An Assessment of the Effectiveness of a Hypertext Instructional Delivery System when Compared to a Traditional CAI Tutorial.

Differences in traditional student performance measures were examined following a computer assisted instruction (CAI) or a hypertext approach for mastering concepts related to intellectual property (i.e., copyright and patent) law. Seventy-six undergraduate business majors at a midwestern state university received CAI or hypertext instruction. Both the CAI tutorial and the hypertext system were developed using HyperCard and its authoring language. Learner control over the number of informational screens was not found to be a factor in overall performance, and there was no significant difference in the number of subject matter screens viewed by the two treatment groups. Neither treatment was found to achieve a greater measure of learning about intellectual property law. There are indications from the study that ability plays a major role in assessing the effectiveness of a tutorial versus hypertext instructional systems. The tutorial appears most effective for high-ability subjects. Six tables and two figures illustrate study findings. (Contains 14 references.) (SLD)
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More than 40 years ago, Vannevar Bush, science advisor to President Roosevelt, proposed a hypothetical machine, the MEMIX, that would allow individuals to browse through information, photographs, maps, and sketches by using links connecting any two source documents. The visionary image provided by Bush coupled with significant advances in computers, software, and high capacity fast access digital storage devices have given rise to databases that today contain documents, graphics, sound, speech, and animated sequences. A database containing information in these varied formats which supports the non-sequential access of information by the user has been coined hypertext.

Hypertext can be visualized as a 'semantic' network of nodes and links. In this model, nodes represent information units (e.g. documents, graphics, sound, etc.) while links serve as the cross-reference threads connecting related nodes. The links connecting nodes are usually denoted by highlighted words, phrases or graphics and are activated by using a mouse or arrow keys to select it. Depending on its purpose and location, a link can: transfer the reader to a new but related topic, show a reference or serve to move from a reference to the article, provide ancillary information, display a related illustration, schematic, photograph or video sequence, display an index or access and run a related application program.

The development of hypertext systems has grown rapidly during the last decade. Today, applications which utilize hypertext include: online help and documentation resources, software engineering tools, encyclopedias, reference manuals and books, and computer assisted learning in numerous educational disciplines.

Hypertext has three characteristics that are not present in traditional instruction which relies heavily on a highly directed flow of information. First, hypertext systems allow huge collections of information in a variety of mediums to be stored in an extremely compact form and accessed easily and readily. The stored information can be linked both explicitly and implicitly. Explicit links can be used by authors to suggest paths through information which learners may or may not choose to follow. Implicit links can be included which support glossaries, dictionaries, and navigational aids to be used as needed by the learner (Marchionini, 1988).

Second, hypertext is an enabling rather than directive environment. Hypertext systems encourage the user to probe information sources. By selecting the order, number, and composition of the nodes accessed, one can acquire and process information in ways that capitalize on their individual cognitive and experiential framework (Schneiderman, 1990). Learning theorists contend user initiated movement also increases the number of retrieval pathways available to access encoded information from the user's own long term memory (Jonassen, 1988). Not only does hypertext offer a new way to learn course content but also offers a new way of learning how to learn.

Third, hypertext offers the potential to alter the roles of teachers and learners and the interactions between them. The flexibility of hypertext enables students to create unique paths and interpretations of the paths which later can be shared with teachers or other students (Marchionini, 1988).

Conversely, others argue that hypertext is less than optimal. Learner control, aptitude-treatment interaction (ATI), disorientation and cognitive overhead are problems often associated with hypertext.

For some learners, the degree of control afforded by hypertext may negatively affect learning. Tennyson and Rothen's (1979) research on learner, adaptive, and
program control strategies employed in computer based instruction concluded that learner control consistently yielded lower post-test scores than other control strategies partially because students terminated instruction too early. Because of the richness of the medium, learners may not know what sequence or content area of hypertext are best for themselves to reach desired learning objectives. Some suggest that the less familiar subjects are with the content of the unit to be mastered, the greater the need for support in the form of clearly stated learner objectives. Such objectives provided to the learner could serve as a 'checklist' indicating to the learner what must be learned while using the hypertext system. Objectives used in this manner provide additional guidance and direction as learners utilize hypertext for instruction.

Other issues related to instructional control appear to be directly related to the learner himself. Hannafin (1984) concluded from reviewing relevant research that learner control is favored over program control when: (1) learners are older and more mature; (2) learners are more capable; (3) and higher order skills rather than factual information are being taught. Stated another way, hypertext may not be the best mode of instruction for all learners or content areas.

Aptitude-treatment interaction phenomenon may be also be aggravated by the lack of structure in such a learning environment. Research by Clark (1982) indicates low-ability students have higher achievement from more structured instructional methods whereas they prefer less structured methods. On the other hand, high-ability students, he claims, will generally prefer more instructional support but may actually perform better when given leaner, less elaborated material where they must take more responsibility for generating encoding strategies. Lower ability students, who need the additional support, may decline to seek it. He hypothesized that both groups prefer what they perceive will demand the lowest 'mental workload' for themselves.

Additionally, Steinberg (1977) addressed the issue of ATI. She suggested that while high achievers seem capable of using most forms of learner control effectively, low achievers seem much less able to make decisions about instructional properties (what, how, or how much information) than from those decisions involving variations in presentational aspects (how information is formatted or delivered). Her research findings suggest when instructional decisions need to be made, better learning is likely to occur with external coaching or advisement regarding which resources to select. Aptitude-treatment interaction research suggests hypertext may not be the most effective environment for low achieving learners. Perhaps a strategy which prescribes closer assessment of learning by the instructor may be necessary.

Disorientation is the result of more degrees of freedom, more dimensions available in which one can move. Technical solutions to disorientation are: (1) graphical, map-like models which depict the current hyperspace and identify the user's position within the space; (2) and providing a means for the learner to backtrack.

Graphical models termed context webs and local maps are used in Brown University's Intermedia system. In this hypertext system, nodes consisting of documents, graphics, sound, and animation related to the same context are grouped to form a web. Using this model, every node belongs to one or more web. When the user activates a node belonging to a web, they can visually see the other links and nodes which also belong to the active web. In addition, a local map can be activated which only shows the present active document and its closely related neighbor nodes (Conklin, 1987).

HyperCard and other developmental shells offer a back-tracking function. By clicking on an icon representing a prior screen, the user is able to move directly to that screen thus enabling a rapid review of previously encountered information.

The additional mental effort and concentration required to make choices about which paths to follow and which to leave alone can result in 'information myopia' or cognitive overhead (Conklin, 1987). Cognitive overhead may be reduced if the user is able to more effectively organize and integrate the new chunks of information extracted from the hypertext medium with existing prior knowledge.

To date, little research has been conducted to support or resolve the above mentioned issues related to hypertext systems. Research performed by Egan, et. al. (1987) and Landow (1989) support the contention that hypertext systems do in fact support a richer learning environment. Other studies conducted by Covey (1990), Lanza
and Roselli (1991), Mays, Kibby, and Watson (1988), and Tripp and Roby (1990) indicate hypertext delivery systems were less effective than other instructional systems.

This study examines differences in traditional student performance measures following a CBI tutorial or a hypertext approach for mastering concepts related to intellectual property (copyright and patent) law.

Method

Subjects
Seventy six voluntary subjects in the study were enrolled in an undergraduate introductory business law course required by all majors in the College of Business at a midwestern state university. The subjects were divided into two treatment groups: one group received instruction using a CBI tutorial and the other group received instruction delivered in a hypertext format which utilized graphical maps. When queried prior to treatment, all participants indicated they had a general awareness of the topic of the instruction, copyright and patent law, but knew nothing about the legal issues and implications related to the subject area.

Each subject received an ability ranking by their current business law professor prior to the study. The levels were based on eight weeks of observations which included assignments and tests.

Each system also contained a HyperCard script which created an audit trail which recorded the movement of each subject as he moved through the the HyperCard stack.

Programs
Two computer based applications, a tutorial and hypertext system, were developed using HyperCard and its authoring language HyperTalk. Both contained identical subject matter but varied in the amount of personal control and structure offered to the user.

In the tutorial, students were presented with a main menu listing the topics in the proper order of study. Once a topic was selected, the subject was required to move through all the related instruction prior to selecting another topic. No restrictions were placed on the number of times a topic could be selected for study.

The hypertext system presented the same topics for study but made no attempt to identify or impose an order in which the topics should be studied. In this system, once a subject area was selected, the student was presented with a graphical map which served to identify the informational nodes associated with the topic as well as depicting how they were related. To move to a node shown on the graphical map, the subject was required to click on the node. A subject using the hypertext system had three control options at any given time: continue to move linearly through the information associated with the selected node; return to the graphical map of the topic and select another related informational node; or return to the list of topics presented and select another topic.

An example of the menus available for both the tutorial and hypertext systems (Figures 1 and 2) are appended at the end of the paper.

Embedded within both systems were numerous opportunities for students to check their comprehension of the subject matter through the use of 'what if' applications. In each situation where responses were solicited and obtained, diagnostic feedback was provided.

Facilities
Both groups used equipment in an academic computing center at a state university in southern Minnesota. The equipment consisted of Macintosh SE computer systems with internal hard drives.

Instruments
The instrument used to measure the students' performance was composed of 30 multiple choice questions reflecting both recall and application of the concepts.
presented in the software. One point was allocated to each question. This instrument was used as both the pre-test and post-test assessment instrument.

The reliability of this instrument as determined by a KR-20 analysis was .688.

Procedure

The procedure used in this study was as follows:

1) Two days prior to the study, subjects unfamiliar with the Macintosh platform used to deliver both forms of instruction received an intensive two hour training session.

2) Treatments were assigned randomly. Detailed instructions on effective use of the assigned treatment as well as a practice period using software similar to the assigned treatment was implemented for each participant.

3) After the practice period, subjects were administered a pre-test and given objectives reflecting the subject material to be mastered.

4) Participants were administered a treatment consisting of either the tutorial or hypertext system and post-test under supervision of the researcher. No time limit was placed on viewing the software.

Results

Table 1 reports the t-test analysis which was applied to the results of the post-test to assess the difference in performance between the tutorial and hypertext treatments. No significant difference was found at the .05 level.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial group</td>
<td>37</td>
<td>20.158</td>
<td>3.6865</td>
</tr>
<tr>
<td>Hypertext group</td>
<td>39</td>
<td>18.313</td>
<td>3.6160</td>
</tr>
</tbody>
</table>

\[ t(74) \text{ df=.45 } p=.643 \]
A t-test for paired samples (pre-test, post-test) analysis when applied to the two treatment groups is represented in Table 2. Significance was found at the .05 level for both treatments.

Table 2. Tutorial vs. Hypertext Group Paired Pre-Test, Post-Test Results

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial group</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
<td>37</td>
<td>17.4054</td>
<td>2.544</td>
<td>.029</td>
</tr>
<tr>
<td>Post-test</td>
<td>37</td>
<td>17.5405</td>
<td>4.018</td>
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<tr>
<td>Hypertext group</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
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<td>13.0513</td>
<td>3.268</td>
<td>.005</td>
</tr>
<tr>
<td>Post-test</td>
<td>39</td>
<td>18.8205</td>
<td>3.546</td>
<td></td>
</tr>
</tbody>
</table>

Table 3 depicts the t-test for paired samples (pre-test, post-test) analysis when applied to the three ability groupings. Significance was found at the .05 level for both low ability and medium ability groups.

Table 3. Ability Groups Paired Pre-Test, Post-Test Results

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
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<th>p</th>
</tr>
</thead>
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<tr>
<td>Low ability</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Pre-test</td>
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<td>11.8571</td>
<td>3.321</td>
<td>.036</td>
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<tr>
<td>Post-test</td>
<td>21</td>
<td>17.0000</td>
<td>3.987</td>
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<td>Medium ability</td>
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<td></td>
<td></td>
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<tr>
<td>Pre-test</td>
<td>36</td>
<td>12.7500</td>
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<td>.030</td>
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<tr>
<td>Post-test</td>
<td>36</td>
<td>18.1389</td>
<td>3.217</td>
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<tr>
<td>High ability</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pre-test</td>
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<td>13.6842</td>
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<tr>
<td>Post-test</td>
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<td>21.5789</td>
<td>2.893</td>
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</table>
A one-way analysis of variance (Table 4) showed no significance at the .05 level between ability and the pre-test scores but significance at the .05 level between ability and the post-test scores. Further follow up with the Scheffe procedure indicated ability groups one and two (low and medium ability) and groups two and three (medium and high ability) were significantly different at the .05 level.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
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</thead>
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<tr>
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<td>.1451</td>
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<td></td>
<td>Within Groups</td>
<td>73</td>
<td>616.4267</td>
<td>8.4031</td>
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<tr>
<td>Post-test</td>
<td>Between Groups</td>
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<td>229.4839</td>
<td>114.7420</td>
<td>10.081</td>
<td>.0001</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>73</td>
<td>830.9371</td>
<td>11.3827</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The data associated with screens viewed per treatment is summarized in Table 5. No significant difference between means was found at the .05 level.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Mean</th>
<th>S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial</td>
<td>123.824</td>
<td>26.903</td>
</tr>
<tr>
<td>Hypertext</td>
<td>118.324</td>
<td>15.813</td>
</tr>
</tbody>
</table>

A one-way analysis of variance (Table 6) showed significance at the .05 level between the post-test tutorial scores and ability groupings while no significance was found between post-test hypertext scores and ability groups.

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Source of Variation</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tutorial treatment</td>
<td>Between groups</td>
<td>2</td>
<td>210.6237</td>
<td>105.3118</td>
<td>9.5181</td>
<td>.0005</td>
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<tr>
<td></td>
<td>Within groups</td>
<td>34</td>
<td>376.1871</td>
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<td></td>
<td></td>
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<tr>
<td>Hypertext treatment</td>
<td>Between groups</td>
<td>2</td>
<td>31.2526</td>
<td>15.6263</td>
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<td>.3513</td>
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<td></td>
<td>Within groups</td>
<td>36</td>
<td>507.3000</td>
<td>14.4943</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Discussion**

The purpose of this study was to assess, in an undergraduate university setting, the effectiveness of a hypertext instructional delivery system when compared to a traditional CAI tutorial. Several findings which relate directly to problematic issues of learner control and ability were noted.

Learner control over the number of informational screens viewed was not found to be a factor in overall subject performance. Quantitative examination of the audit trail compiled by each subject's treatment indicated there was no significant difference in the number of subject matter screens viewed by the tutorial versus hypertext treatment.
groups. Subjects in both treatment groups appear to have taken the treatments earnestly. Each treatment group viewed nearly one fourth of subject screens twice. The novelty of the instructional mode should not be ruled out in further studies as a factor which may play a significant role in this aspect of evaluating learner control.

Although learner control in this study did not hinder a subject's ability to navigate through the screens, it did not facilitate a greater understanding of the material as assessed by the post-test instrument. Neither treatment was found to achieve a greater measure of learning of intellectual property law.

There are indications from this study that ability plays a major role in assessing the effectiveness of a tutorial versus hypertext instructional systems. Examination of post-test performance when viewed in relation to treatments and ability groupings revealed variations. No significant differences in post-test scores were found between the three ability groupings in the hypertext treatment. Even though practice using a similar hypertext system was done prior to treatment, the subjects' lack of experience and unfamiliarity with non-linear learning may have been a factor in these results. Another factor may relate to the instrument used for evaluation. Perhaps a different method of assessment which emphasizes the broad scope of potential associations made in hypertext environments may be more suitable. Significant results were obtained between the low and high ability groups as well as the average and high ability groups in the tutorial treatment. These results indicated the tutorial was most effective for high ability subjects.

This study was an attempt to assess the effectiveness of tutorial versus hypertext delivery systems and to identify learner characteristic which may be used to prescribe the most beneficial mode of instruction. Overall, findings indicate learner control was not a factor in the hypertext mode of instruction. Additionally, ability appears to play a key role in the effectiveness of the tutorial as determined by the post-test instrument while it had little if any effect on subject performance as determined by the post-test instrument in the hypertext mode.

This study set forth additional questions to be answered through research. What type of instrument most effectively assesses learning in hypertext environments? Can different learning styles or learner characteristics be used to predict success in a tutorial or hypertext system? Does novelty play a role in tutorial, hypertext, or both forms of instruction systems? Can quantitative analysis of audit trails provide insight to designers of hypertext systems? Answers to these questions and others must be sought to validate the use of hypertext as an instructional system.
References


MENU SELECTIONS

1. Government's Role
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3. Copyright/Patent Categories
4. Eligibility Requirements
5. What Constitutes Infringement?
6. Infringement Exceptions
7. Compensation for Infringement
8. Registration
9. ***Author/Inventor Challenges***
10. Quit

Click on desired selection

Figure 1. Tutorial Main Menu

MENU SELECTIONS

**Author/Inventor Challenges**

Government's Role

Copyright/Patent Categories

Definitions

Infringement Compensation

Eligibility Requirements

What's Infringement?

Infringement Exceptions

Quit

Figure 2. Hypertext Main Menu