DOES HYPERTEXT DISADVANTAGE LESS ABLE READERS?

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ABSTRACT

This article reports on an investigation of the relationship between print and hypertext reading skills in university students. The study employed a counterbalanced repeated measures design that required subjects to answer questions using both print and hypertext versions of a student advising handbook. Two research questions guided the study. One question explored whether readers in general experience greater difficulty with hypertext than they do in traditional print. The second question focused specifically on what, if any, differential disadvantage might be experienced by less able print readers. Significant effects included a practice effect, a general format effect favoring print over hypertext, and a question-set effect. The study supports the claim that readers find hypertext more difficult, but there was no evidence that hypertext differentially disadvantages less able print readers.

INTRODUCTION

We are reminded daily in the popular press that the World Wide Web has seen explosive growth that has surprised even the most forward thinking futurists of just a few years ago. As is often true with new technologies, however, our capacity to implement new technologies is far more developed than our understanding of what it means for the older methods and materials that are being augmented or replaced. More specifically, we now know how to “do” hypertext, but it is not at all clear we know what the consequences are for our theories and practices in literacy, learning, and instruction.

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The problems associated with the "meaning" of new technologies have more commonly been raised in social contexts. Some social theorists and educators, for instance, have questioned whether new technologies will divide students (and society at large) into "haves" and "have-nots"—those that have the financial resources to acquire technological skills and those for whom the resources required are not available (Wresch, 1996). But there are also cognitive and instructional dimensions to this issue. It may be that becoming Web-literate depends on specific cognitive and instructional resources that are not uniformly available. It may be that the new literacies of the information age introduce new problems as well as new possibilities and solutions.

Research suggests, for instance, that hypertext materials may be more cognitively demanding (Egan et al., 1989), or require a greater degree of higher-level relational processing (Wenger & Payne, 1996) than traditional print. There are consistent findings that even highly skilled readers of print experience "navigational" problems as they move around within hypertext networks (Edwards & Hardman, 1989). Studies exploring relationships between hypertext use and learner characteristics consistently identify less effective use of hypertext by individuals with characteristics traditionally associated with disabled readers such as field dependence (Weller, Repman, Rooze, & Parker, 1994), poor visualization and spatial ability (Campognoni & Erlich, 1989), external locus of control (Gray, Barber, & Shasha, 1991), and use of less active learning strategies (Chen & Rada, 1996).

Although the interactive nature of computer-mediated learning materials seems, on face value, to make a compelling logical argument in support of technology as "assistive," the citations noted above suggest that the power that technology provides learners depends on user skills that are, by no means, assured among all learners. While it may be that technology can be used to assist less able readers, the evidence reviewed suggests it could just as easily prove an impediment to learning rather than an aid.

The purpose of this article is to report results of an empirical study that explored the relationship between reading skills in traditional print and in hypertext environments. Since prior work has suggested that hypertext places increased cognitive demands on readers, one general question addressed in the study explored whether, given the same reading material, readers make more effective use of hypertext or traditional print formats in a reading and question-answering task. A second question, also related to the apparent cognitive demands of the hypertext, focused on a subset of the total subject pool for which a standardized measure of reading ability was available. Specifically, this question explored whether hypertext differentially disadvantages readers with more limited print reading skills.
DESIGN OF THE STUDY

Participants in the experiment were adult students at a medium-sized Midwestern public university. All data was coded so that individuals could not be identified. The experimental design and all procedures were reviewed and approved by a university human subjects review board.

A total of 90 subjects participated in the study. In addition to data based on the experimental task, university records were utilized to collect information about students' reading skills in traditional print. As a result of an existing university admissions requirement, scores were available for 29 of the students participating in the study. High- and low-ability reader groups in the study were based on the Nelson Denny Reading Test, a standardized measure of reading achievement (Brown, Bennett, & Hanna, 1981) routinely administered to entering freshman at the university. Data included vocabulary, comprehension, and reading total scores, with high- and low-ability readers sorted on the reading total score.

The experiment employed a counter-balanced repeated-measures design, requiring subjects to respond to two sets of academic advising questions, once using a printed handbook and once using the hypertext version of the handbook. In the analysis focusing on possible differential disadvantage for less able readers, subjects for whom prior reading ability scores were available were divided into high- and low-ability reading groups. Reader ability was, therefore, manipulated between subjects and handbook format was manipulated within subjects with the order of use of print and hypertext materials counterbalanced across four groups, resulting in a repeated measures Latin square design.

Materials employed in the experiment included two versions (print and hypertext) of an undergraduate advising handbook used to assist teacher education students in academic planning. The print version of the handbook consists of 74 single-space loose-leaf pages in a three-ring binder. The handbook consists of approximately 31,000 words. The print version includes a table of contents identifying the first page of each of the 92 sections in the handbook. The hypertext version of the handbook duplicates the content and overall structure of the print version in a document consisting of 78 text nodes structured in a hierarchical-linear fashion with major handbook divisions organized hierarchically and nodes within those divisions organized linearly.

Subjects read and responded to questions using each version of the handbook with one half starting with the print version and the other half starting with the hypertext version. Since one of the two questions addressed in the study specifically concerned differential disadvantage of less able print readers a timed reading task was selected, since this kind of task puts greater emphasis on fluent and efficient performance and thus would be more likely to reveal differences that might exist. Students were provided a set of 10 questions and asked to answer
as many as possible within 15 minutes. After 15 minutes, answer sheets were retrieved and the subjects were provided a second set of questions and the advising handbook in the alternative presentation format. As before, subjects had 15 minutes to answer as many questions as possible.

The hypertext handbook was developed as a dynamic HTML document and presented using a JavaScript-based modification of the Netscape browser illustrated in Figure 1. The browser consists of three horizontally arrayed panels that eliminate standard Netscape navigational aids so that subject movement through passages can be recorded and, to a certain extent, controlled by the system. The use of this simplified interface was intended to replicate a more traditional "closed" hypertext model limiting access to nodes and links that are a part of the experimental material, since in the absence of such controls readers might inadvertently stray into material unrelated to the study. The narrow top panel provides a title bar ("Undergraduate Education Online Advisor"), next and back buttons ("-->" and "<--", respectively) that support sequential movement through the document, a "CONTENTS" button linked to a main table of contents, a "HELP" button, and a "QUIT" button that terminates the experimental session. Reading materials are presented in the large middle panel with a right-side scroll bar appearing as needed. Non-sequential links to other nodes in the handbook are presented in a link panel at the bottom.

DATA ANALYSIS AND RESULTS

Two different analyses were carried out, corresponding to the two research questions. In the first analysis, focusing on the issue of differential disadvantage, a GLM repeated measures ANOVA (Keppel, 1982; SPSS, 1996) was employed to determine whether there were main effects for print reading ability and presentation format or interaction effects across these variables. Counter-balancing groups were also considered as a factor. Since prior print reading scores were not available for all subjects, analysis at this stage was based on those 29 subjects for whom scores were available. Conditions for the counter-balancing groups and numbers for both the first and second analyses are indicated in Table 1.

The purpose of the second analysis was to explore the more general question about whether readers make more effective use of hypertext or traditional print formats in a reading and question-answering task. In addition, the second analysis provided a more powerful test of the presentation format effect revealed in the first analysis and a basis for exploring practice and question set effects. The data set employed in the second stage of analysis included all 90 participants in the study.

The second stage of analysis consisted of a series of three GLM repeated measures ANOVAs with presentation format, question set, and order as the within-subjects factors and the four counter balancing groups as a
**DEGREE AND CERTIFICATION REQUIREMENTS**

**ELEMENTARY EDUCATION BACHELOR'S DEGREE PROGRAM, STUDENT TEACHING AND DEGREE REQUIREMENTS**

<table>
<thead>
<tr>
<th>Program Requirements</th>
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<tbody>
<tr>
<td>Student Teaching Practicum Requirements</td>
</tr>
<tr>
<td>GPA Requirements and Correspondence Courses</td>
</tr>
<tr>
<td>Degree Requirements</td>
</tr>
</tbody>
</table>

Program Requirements: Once accepted into the Division of Education as a Pre-Education student (see section on Application/Admission steps), pursuing an undergraduate degree and/or license in Elementary Education is a four step process which is outlined below.

1. The sequence of coursework begins with the successful completion of the Pre-Professional Skills Test (PPST) and P250 (Educational Psychology). P250 and the PPST must be passed before moving on to Step 2. There are only two Education courses which can be taken without passing the PPST and P250. These are K230/K230 (Introduction to Exceptional Children) and W200 (Microcomputers for Educators).

2. Once the PPST has been passed and Educational Psychology has been taken, you can move into Step 2. This step consists of three courses: P201/P202 (Exploring the Personal Demands of Teaching/Field experience), M318/M301 (General Methods), and H360 (Education in American Culture). These courses cannot be taken until P250 and the PPST have been passed.

K205/K200 and W200 may be taken in Step 1 or Step 2.

Students must be admitted into the Teacher Education Program (TEP) before moving on to Step 3 (Upper Level Methods). Admission into the TEP requires:
- A 2.5 overall GPA
- Completion of W131 (English Composition) and S121 (Public Speaking) with at least a C in each course. Correspondence credit will not be accepted for these courses.
- Completion of at least one Fine Arts course, one Science course, one Social Studies course, and T101 (Math for Elementary Teachers I), with a minimum 2.5 overall GPA for these four courses.
- Completion of P259, K230/K230, W200, P201/P202, M318/M301, and H360 (with a C or better in each course).
- Successful completion of the PPST (or qualifying score on the SAT/ACT - See section on PPST).

Upon completion of these requirements, you need to complete an application (available at the Education Student Services Office, G126) for admission into the TEP. Completed applications are turned back to the Education Student Services Office. All students will be required to attend a TEP Induction Seminar. A

![Figure 1. Browser interface used in the study.](image-url)
Table 1. Conditions and Number of Subjects in First (and Second) Analysis for Each Group

<table>
<thead>
<tr>
<th>GROUP 1</th>
<th>GROUP 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>First: Print/Question Set 1</td>
<td>First: Hypertext/Question Set 2</td>
</tr>
<tr>
<td>Second: Hypertext/Question Set 2</td>
<td>Second: Print/Question Set 1</td>
</tr>
<tr>
<td>( n = 10 ) (24)</td>
<td>( n = 6 ) (20)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GROUP 3</th>
<th>GROUP 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>First: Print/Question Set 2</td>
<td>First: Hypertext/Question Set 1</td>
</tr>
<tr>
<td>Second: Hypertext/Question Set 1</td>
<td>Second: Print/Question Set 2</td>
</tr>
<tr>
<td>( n = 5 ) (24)</td>
<td>( n = 8 ) (22)</td>
</tr>
</tbody>
</table>

"First" indicates Format and Question Set in the first episode of reading. "Second" indicates Format and Question Set in the second episode of reading. "n = " indicates numbers of subjects in the first and second (in parentheses) analyses.

between-subjects factor. Counter-balancing groups in the second stage of analysis were identical to those in the first stage, apart from increased numbers of subjects in each group. Numbers of subjects in each group in the second stage of analysis are indicated in parentheses in Table 1.

Results of the first analysis revealed a significant main effect for presentation format \((F(1, 21) = 10.157, p < .01)\) and a significant format by group interaction effect \((F(3, 21) = 16.112, p < .001)\). There was no significant interaction across print ability and presentation format. There was, however, a marginally non-significant three-way interaction across print ability, presentation format, and counter-balancing group \((F(3, 21) = 2.654, p = .075)\).

As indicated above, the purpose of the second analysis was to address more general questions related to the presentation formats and to provide a statistically more powerful test of effects that were noted in the first analysis. Significant main and group interaction effects were found in all three analyses. There was a main effect for presentation format \((F(1, 86) = 20.217, p < .001)\) and an interaction effect across format and group \((F(3, 86) = 14.846, p < .001)\). There was a main effect for question set \((F(1, 86) = 39.084, p < .001)\) and an interaction across question set and group \((F(3, 86) = 8.270, p < .001)\). There was also a practice (i.e., order) effect \((F(1, 86) = 5.913, p < .05)\) that interacted across groups \((F(3, 86) = 19.416, p < .001)\). Statistics and effect sizes for these analyses are reported in Table 2.
Table 2. Results of the Second Stage of Analysis

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>$F(1, 86)$</th>
<th>$p$</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Print</td>
<td>6.267</td>
<td>1.870</td>
<td>20.217</td>
<td>&lt; .001</td>
<td>.432</td>
</tr>
<tr>
<td>Hypertext</td>
<td>5.483</td>
<td>1.759</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qst Set 1</td>
<td>6.444</td>
<td>1.941</td>
<td>39.084</td>
<td>&lt; .001</td>
<td>.648</td>
</tr>
<tr>
<td>Qst Set 2</td>
<td>5.306</td>
<td>1.573</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First episode</td>
<td>5.689</td>
<td>1.906</td>
<td>5.913</td>
<td>&lt; .05</td>
<td>-.201</td>
</tr>
<tr>
<td>Second episode</td>
<td>6.061</td>
<td>1.788</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DISCUSSION

Results of the first analysis provide clear evidence that subjects found the hypertext version of the advising handbook more difficult to use than the print version. This effect is clearly evident in the decline in mean print and hypertext scores illustrated in Figure 2. The effect size observed was medium (Cohen, 1988), corresponding to a 13 percent reduction in scores across the print and hypertext versions of the handbook. Although there was no statistically significant print ability by presentation format interaction there is a visual suggestion of such an influence in Figure 2. While it seems reasonable to suppose that familiarity with technology tools and practices (e.g., use of hypertext and browsers) probably accounts for some of the variability observed, correlational analysis between self-reports on Web experience and prior use of technology in university courses provided no significant evidence that these factors were related to performance in the hypertext condition, suggesting that other variables were likely to be involved in the observed effects.

The second stage of analysis confirmed main effects across three variables of interest: presentation format, order, and question set. As in the first analysis, there was a pronounced advantage for readers using the print version of the handbook. Readers also appeared to benefit from a practice effect, with performance on the second set of questions consistently superior to those presented first, and a question set effect indicating question set 1 was easier for students to answer than was question set 2.

In addition to these main effects, there was an interaction effect across each variable and the counterbalancing groups, although it appears that the observed interactions can be accounted for by the accumulation of benefits across several variables that are simultaneously considered within the single group factor. Inspection of the group means from the second stage of analysis reported in Table 3 reveals, for instance, a “mirror-image” pattern across the print/hypertext
Figure 2. Reading scores by print reading ability groups

Table 3. Presentation Format Statistics by Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>$N$</th>
<th>Mean</th>
<th>$SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertext</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>24</td>
<td>5.333</td>
<td>1.653</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>5.025</td>
<td>1.970</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>5.979</td>
<td>1.862</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>5.523</td>
<td>1.516</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
<td>5.483</td>
<td>1.759</td>
</tr>
<tr>
<td>Print</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>24</td>
<td>6.896</td>
<td>2.137</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>7.475</td>
<td>1.658</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>5.188</td>
<td>1.413</td>
</tr>
<tr>
<td>4</td>
<td>22</td>
<td>5.659</td>
<td>1.257</td>
</tr>
<tr>
<td>Total</td>
<td>90</td>
<td>6.267</td>
<td>1.870</td>
</tr>
</tbody>
</table>
factor. While the high-to-low sequence of means in the hypertext format is 3-4-1-2, the high-to-low pattern in the print format is 2-1-4-3.

Although this pattern of scores might appear remarkable, it can be explained on the basis of the main effects that have been noted and the fact that the counterbalancing groups incorporate the contributions of more than one variable. Since there is a practice effect and an effect based on question sets, the highest score for a given format should occur when that format is presented second and accompanied by the easier question set and this is precisely the case. For the hypertext format, for instance, group 3 had the simultaneous benefit of the easier question set (#1), and of practice (having completed the print task first). It is for this reason that group 3 has the highest hypertext score. Conversely, group three has the lowest print score because this group had to contend both with the more difficult question set and did not have the benefit of any practice in using either form of the handbook.

Although the question set effect has no meaningful generalization beyond the circumstances of the present study, the practice effect is of interest inasmuch as it documents a transfer of knowledge from one presentation format to another. This transfer could be nothing more than simple recall of facts encountered in the first episode of reading, or it could reflect more general learning about the document, related to its overall organization or the manner in which content is delivered. The design of the present study does not, however, provide a way to examine these possibilities.

Electronic delivery of text material is an increasingly widespread practice in many different domains of human communication. Although this practice has been adopted and promoted in many areas, apart from general admonitions about the “lost-in-space” problem (Edwards & Hardman, 1989), there has been little attention paid to the decline in reading effectiveness that hypertext seems to entail, even among readers who indicate experience in this reading environment. While it may be that this decline in effectiveness can be addressed, either through user interface features or through instructional means, we are only just beginning to learn how we might do this. History lists (Jones & Cockburn, 1996; Tauscher & Greenberg, 1997) and typed links (Kopak, 1999; Weinrich, Obendorf, & Lamersdorf, 2001), for example, illustrate user interface approaches to supporting readers, while more cognitively oriented work has begun to reveal critical cognitive operations (Wenger & Payne, 1996) and more effective browsing strategies (McEneaney, 2001) that may be amenable to enhancement through instructional intervention.

LIMITATIONS AND CONCLUSIONS

Although this study has highlighted one important aspect of the relationship between print and hypertext reading skills, it has left a number of other important questions unanswered. Although there was no significant interaction effect across
print reading ability and presentation format, the limited size of the subject pool in the first analysis resulted in statistical power approximately equal to .52, below the generally recommended level of .80 (Cohen, 1988). Given this, however, it may be important to note the visual character of Figure 2, suggesting an interaction that was not discerned, perhaps as a result of low statistical power. Related to this question, it is also relevant to note that the print reading score used in the study was not administered by the investigator, but was obtained through existing university files and that subsequent work should probably seek to incorporate an investigator applied print reading measure to avoid potential confounding sources of variance.

Another critical question that cannot be answered by this study is why readers found the hypertext material more difficult. Although one explanation might attribute differences to variation in familiarity with technology, the absence of significant correlations between hypertext scores and subjects' self-reports on the frequency with which they surf the Web and their prior use of technology in university courses suggests otherwise. If a general familiarity with technology were an important source of variance in the hypertext measure, a significant correlation would have been expected.

Limitations notwithstanding, the present study confirms the consistently reported finding that electronic reading environments can create difficulties for readers that may not have parallels in print materials. It may be, as suggested by Wenger and Payne (1996) that reading in hypertext draws on a different balance of skills than those required in traditional print and that what defines a “less able” reader may depend in important ways on the technologies we use to deliver text.

APPENDIX

Question Sets Used in the Study

Question Set 1

1. How many total credit hours are required to complete a Bachelor of Science degree in Education?
2. What student education organizations are represented on campus?
3. What is the minimum GPA required for admission to your undergraduate program in teacher education?
4. Why can't education students take Educational Psychology and General Methods/AV at the same time?
5. What cumulative GPA will result in a student being placed on academic probation?
6. What are three courses required in every Bachelors degree in Education?
7. What three courses make up the first of two advanced methods “blocks” in the Elementary Education program?
8. In what order could the following courses be taken: Multicultural Issues in Education, Educational Psychology, & General Methods?
9. What are the NTE qualifying scores for Music, General Science, and Professional Knowledge?
   Music = General Science = Professional Knowledge =
10. What does a student Placement/Credential File include?

**Question Set 2**

1. What Pre-Professional Skills Test scores in Math, Reading, and Writing are considered “passing”?
   
   Math = Reading = Writing =
2. What are three courses that must be completed before a student can take Upper Level Methods courses?
3. How many Secondary Education majors are available to students?
4. How many English as a Second Language courses are available at this university?
5. What is university policy concerning out-of-state student teaching placements?
6. At what point in their program (year and semester) do Special Education students usually take Educational Measurement?
7. What is the minimum GPA required to graduate with “Highest Distinction”?  
8. What is the PPST?
9. When do I need to apply to student teach?
10. How many correspondence course credits can be counted toward a Bachelors degree?

**REFERENCES**


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