin
cementum
*enamel

2. The digestion of food occurs principally in the_____.
   stomach
   *small intestine
   mouth
   large intestine

3. Contraction of the smooth muscle in the digestive tract is called _____.
   *peristalsis
digestion
diastasis
locomotion

4. Worn-out red blood cells are decomposed in the _____.
   heart
   small intestine
   kidneys
   *liver

5. Sweating is a primary means of _____.
   reduction of blood cholesterol
   opening of pores
   reduction of body weight through fluid loss
   *regulation of body temperature

6. Endocrine glands produce _____.
   cytoplasm
   endoplasm
   *hormones
   serums
7. The body is stimulated during stressful activity by increased secretion from the _____.
   pancreas
   *adrenal gland
   thyroid gland
   thymus gland

8. The spinal cord is made up of _____.
   bone tissue
   cartilage tissue
   connective tissue
   *nerve tissue

9. Nerves from the eyes and ears are connected to the _____.
   cerebellum
   *cerebrum
   medulla
   spinal cord

10. The ribs form joints at the front of the body at the _____.
    thorax
    cartilage
    diaphragm
    *sternum

11. The ribs protect the _____.
    diaphragm
    sternum
    spinal cord
    *lungs

12. The hollow interior of the long bones is filled with _____.
    periosteum
    *marrow
    osseous tissue
    endosteum

13. The trachea is located _____ the esophagus.
    *in front of
    behind
    to the left of
    to the right of
14. The carbon dioxide-oxygen exchange occurs in the _____.
   left ventricle
   trachea
   *lungs
   esophagus

15. Blood is oxygenated in the capillaries of the _____.
   aorta
   *alveoli
   heart
   pulmonary artery

16. During inspiration, the ribs _____.
   do not move
   move downward
   move inward
   *move upward

17. The part of the brain that controls respiration is the _____.
    *medulla
    cerebellum
    cerebrum
    spinal cord

18. The body is defended against infectious disease by _____.
    hemoglobin
    *white blood cells
    red blood cells
    blood platelets

19. The disease hemophilia is associated with _____.
    formation of white blood cells
    *blood clotting
    nerve cells
    formation of red corpuscles

20. The liquid that bathes every cell and acts as a medium of exchange is called _____.
    *extracellular fluid
    serum
    lymph
    fibrin
21. Urine is stored in the _____.
   - urethra
   - kidney
   *bladder
   - ureters

22. Inability of the eye to focus on distant objects is called _____
   - astigmatism
   - myopia
   - refraction
   - hyperopia

23. Inactivity of the thyroid gland from infancy may produce a condition known as _____.
   - diabetes
   - beriberi
   *cretinism
   - Addison's disease

24. Diabetes is caused by the improper functioning of the _____.
   - thymus
   - thyroid gland
   *pancreas
   - adrenal gland

25. Blood enters the heart through the _____.
   - arteries
   - capillaries
   - aorta
   *veins

26. Blood leaves the heart through the _____.
   - inferior vena cava
   *arteries
   - superior vena cava
   - veins

27. The part of the heart that divides it into right and left halves is called the _____.
   - myocardium
   - tendons
   - pericardium
   *septum

28. The blood vessel that carries deoxygenated blood to the lungs is called the _____.
   - aorta
   *pulmonary artery
   - hepatic artery
   - pulmonary vein
29. The backward flow of blood in the veins to the heart is prevented by the _____.
   muscles
   *valves
   septum
   lymph ducts

30. The chamber of the heart which pumps oxygenated blood to all the parts of the body is the _____.
   left atrium
   right ventricle
   right atrium
   *left ventricle
Appendix I: Phase II Study—Recruitment Email and Informed Consent Form

Recruitment Email

Hello!

Thank you for taking the time to read this message.

We are asking for volunteers, individuals like yourself, who are currently enrolled in the summer session of EGEE 102 at Penn State to participate in a research study that is investigating the use of advanced Web 2.0 technologies for designing online tests. During the study you will experience a cutting edge online testing environment—we expect that you will enjoy this experience! If you COMPLETE the study you will receive extra credit for your class that amounts to 2% of the entire course grade. This is equivalent to 18 points on the final exam.

If you do not want to participate in this study, but would still like to earn the extra credit, you will have the option to read a research article related to this course and prepare a one-page reaction to it. You will get details about this option upon signing up for the study by visiting the link provided below.

The study has two parts. You must complete Part 1 of the study to be able to complete Part 2.

<table>
<thead>
<tr>
<th>Part</th>
<th>Items</th>
<th>Duration</th>
<th>Open</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part1</td>
<td>You will be asked to complete the Human Anatomy and Spatial Ability tests.</td>
<td>25 minutes</td>
<td>Sun, Jul 27, 2008 (12:00 AM) —&gt; Sat, Aug 02, 2008 (11:59 PM)</td>
</tr>
<tr>
<td>Part2</td>
<td>You will read a 2000-word text on the human heart. After this you will be asked to respond to five sets of questions that will test your knowledge of the human heart.</td>
<td>90 minutes</td>
<td>Sat, Aug 02, 2008 (12:00 AM) —&gt; Sun, Aug 10, 2008 (11:59 PM)</td>
</tr>
</tbody>
</table>

For you to be able to participate in the study you have to reserve slots for both parts of the study. You can do so by visiting the link below:

http://learning-research.com/reservation/

Upon making a reservation you will be emailed the link to the study Web site.

Please note that you must be 18 years or older to participate in the study.
any concerns or questions about this study, please do not hesitate to contact me.

Sincerely,

Khusro Kidwai

Doctoral Candidate in Instructional Systems
315 Keller Building University Park, PA 16802
Phone: (814) 441-0210
Email: khk122@psu.edu
Informed Consent Form

Title of Project: Investigating the use of Web 2.0 technologies for developing cognitive tests

Principal Investigator: Khusro Kidwai,  
Doctoral Candidate in Instructional Systems  
315 Keller Building, University Park, PA 16802  
Phone: (814) 441-0210 | Email: khk122@psu.edu

Doctoral Advisor: Dr. Barbara Grabowski  
310E Keller Building, University Park, PA 16802  
Phone: (814) 863-7380 | Email: blg104@psu.edu

Other Investigator(s): Peggy van Meter, Frank Dwyer, Chris Hoadley

1. **Purpose of the Study:** The purpose of this research study is to explore the use of Web 2.0 technologies in the development of cognitive tests.

2. **Procedures to be followed:** There are two parts to this study:
   - Part 1: You will be asked to complete the Human Anatomy and Spatial Ability tests.
   - Part 2: You will read a short text on the human heart. After this they will be asked to respond to five sets of questions that will test your knowledge of the human heart.


4. **Benefits:** During this study you will have an opportunity to interact with a cutting-edge Web 2.0 testing environment. By participating in this study you will earn extra credit for your class which amounts to 2% of the entire course grade. If you do not want to participate in this study, you have another option to receive the extra credit. For this you will be asked to prepare a one-page (450-500 words) response to an assignment on a topic related to the course. You will be provided details about this option if you choose to not participate in this study.

5. **Statement of Confidentiality:** Your responses will be recorded confidentially. In the event of any publication or presentation resulting from the research, no personally identifiable information will be shared. Your confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties.
6. **Right to Ask Questions:** Please contact Khusro Kidwai at (814)441-0210 or email khk122@psu.edu with questions or concerns about this study.

7. **Voluntary Participation:** Your decision to participate in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Completion and submission of the online tests implies that you have read the information in this form and consent to take part in the research. Please print this form to keep for your records.
Appendix J: Phase II Study—Screenshots of Study Web Sites

Online Reservation

Hello and welcome to the Online Reservation Web page of the Human Heart Study.

There are two parts to Human Heart study both of which can be completed online. On this Web page you will be able to book time slots for completing the two parts of the study.

Remember, for each part of the study you will be allowed access to the study Web site only WITHIN 30 minutes of the time that you book on this page. You can revisit this Web site to reschedule or cancel a booking.

Upon making a reservation you will be emailed the link to the study Web site as well as further instructions.

<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Open During</th>
<th>Booking</th>
<th>Modify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>30 minutes</td>
<td>Sun, Jul 27, 2008 (12:00 AM) —&gt; Fri, Aug 08, 2008 (11:59 PM)</td>
<td>You have not booked a slot yet. Book a slot</td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td>60 minutes</td>
<td>Fri, Aug 01, 2008 (12:00 AM) —&gt; Sun, Aug 10, 2008 (11:59 PM)</td>
<td>You have not booked a slot yet. Book a slot</td>
<td></td>
</tr>
</tbody>
</table>

If you have questions, do not hesitate to contact Khusro Kidwai @ kkh122@psu.edu.

Figure J1. Reservation Website—No reservations made yet.
Figure J2. Booking a time slot for Part 1 of the study.
**Online Reservation**

Hello and welcome to the Online Reservation Web page of the Human Heart Study.

There are two parts to Human Heart study both of which can be completed online. On this Web page you will be able to book time slots for completing the two parts of the study.

Remember, for each part of the study you will be allowed access to the study Web site only WITHIN 30 minutes of the time that you book on this page. You can revisit this Web site to reschedule or cancel a booking.

Upon making a reservation you will be emailed the link to the study Web site as well as further instructions.

<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Open During</th>
<th>Booking</th>
<th>Modify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>30 minutes</td>
<td>Sun, Jul 27, 2008 (12:00 AM) — Fri, Aug 01, 2008 (11:59 PM)</td>
<td>Fri, Aug 01, 2008 8:45 AM</td>
<td>Update Booking, Cancel Booking, Email Info, Study Web site</td>
</tr>
<tr>
<td>Part 2</td>
<td>90 minutes</td>
<td>Fri, Aug 01, 2008 (12:00 AM) — Sun, Aug 10, 2008 (11:59 PM)</td>
<td>You have not booked a slot yet.</td>
<td>Book a slot</td>
</tr>
</tbody>
</table>

If you have questions, do not hesitate to contact Khusro Kidwai @ kkh122@psu.edu.

*Figure J3. Reservation Website—Slot booked for Part 1 of the study.*
Hello and welcome to the Human Heart Study!

There are two parts to this study:

- In Part 1, you will take the Human Anatomy Test and the Spatial Ability Test.
- In Part 2, you will first read a 2000-word essay on the Human Heart. After reading the essay, you will be asked to respond to five sets of questions that will test your knowledge of the human heart.

The entire study can be completed online. You can participate in Part 2 of the study only after you have completed Part 1 of the study.

Below you will find information on your participation status in the study. This status will change as you complete tests. You will be allowed access to the two parts of the study only within 30 minutes of the times that you have booked.

### Part 1

<table>
<thead>
<tr>
<th>Test</th>
<th>Duration</th>
<th>Status</th>
<th>Reservation</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Anatomy [30 questions]</td>
<td>10 minutes</td>
<td>Completed</td>
<td>Fri, Aug 01 2008 8:45 AM</td>
<td></td>
</tr>
<tr>
<td>Spatial Ability [40 questions]</td>
<td>15 minutes</td>
<td>Completed</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Part 2

<table>
<thead>
<tr>
<th>Test</th>
<th>Duration</th>
<th>Status</th>
<th>Reservation</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instruction (~2000 words)</td>
<td>30 minutes</td>
<td>Open</td>
<td></td>
<td>Open</td>
</tr>
<tr>
<td>Test01a [20 questions]</td>
<td>10 minutes</td>
<td></td>
<td></td>
<td>Read the Essay</td>
</tr>
<tr>
<td>Test01b [15 questions]</td>
<td>10 minutes</td>
<td>Open</td>
<td>Sat, Aug 02 2008 6:10 PM</td>
<td>You must read the essay before taking this test</td>
</tr>
<tr>
<td>Test02 [13 questions]</td>
<td>5 minutes</td>
<td></td>
<td></td>
<td>You must complete Test01b before taking this test</td>
</tr>
<tr>
<td>Test03 [17 questions]</td>
<td>10 minutes</td>
<td></td>
<td></td>
<td>You must complete Test02 before taking this test</td>
</tr>
<tr>
<td>Test04 [13 questions]</td>
<td>15 minutes</td>
<td></td>
<td></td>
<td>You must complete Test03 before taking this test</td>
</tr>
</tbody>
</table>

Figure J4. Study Website—Part 1 completed; starting Part 2.
Appendix K: Phase II Study—DLD Algorithm

```c
int DamerauLevenshteinDistance(char str1[1..lenStr1], char str2[1..lenStr2])
// d is a table with lenStr1+1 rows and lenStr2+1 columns
declare int d[0..lenStr1, 0..lenStr2]
// i and j are used to iterate over str1 and str2
declare int i, j, cost

for i from 0 to lenStr1
    d[i, 0] := i
for j from 1 to lenStr2
    d[0, j] := j

for i from 1 to lenStr1
    for j from 1 to lenStr2
        if str1[i] = str2[j] then cost := 0
        else cost := 1
        d[i, j] := minimum(
            d[i-1, j] + 1,     // deletion
            d[i  , j-1] + 1,     // insertion
            d[i-1, j-1] + cost   // substitution
        )
        if(i > 1 and j > 1 and str1[i] = str2[j-1] and str1[i-1] = str2[j]) then
            d[i, j] := minimum(
                d[i, j],
                d[i-2, j-2] + cost // transposition
            )

return d[lenStr1, lenStr2]
```
Appendix L: Phase III Study—Recruitment Email and Informed Consent Form

Recruitment Email

Hello,

Thank you for taking the time to read this message. We are seeking volunteers, individuals like yourself, to participate in a research study on the impact of a Web 2.0 learning environment that is designed to support a set of reading comprehension strategies (for example note-taking, reorganizing paragraphs and images on a Web page by dragging-dropping etc.).

**Procedures to be followed:** There are two parts to this study. Each participant is expected to complete both parts.

- **Part 1:** You will be asked to complete a human-anatomy and a spatial ability test. Both these tests can be completed online.
- **Part 2:** You will be asked to read a short text on the human heart in a Web 2.0 learning environment. A subset (one out of five) of the participants will be randomly chosen to read the human heart text on-page. If you choose to participate in the shorter version of Part 2, this will be your last step in Part 2. If on the other hand you choose to participate in the longer version for Part 2, you will be asked to respond to a set of questions that will test your knowledge and understanding of the human heart text. Payment for participation will differ depending on the condition you choose to participate in (see below).

**Duration:** Part 1 and Part 2 together will take less than 1.5 hour or 3 hours depending on the condition you participate in.

**Payment for participation:** By participating in this study you will earn extra credit for your class which amounts to 2% of the entire course grade. If you do not want to participate in this study, but would still like to earn the extra credit, you will be asked to prepare a one-page response to a question related to your course. You will be provided further details about this option if you choose to not participate in this study. For your participation in the study you will also receive a $10 or a $25 dining certificate(s) for a local restaurant (valid on a minimum purchase of $15 and $35 respectively) depending on the condition you participate in (1.5 or 3 hours).

Participation in this study is not required. You must be 18 years or older to participate in the study.

In order to participate in the study you will have to book timeslots in advance for both parts of the study. Part 1 can be completed online, at any time within a one week time frame, from any location. Part 2 will take place in a lab and specific time slots will be available for participation.
These time slots will be booked on a **first-come-first-serve** basis. You will be able to book time slots for both parts starting 8pm, Wednesday, October 1, 2008 by visiting the link below. Please use your Penn State ID to login.

http://learning-research.com/reservation/

You can visit this link before 8pm, Wednesday, October 1, 2008, but you will not be able to book until this time.

Upon making a reservation you will be emailed detailed directions for participation in both parts of the study.

If at any time, you have any concerns or questions about this study, please do not hesitate to contact me.

Sincerely,

Khusro Kidwai,
Doctoral Candidate in Instructional Systems
315 Keller Building
University Park, PA 16802
Phone: (814) 441-0210
Email: khk122@psu.edu
Informed Consent Form

Title of Project: Investigating the use and impact of a Web 2.0 learning environment that is designed to support the use of a set of reading comprehension strategies.

Principal Investigator: Khusro Kidwai,
Doctoral Candidate in Instructional Systems
315 Keller Building, University Park, PA 16802
Phone: (814) 441-0210 | Email: khk122@psu.edu

Doctoral Advisor: Dr. Barbara Grabowski
310E Keller Building, University Park, PA 16802
Phone: (814) 863-7380 | Email: blg104@psu.edu

Other Investigator(s): Dr. Peggy van Meter, Dr. Frank Dwyer, Dr. Chris Hoadley

1. Purpose of the Study: The purpose of this research is to investigate the impact of a Web 2.0 learning environment that is designed to support the use of a set of reading comprehension strategies.

2. Procedures to be followed: There are two parts to this study:
   - Part 1: You will be asked to complete a human-anatomy and a spatial ability test. Both these tests can be completed online.
   - Part 2:
     a. You will be asked to read a short text on the human heart in a Web 2.0 learning environment. A subset (one out of five) of the participants will be randomly chosen to read the human heart text on-page. During this step we will use screen capture software, and audio-video equipment to record your interactions with the human heart text in the learning environment.
     b. You will be asked to respond to a short list of questions about your experience with the learning environment.
     c. If you choose to participate in the shorter version of Part 2, this will be your last step in Part 2.
     d. If on the other hand you choose to participate in the longer version for Part 2, you will be asked to respond to a set of questions that will test your knowledge and understanding of the human heart text.

Payment for participation will differ depending on the condition you choose to participate in (see below).
3. **Duration:** Part 1 and Part 2 together will take less than 1.5 hour or 3 hours depending on the condition you participate in.

4. **Payment for participation:** During this study you will have an opportunity to learn about the human heart and interact with a Web 2.0 learning environment as well as measurement instruments that are developed with cutting-edge technology. By participating in this study you will earn extra credit for your class which amounts to 2% of the entire course grade. If you do not want to participate in this study, but would still like to earn the extra credit, you will be asked to prepare a one-page response to a question related to your course. You will be provided further details about this option if you choose to not participate in this study. For your participation in the study you will also receive a $10 or a $25 dining certificate(s) for a local restaurant (valid on a minimum purchase of $15 and $35 respectively) depending on the condition you participate in (1.5 or 3 hours).

5. **Statement of Confidentiality:** Your responses will be recorded confidentially. Your confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties.

6. **Video, Audio and Screen Capture Data:** All video, audio and screen capture recordings will be stored in digital format on an external hard drive that will be placed securely in the principal investigator’s office. All recordings will be retained only for a period of five years after the date of approval of this study. During this time only the investigators listed on the IRB application for this research will have access to this data. Please note below if you would like to give us permission for recording your interaction with the learning environment and using segments of these recordings at conference presentations:

- [ ] I allow video, audio, and screen capture recordings of my interactions with the learning environment.
- [ ] I do not allow video, audio, and screen capture recordings of my interactions with the learning environment.
- [ ] I allow that segments of the video, audio, and screen capture recordings made of my participation in this research may be used for conference presentations.
- [ ] I do not allow that segments of the video, audio, and screen capture recordings made of my participation in this research may be used for conference presentations.

7. **Right to Ask Questions:** Please contact Khusro Kidwai at (814)441-0210 or email khk122@psu.edu with questions or concerns about this study.

8. **Voluntary Participation:** Your decision to participate in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.
Participation in the study implies that you have read the information in this form and consent to take part in the research. You may print this page or download a pdf copy of the consent form for your records.

Click on the Agree button below if you have read this information and consent to take part in the research.

If you do not want to participate in the study but would still like to earn the extra credit by writing a one page reaction paper, click on the Disagree button. This will take you to a Web page with information on the extra credit assignment that is related to your course.
Appendix M: Phase III Study—Screen Shots of Web sites

Online Reservation

Hello and welcome to the Online Reservation Web page of the Learning Environment study.

There are two parts to the Learning Environment study. In order to receive the extra credit for your class you must complete both parts of the study. On this Web page you will be able to book time slots for participating in the two parts of the study.

**Part 1** can be completed online. This Part will take less than 30 minutes to complete. **Note:** You will be allowed access to this part of the study only **WITHIN** 30 minutes of the time that you book for this Part through this Web page.

**Part 2** will take place in a lab. **Note:** You can only participate in this Part of the study **AFTER** you have completed Part 1. Reservation of slots for this part of the study will be on a first-come-first-serve basis — booking opens at 8pm on Tuesday, October 14, 2008.

**Note:** You can revisit this Web site to update or cancel your booking. Upon making a reservation you will be receive an email with further instructions. If you do not receive this email please contact Khusro Kidwai (khk122@psu.edu).

<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Open During</th>
<th>Booking</th>
<th>Modify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>30 minutes</td>
<td>Tue, Oct 14, 2008 (12:00 AM) —&gt; Fri, Oct 31, 2008 (11:59 PM)</td>
<td>You have not booked a slot yet.</td>
<td>Book a slot</td>
</tr>
<tr>
<td>Part 2</td>
<td>1—2 hours*</td>
<td>Wed, Oct 15, 2008 —&gt; Fri, Oct 31, 2008</td>
<td>You have not booked a slot yet.</td>
<td>Book a slot</td>
</tr>
</tbody>
</table>

**Payment:**

<table>
<thead>
<tr>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 hour</td>
<td>3% extra credit + $10 dining certificate for a local restaurant (valid on a minimum purchase of $15)</td>
</tr>
<tr>
<td>2 hours</td>
<td>3% extra credit + $25 dining certificate for a local restaurant (valid on a minimum purchase of $35)</td>
</tr>
</tbody>
</table>

If you have questions, do not hesitate to contact Khusro Kidwai @ khk122@psu.edu.

*Figure M1.* Reservation Website—No reservations made yet.
### Online Reservation

Select a Date and Time for Completing Part 1 of the Study

Select the starting time for a 30-minute time slot. You can choose any time between: 
**Tue, Oct 14, 2008 (12:00 AM) → Fri, Oct 31, 2008 (11:59 PM)**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>October 2008</strong></td>
<td></td>
</tr>
<tr>
<td>Su Mo Tu We Th Fr Sa</td>
<td></td>
</tr>
<tr>
<td>28 29 30 1 2 3 4</td>
<td></td>
</tr>
<tr>
<td>5 6 7 8 9 10 11</td>
<td></td>
</tr>
<tr>
<td>12 13 14 15 16 17 18</td>
<td></td>
</tr>
<tr>
<td>19 20 21 22 23 24 25</td>
<td></td>
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<tr>
<td>26 27 28 29 30 31 1</td>
<td></td>
</tr>
<tr>
<td><strong>November 2008</strong></td>
<td></td>
</tr>
<tr>
<td>Su Mo Tu We Th Fr Sa</td>
<td></td>
</tr>
<tr>
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</tr>
<tr>
<td>23 24 25 26 27 28 29</td>
<td></td>
</tr>
<tr>
<td>30 1 2 3 4 5 6</td>
<td></td>
</tr>
</tbody>
</table>

*Figure M2. Booking a time slot for Part 1 of the study.*
Figure M3. Booking a lab session for Part 2 of the study.
Online Reservation

Hello and welcome to the Online Reservation Web page of the Learning Environment study.

There are two parts to the Learning Environment study. In order to receive the extra credit for your class you must complete both parts of the study. On this Web page you will be able to book time slots for participating in the two parts of the study.

Part 1 can be completed online. This Part will take less than 30 minutes to complete. Note: You will be allowed access to this part of the study only WITHIN 30 minutes of the time that you book for this Part through this Web page.

Part 2 will take place in a lab. Note: You can only participate in this Part of the study AFTER you have completed Part 1. Reservation of slots for this part of the study will be on a first-come-first-serve basis — booking opens at 5pm on Tuesday, October 14, 2008.

Note: You can revisit this Web site to update or cancel your booking. Upon making a reservation you will be receive an email with further instructions. If you do not receive this email please contact Khusro Kidwai (khk122@psu.edu).

<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Open During</th>
<th>Booking</th>
<th>Modify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>30 minutes</td>
<td>Tue, Oct 14, 2008 (12:00 AM) — Fri, Oct 31, 2008 (11:59 PM)</td>
<td>Tue, Oct 21 2008 7:00 PM</td>
<td>Modify booking anyway Cancel booking Email Info Study Web site</td>
</tr>
<tr>
<td>Part 2</td>
<td>1—2 hours*</td>
<td>Wed, Oct 15, 2008 — Fri, Oct 31, 2008</td>
<td>Tuesday, October 21, 2008, 4:30pm—5:30pm</td>
<td>Modify booking anyway Cancel booking Email Info Study Web site</td>
</tr>
</tbody>
</table>

*Payment:

1 hour  3% extra credit + $10 dining certificate for a local restaurant (valid on a minimum purchase of $15)
2 hours ** 3% extra credit + $25 dining certificate for a local restaurant (valid on a minimum purchase of $35)

If you have questions, do not hesitate to contact Khusro Kidwai @ khk122@psu.edu.

Figure M4: Reservation Website—Slots booked for Part 1 and Part 2 of the study.
Hello and welcome to the Learning Environment study!

There are two parts to this study.

**Part 1** can be completed online. This part includes a human-anatomy and a spatial ability test. Links to both these tests will become available on this page WITHIN 30 minutes of the time that you booked for this Part.

**Part 2** will take place in a lab. Your reservation status (date and location) for this Part is displayed below.

**Note:** You can participate in Part 2 of the study only after you have completed Part 1 of the study.

### Part 1

<table>
<thead>
<tr>
<th>Test</th>
<th>Duration</th>
<th>Status</th>
<th>Reservation</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Anatomy [30 questions]</td>
<td>10 minutes</td>
<td>Completed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Ability [40 questions]</td>
<td>15 minutes</td>
<td></td>
<td>Tue, Oct 21 2008 7:00 PM</td>
<td>Take the Test</td>
</tr>
</tbody>
</table>

### Part 2

**Tuesday, October 21, 2006, 4:30pm—5:30pm**  
Please try to reach room 433, EEB (Earth and Engineering Sciences building) 10 minutes before the scheduled time. See [map](#).  

[Modify Booking](#)

*Figure M5. Study Website—Part 1 in progress; Part 2 booked.*
Appendix N: Phase III Study—Equipment Checklist

<table>
<thead>
<tr>
<th>Date:</th>
<th>Student</th>
<th>Video Camera</th>
<th>WebCam</th>
<th>MP3 Recorder 1</th>
<th>MP3 Recorder 2</th>
<th>Screen Capture Software</th>
<th>Sign-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student ID:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time:</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Student ID:</td>
<td></td>
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<td></td>
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<tr>
<td>Time:</td>
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<tr>
<td>Student ID:</td>
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</tr>
<tr>
<td>Time:</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student ID:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix O: Phase III Study—Paper-Form of Web-Based Learning Environment Checklist

Checklist

Your task today is to read the Human Heart text that is provided to you in a booklet. The same text is printed on 25 cards (let’s call these cards Elements). As you read through the text, organize it into Sections. You do this by moving Elements (cards) inside Sections. Each Section can have one or more Elements.

For each Section that you create, you should attach the following:
- Summary (Red Post-its)
- Image(s)*
- Comfort-meter

You can also attach Notes (Yellow Post-its) to individual Elements.

* You can attach more than one image to a Section. Use as many images from the library of images as you like. You do not have to use all the images in the library.
Appendix P: Phase III Study—Paper-Form of Web-based Learning Environment Props

Figure. Labels used by participants to label sections; checklist for summarization, imagery and comfort-meter strategies on the right.

Figure. Comfort-meter used by participants for the sections they created.

Figure. An example of an image from the library of images used in the paper-form of the Web-based learning environment.
Appendix Q: Phase III Study—Feedback survey

**Demographics**

Please indicate your Gender: 〇 Female 〇 Male

Do you like reading SCIENCE texts in general? 〇 Yes 〇 No

Do you like reading BIOLOGY texts in general? 〇 Yes 〇 No

| Rate your knowledge of the human heart **BEFORE** participating in this study. |
|---|---|---|
| No Response | Very Poor | Very High |

| Rate your knowledge of the human heart **AT THIS TIME**. |
|---|---|---|
| No Response | Very Poor | Very High |

| How **MOTIVATED** were you to participate in this study? |
|---|---|---|
| No Response | Not at all Motivated | Extremely Motivated |

| How **DIFFICULT** did you find **READING** the essay on the Human Heart? |
|---|---|---|
| No Response | Not at all Difficult | Extremely Difficult |
Experience in the Learning Environment

How would you rate your overall experience in the Learning Environment?

The following strategies are designed in the Learning Environment. Please tell us how useful you found each of these strategies.

<table>
<thead>
<tr>
<th>The following strategies are designed in the Learning Environment. Please tell us how useful you found each of these strategies.</th>
<th>No Response</th>
<th>Not at all Useful</th>
<th>Extremely Useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Breaking-up the text into smaller pieces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Note-taking</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Preparing Summaries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Attaching Images</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Setting the Comfort-meter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What features did you like in the Learning Environment?

What did you not like about the Learning Environment? What would you like changed?

Do you think you benefited from reading the Human Heart text in the Learning Environment?

Do you think you spent more time reading the Human Heart text in the Learning Environment when compared with the time you would have spent reading the same text on a regular Web page or on paper? If yes, by how much? Do you think this extra time spent was beneficial?

Finally, would you like to use this Learning Environment to read papers for courses that you will be taking next semester?

Yes  No
Experience with the Heart Tests

Rate your OVERALL EXPERIENCE of the TESTS that you just completed.

<table>
<thead>
<tr>
<th>How EFFECTIVE did you find these TESTS in measuring your knowledge of the Human Heart essay?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Response</td>
</tr>
</tbody>
</table>

Briefly note down any COMMENTS that you may have regarding your experience with the TESTS. For example, what you liked and did not like about them.
Overall Experience in the Research Study

Rate your OVERALL EXPERIENCE in the research study.

Was the study WORTH YOUR TIME?

Briefly note down any COMMENTS that you may have regarding your OVERALL EXPERIENCE in this research study.
Recruitment Email

Hello,

Thank you for taking the time to read this message. We are seeking volunteers, individuals like yourself, to participate in a research study on the impact of a Web-based learning environment.

**Procedures to be followed:** There are two parts to this study. You will be asked to complete both parts. Part 1 of the study can be completed online, at any time, from any location. You will be asked to visit a computer lab on the University Park campus to participate in Part 2.

- Part 1: You will complete a human-anatomy and a spatial ability test.
- Part 2: You will read a short text on the human heart. After reading the text you will be asked to respond to a set of questions that will test your knowledge and understanding of the human heart text. You will also be asked to respond to two short surveys.

**Duration:** Part 1 will require less than 30 minutes. You will need about 2 hours to complete Part 2.

**Payment for participation:** By participating in this study you will earn extra credit for your class which amounts to 3% of the entire course grade. If you score 90% or more on the tests in Part 2 you will receive a $25 dining certificate for a local restaurant (valid on a minimum purchase of $35). Participants who score 80-89% on tests in Part 2 will receive a $10 dining certificate for a local restaurant (valid on a minimum purchase of $15).

If you do not want to participate in this study, but would still like to earn the 3% extra credit, you will be asked to prepare a three-page response (1500 words) to a question related to your course. Your response will be graded. If you score 90% or more you will receive a $25 dining certificate for a local restaurant (valid on a minimum purchase of $35). If you score 80-89% you will receive a $10 dining certificate for a local restaurant (valid on a minimum purchase of $15). You will be provided further details about this option if you choose to not participate in this study.

Participation in this study is not required. You must be 18 years or older to participate in the study.

In order to participate in the study you will have to book timeslots in advance for both parts of the study. Time slots for Part 2 will be booked on a first-come-first-serve basis. You can make reservations for both parts of the study by visiting: http://www.learning-research.com/reservation
Upon making a reservation you will be emailed detailed directions for participation in both parts of the study.

If at any time, you have any concerns or questions about this study, please do not hesitate to contact me.

Sincerely,

Khusro Kidwai,
Doctoral Candidate in Instructional Systems
315 Keller Building
University Park, PA 16802
Phone: (814) 441-0210
Email: khk122@psu.edu
Informed Consent Form

Title of Project: Investigating the impact of a Web-based learning environment that is designed to support the use of a set of reading comprehension strategies.

Principal Investigator: Khusro Kidwai, Doctoral Candidate in Instructional Systems 315 Keller Building, University Park, PA 16802 Phone: (814) 441-0210 | Email: khk122@psu.edu

Doctoral Advisor: Dr. Barbara Grabowski 310E Keller Building, University Park, PA 16802 Phone: (814) 863-7380 | Email: blg104@psu.edu

Other Investigator(s): Dr. Peggy van Meter, Dr. Frank Dwyer, Dr. Chris Hoadley

1. **Purpose of the Study:** The purpose of this research is to investigate the impact of a Web-based learning environment.

2. **Procedures to be followed:** There are two parts to this study. You will be asked to complete both parts. Part 1 of the study can be completed online, at any time, from any location. You will be asked to visit a computer lab on the University Park campus to participate in Part 2.
   - Part 1: You will complete a human-anatomy and a spatial ability test.
   - Part 2: You will read a short text on the human heart. After reading the text you will be asked to respond to a set of questions that will test your knowledge and understanding of the human heart text. You will also be asked to respond to two short surveys.

3. **Duration:** Part 1 will require less than 30 minutes. You will need about 2 hours to complete Part 2.

4. **Payment for participation:** By participating in this study you will earn extra credit for your class which amounts to 3% of the entire course grade. If you score 90% or more on the tests in Part 2 you will receive a $25 dining certificate for a local restaurant (valid on a minimum purchase of $35). Participants who score 80-89% on tests in Part 2 will receive a $10 dining certificate for a local restaurant (valid on a minimum purchase of $15).

If you do not want to participate in this study, but would still like to earn the 3% extra credit, you will be asked to prepare a three-page response (1500 words) to a question related to your course. Your response will be graded. If you score 90% or more you will receive a $25 dining certificate for a local restaurant (valid on a minimum purchase of $35). If you score
80-89% you will receive a $10 dining certificate for a local restaurant (valid on a minimum purchase of $15). You will be provided further details about this option if you choose to not participate in this study.

5. **Statement of Confidentiality:** Your responses will be recorded confidentially. Your confidentiality will be maintained to the degree permitted by the technology used. Specifically, no guarantees can be made regarding the interception of data sent via the Internet by any third parties.

6. **Right to Ask Questions:** Please contact Khusro Kidwai at (814)441-0210 or email khk122@psu.edu with questions or concerns about this study.

7. **Voluntary Participation:** Your decision to participate in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer.

You must be 18 years of age or older to take part in this research study.

Participation in the study implies that you have read the information in this form and consent to take part in the research. You may print this page or download a pdf copy of the consent form for your records.

Click on the Agree button below if you have read this information and consent to take part in the research.

If you do not want to participate in the study but would still like to earn the extra credit by writing a three-page response to a question related to your course, click on the Disagree button. This will take you to a Web page with information on the alternative extra credit assignment.
Learning Environment Study — Online Reservation

Hello and welcome to the Reservation Web-site for the Learning Environment Study.

There are two parts to the Learning Environment study, in order to receive the extra credit for your class you must complete both parts of the study. On this Web page you will be able to book time slots for participating in the two parts of the study.

Part 1 can be completed online and from any location. This Part will take less than 30 minutes to complete. **Note:** You will be allowed access to this part of the study only **WITHIN 30 minutes of the time that you book for this Part through this Web page.**

Part 2 will take place in labs on the University Park campus. **Note:** You can only participate in this Part of the study AFTER you have completed Part 1. Reservation of slots for this part of the study will be on a first-come-first-serve basis — booking opens at 5:00 pm on Wednesday, November 26, 2008.

**Note:** You can revisit this Web site to update or cancel your booking. Upon making a reservation you will be receive an email with further instructions for completing the study. If you do not receive this email please contact Khusro Kidwai (khk122@psu.edu).

<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Open During</th>
<th>Booking</th>
<th>Modify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>30 minutes</td>
<td>Sat, Nov 22, 2008 (12:00 AM) -&gt; Sun, Nov 20, 2008 (11:59 PM)</td>
<td>You have not booked a slot yet. Book a slot</td>
<td></td>
</tr>
<tr>
<td>Part 2</td>
<td>2 hours</td>
<td>Mon, Dec 01, 2008 -&gt; Fri, Dec 12, 2008</td>
<td>You have not booked a slot yet. Book a slot</td>
<td></td>
</tr>
</tbody>
</table>

If you have questions, do not hesitate to contact Khusro Kidwai @ khk122@psu.edu.

*Figure S1. Reservation Website—No reservations made yet.*
### Online Reservation

Select a Date and Time for Completing Part 1 of the Study

Select the starting time for a 30-minute time slot for completing Part 1 of the study. You can choose any time between: Sat, Nov 22, 2008 (12:00 AM) --> Sun, Nov 30, 2008 (11:59 PM)

**Note:** You will be allowed access to Part 1 of the study only WITHIN 30 minutes of the time that you book here.

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 2008</td>
<td></td>
</tr>
<tr>
<td>Su Mo Tu We Th Fr Sa</td>
<td></td>
</tr>
<tr>
<td>26 27 28 29 30 31 1</td>
<td></td>
</tr>
<tr>
<td>2  3  4  5  6  7  8</td>
<td></td>
</tr>
<tr>
<td>9 10 11 12 13 14 15</td>
<td></td>
</tr>
<tr>
<td>16 17 18 19 20 21 22</td>
<td></td>
</tr>
<tr>
<td>23 24 25 26 27 28 29</td>
<td></td>
</tr>
<tr>
<td>30 1 2 3 4 5 6</td>
<td></td>
</tr>
</tbody>
</table>

Figure S2. Booking a time slot for Part 1 of the study.
**Available Lab Slots**

Please book one of the following lab slots. Upon making a reservation you will receive an email confirming your reservation.

**Note 1:** Reservation is on a first-come, first-served basis.
**Note 2:** You can revisit this website anytime to update or cancel your booking.

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Time Slot</th>
<th>Lab Location</th>
<th>Seats Remaining</th>
<th>Sign Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>December 01, 2008</td>
<td>3:30pm - 5:30pm</td>
<td>Bou - Room 112</td>
<td>45</td>
<td>○</td>
</tr>
<tr>
<td>Mon</td>
<td>December 01, 2008</td>
<td>6:30pm - 8:30pm</td>
<td>Bou - Room 214</td>
<td>75</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 02, 2008</td>
<td>11:00am - 1:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 02, 2008</td>
<td>2:30pm - 4:30pm</td>
<td>Cad - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 02, 2008</td>
<td>5:30pm - 7:30pm</td>
<td>Cad - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 03, 2008</td>
<td>1:15pm - 3:15pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 03, 2008</td>
<td>4:00pm - 6:00pm</td>
<td>IST - Room 203</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 03, 2008</td>
<td>7:00pm - 9:00pm</td>
<td>IST - Room 203</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Thu</td>
<td>December 04, 2008</td>
<td>12:00noon - 2:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Thu</td>
<td>December 04, 2008</td>
<td>4:00pm - 6:00pm</td>
<td>Bou - Room 112</td>
<td>45</td>
<td>○</td>
</tr>
<tr>
<td>Thu</td>
<td>December 04, 2008</td>
<td>7:00pm - 9:00pm</td>
<td>Bou - Room 112</td>
<td>45</td>
<td>○</td>
</tr>
<tr>
<td>Fri</td>
<td>December 05, 2008</td>
<td>11:10am - 1:10pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Fri</td>
<td>December 05, 2008</td>
<td>2:30pm - 4:30pm</td>
<td>Cad - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Fri</td>
<td>December 05, 2008</td>
<td>5:30pm - 7:30pm</td>
<td>Cad - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Sat</td>
<td>December 06, 2008</td>
<td>11:00am - 1:00pm</td>
<td>Cad - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Sat</td>
<td>December 06, 2008</td>
<td>2:00pm - 4:00pm</td>
<td>Cad - Room 134</td>
<td>55</td>
<td>○</td>
</tr>
<tr>
<td>Sun</td>
<td>December 07, 2008</td>
<td>3:00pm - 5:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Sun</td>
<td>December 07, 2008</td>
<td>6:00pm - 8:00pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Mon</td>
<td>December 08, 2008</td>
<td>11:10am - 1:10pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Mon</td>
<td>December 08, 2008</td>
<td>4:00pm - 6:00pm</td>
<td>Bou - Room 112</td>
<td>45</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 09, 2008</td>
<td>1:15pm - 3:15pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 09, 2008</td>
<td>3:30pm - 5:30pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Tue</td>
<td>December 09, 2008</td>
<td>6:00pm - 8:00pm</td>
<td>Cad - Room 134</td>
<td>50</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 10, 2008</td>
<td>1:15pm - 3:15pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 10, 2008</td>
<td>3:30pm - 5:30pm</td>
<td>War - Room 108</td>
<td>35</td>
<td>○</td>
</tr>
<tr>
<td>Wed</td>
<td>December 10, 2008</td>
<td>4:00pm - 6:00pm</td>
<td>IST - Room 203</td>
<td>38</td>
<td>○</td>
</tr>
</tbody>
</table>

*Figure S3. Booking a lab session for Part 2 of the study.*
Learning Environment Study — Online Reservation

Hello and welcome to the Reservation Web-site for the Learning Environment Study.

There are two parts to the Learning Environment study. In order to receive the extra credit for your class you must complete both parts of the study. On this Web page you will be able to book time slots for participating in the two parts of the study.

Part 1 can be completed online and from any location. This Part will take less than 30 minutes to complete. Note: You will be allowed access to this part of the study only WITHIN 30 minutes of the time that you book for this Part through this Web page.

Part 2 will take place in labs on the University Park campus. Note: You can only participate in this Part of the study AFTER you have completed Part 1. Reservation of slots for this part of the study will be on a first-come-first-serve basis — booking opens at 5:00 pm on Wednesday, November 26, 2008.

Note: You can revisit this Web site to update or cancel your booking. Upon making a reservation you will be receive an email with further instructions for completing the study. If you do not receive this email please contact Khusro Kidwai (khh122@psu.edu).

<table>
<thead>
<tr>
<th>Part</th>
<th>Duration</th>
<th>Open During</th>
<th>Booking</th>
<th>Modify</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>30 minutes</td>
<td>Sat, Nov 22, 2008 (12:00 AM) —&gt; Sun, Nov 30, 2008 (11:59 PM)</td>
<td>Sat, Nov 22 2008 7:00 PM</td>
<td>Update / Cancel Booking, Cancel Booking, Email Info, Study Web site</td>
</tr>
<tr>
<td>Part 2</td>
<td>2 hours</td>
<td>Mon, Dec 01, 2008 —&gt; Fri, Dec 12, 2008</td>
<td>Tue, December 02, 2008 5:30pm - 7:30pm Cedar - Room 134</td>
<td>Update Booking, Cancel Booking, Email Info, Study Web site</td>
</tr>
</tbody>
</table>

Note: Please try to reach the lab 10 minutes before the start time.

If you have questions, do not hesitate to contact Khusro Kidwai @ khh122@psu.edu.

Figure S4. Reservation Website—Slots booked for Part 1 and Part 2 of the study.
Hello and welcome to the Learning Environment Study!

There are two parts to this study. Part 1 of the study can be completed online and from any location. You will be asked to visit a computer lab on the University Park campus to participate in Part 2.

- In Part 1, you will take the Human Anatomy Test and the Spatial Ability Test.
- In Part 2, you will first read a 2000-word essay on the Human Heart. After reading the essay, you will be asked to respond to five sets of questions that will test your knowledge of the human heart.

Below you will find information on your participation status in the study. This status will change as you complete items.

**Note 1:** You can participate in Part 2 of the study only after you have completed Part 1 of the study.

**Note 2:** You will be allowed access to Part 1 of the study only within 30 minutes of the times you have booked. You can reschedule your reservation at any time.

### Part 1

<table>
<thead>
<tr>
<th>Test</th>
<th>Duration</th>
<th>Status</th>
<th>Reservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Anatomy</td>
<td>10 minutes</td>
<td>Completed</td>
<td>Sat, Nov 22 2008 7:00 PM</td>
</tr>
<tr>
<td>[30 questions]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spatial Ability</td>
<td>15 minutes</td>
<td>Take the Test</td>
<td></td>
</tr>
<tr>
<td>[40 questions]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Part 2

<table>
<thead>
<tr>
<th>Reservation</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tue, December 02, 2008 5:30pm – 7:30pm Cedar - Room 134</td>
<td>Update / Cancel Booking</td>
</tr>
<tr>
<td>Note: Please try to reach the lab 10 minutes before the start time.</td>
<td></td>
</tr>
</tbody>
</table>

*Figure S5. Study Website—Part 1 in progress; Part 2 booked.*
Appendix T: Phase IV Study—Welcome Script

Control Group

Introductory Remarks

Thanks for completing Part 1 of the study. Your participation in the study is valuable to us. Today you are here to complete the 2\textsuperscript{nd} and final part of the study. In this part you will read an essay on the human heart. After reading the essay you will respond to questions. I will tell you more about these questions shortly. Even though the text that you read is not directly related to your course, the research in this study stands to impact online learning.

Benefits

There are several benefits for participating in this study:

- You will be receiving extra credit points for your course. You should be able to track these in ANGEL during the week of 12/15.
- You have a chance to win $25 or $10 dining certificates for local restaurant.
- You will learn everything you would ever want to learn about the human heart!
- And you will contribute to research on online Learning Environments.

We hope you will find the experience enjoyable.

Procedure

- You will be asked to read a 2000 word text on the human heart. The essay on the human heart is complex.
- After this you will be asked to respond to a series of tests. These tests will cover different types of knowledge. For example, some questions test facts while others test for deeper understanding.
- The tests can be VERY CHALLENGING, especially if you don’t read the essay carefully. On the other hand, if you read the essay carefully, you will find the tests relatively easy and hopefully fun too.
- REMEMBER that all the information that you need to answer the questions on the tests is included in the essay. SO READ CAREFULLY.

Final Remarks

You can spend as much time as you like reading the essay and answering questions. Your experience can be quite demanding and intense so be prepared. Different people in this room are assigned slightly different conditions, and this means that you might take a little more or a little less time than others in the room.

Once again, we thank you for your participation in the study.
Treatment Groups

Introductory Remarks

Thanks for completing Part 1 of the study. Your participation in the study is valuable to us. Today you are here to complete the 2\textsuperscript{nd} and final part of the study. In this part you will read an essay on the human heart inside a Learning Environment that is designed to help you read better. After reading the essay you will respond to questions. I will tell you more about this shortly. Even though the text that you read is not directly related to your course, the research in this study stands to impact online learning.

Benefits

There are several benefits for participating in this study:

- You will be receiving extra credit points for your course. You should be able to track these in ANGEL during the week of 12/15.
- You have a chance to win $25 or $10 dining certificates for local restaurant.
- You will learn everything you would ever want to learn about the human heart!
- And you will contribute to research on online Learning Environments.

We hope you will find the experience enjoyable.

Procedure

- You will be asked to read a 2000 word text on the human heart. You will do this inside a Learning Environment. The essay on the human heart is complex.
- After this you will be asked to respond to a series of tests. These tests will cover different types of knowledge. For example, some questions test facts while others test for deeper understanding.
- The tests can be VERY CHALLENGING, especially if you don’t read the essay carefully. On the other hand, if you read the essay carefully, you will find the tests relatively easy and hopefully fun too.
- REMEMBER that all the information that you need to answer the questions on the tests is included in the essay. SO READ CAREFULLY.

Final Remarks

You can spend as much time as you like reading the essay and answering questions. Your experience can be quite demanding and intense so be prepared. Different people in this room are assigned slightly different conditions, and this means that you might take a little more or a little less time than others in the room. Once again, we thank you for your participation in the study.
Appendix U: Extension of the Web-based Learning Environment

Figure U1. “Login” window

Figure U2. “Inbox” window
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Vita

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