Hypermedia: Improving science literacy for student with reading difficulties

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1. Problem Statement

Students with learning disabilities (LD) in reading and poor readers who are not LD often fail to learn scientific concepts (Bryant, 2003). These students are among the most difficult to teach due to learning inefficiencies that limit their ability to profit from traditional instruction (Mastropieri, Scruggs, & Graetz, 2003). According to the U.S. Department of Education (2002), 2.25 million students are identified with LD in reading. An additional 10 million children will experience significant difficulties learning to read (National Institute of Child Health and Human Development, 1999). Current policy initiatives by the U.S. Department of Education (2003) call for revised instructional methods in science that utilize inquiry-based instruction combined with new technologies. An important question, then, is how can we improve science literacy in an inquiry-based, technology enhanced curriculum?

The proposed study will investigate the efficacy of incorporating hypermedia in middle school science curricula by quantitatively measuring how built-in accommodations, in the form of cognitive tools and textual enhancements, affect students' with reading difficulties scientific literacy development. The results of this study will add to the limited pool of extant research regarding the types of tools that are most beneficial to the 12 million students in the United States with reading difficulties. This study aligns with TNE Design Principle 1, decisions driven by evidence, by providing teachers and administrators with evidence-based tools to consider when incorporating federally mandated technology initiatives into their science curricula.

Increased numbers of students with reading difficulties in inclusive classrooms present challenges for today’s educators. Teachers, especially at the secondary level, often feel pressured to progress through the curriculum, even when students have failed to master the content of the current lesson (Mastropieri et al., 2003). Teachers’ abilities to provide meaningful accommodations for students are hampered by large class sizes, high numbers of students, and a lack of appropriate resources. As Lancaster, Schumaker, and Deshler (2002) stipulate, finding time to provide specifically designed instruction to students is increasingly challenging as more students participate in the general education curriculum.

Beginning in fourth grade, students are increasingly expected to learn information from expository text sources such as science, social studies, and geography textbooks (Wilson & Rupley, 1997). These texts present complex vocabulary at a pace students with reading difficulties struggle to achieve (Lapp, Flood, & Ranck-Buhr, 1995; Maccini, Gagnon, & Hughes, 2002). Expository texts typically include long reading segments containing abstract passages that are unfamiliar to students who are used to reading narrative texts (Kucan & Beck, 1997). Meyer, Brandt, and Bluth (1980), in a seminal study, note that students with reading difficulties are often unaware of the expository text structures they are reading. They retrieve information randomly, without a plan of action. This approach undermines their ability to use the text to formulate questions and hypotheses (Wilson & Rupley, 1997). Complex expository texts must be modified and supplemented to meet the students’ needs. However, many general education teachers are not adequately trained, and do not have the time, to provide meaningful accommodations on a daily basis (Mastropieri et al., 2003).

An analysis of expository textbooks, such as those traditionally used in science classrooms, indicates that they are typically written at a higher-grade level than where they are intended to be used. In one analysis, Kinder, Bursuck, and Epstein (1992) found that readability levels for eighth grade social studies textbooks ranged from ninth grade to the third year of college with a mean of tenth grade. Yager (1983), in an analysis of middle level textbooks, found that science texts introduce more vocabulary words in one year than in the first year of a foreign language class. The use of these texts can have demoralizing affects on adolescents with reading difficulties who typically read at the fourth or fifth grade level (Mastropieri, Scruggs, Bakken & Whedon, 1996).

Students with reading difficulties are often unable to utilize text cues as aids when encountering new textual information (Gersten, Fuchs, Williams, & Baker, 2001). As a result, they have difficulty determining essential information and lack the ability to make abstract connections outside the domain of their current readings (Engert & Thomas, 1987). A lack of prior knowledge, particularly in history, geography, and science, coupled with the inability to recognize when they are not understanding new information, further undermines student learning (Gersten et al., 2001). Another challenge for students with reading difficulties is task persistence. These students...
find many reading activities daunting. This leads to frustration, lower motivation, and an expectation for failure when encountering complex academic tasks (McKinney, Osborne, & Schulte, 1993).

According to McCray (2001), middle school students with reading difficulties express a desire to learn that is undermined by academic failure. The use of hypermedia (defined as high level software which allows learners to interact with information in a nonlinear fashion) offers great promise in improving scientific literacy by integrating empirically validated comprehension strategies and text enhancements with instructional practices (Mastropieri et al., 2003). Technology-enhanced learning activities foster dynamic environments that promote active learning and problem solving (Gardner, Wissick, Schweder, & Canter, 2003). Hypermedia provides a unique approach to presenting expository texts by incorporating the features of supported text. Horney and Anderson-Inman (1999) describe eight types of resources that can be incorporated in a supported text environment: (a) translational resources, (b) illustrative resources, (c) summarizing resources, (d) instructional resources, (e) enrichment resources, (f) notational resources, (g) collaborative resources, and (h) general purpose resources.

Lajoie (1993), in an examination of tools available in hypermedia programs, identifies four types of tools that improve student learning. These include tools that (a) support cognitive and metacognitive processes, (b) share cognitive load by providing information as needed, thus allowing the user to concentrate on higher order thinking processes, (c) allow users to conduct activities that would not be possible in a traditional classroom environment, and (d) allow users to solve problems by generating hypotheses, collecting data, and interpreting results in a simulated environment. Lancaster et al. (2002) note that hypermedia may eliminate the overuse of expository texts, which hamper learning for students with reading difficulties.

2. Related Work

According to Driscoll and Dick (1999), the preponderance of published articles examining the effectiveness of hypermedia programs has been theoretical, rather than experimental. Maccini et al., (2002) point out that while hypermedia programs were effective in improving student comprehension. However, they note that there were relatively few studies (N=10) that met the following criteria for inclusion in their review: (1) targeted adolescents with LD, (2) involved instruction and/or assessment that measured at least one dependent variable, (3) included technology-based interventions or assessment formats as the independent variable, (4) measured effects on student performance, and (5) were published in refereed journals. Of the ten studies included in the review, only one focused on science. That study was limited to the presentation of text that was scanned from a textbook and did not include the textual enhancements available in hypermedia.

Other studies have examined the efficacy of electronic environments with students with LD. MacArthur, Ferretti, Okolo, and Cavalier (2001) found that high school students with LD who received enhanced text (e.g., links between text and graphics, highlighted main ideas, and supplemental explanations) showed significantly higher comprehension rates than those students using traditional science texts. Horney and Anderson-Inman (1999) report that middle school students with disabilities used tools such as pictures, definitions and hypermedia-based notebooks most often. However, an analysis of how tool use affected student achievement was not conducted. Bangert-Drowns and Pike (2002), in a study of two fifth-grade classrooms in a science and technology magnet school, concluded that hypermedia programs allow students to utilize cognitive flexibility while engaging in literacy activities. They noted that student engagement fluctuated based on software type and classroom context. This idea is supported by Palincsar, Magnusson, Collins, and Cutter (2001) who point out that the appropriate selection of research-based hypermedia programs is critical in inquiry-based classrooms.

Several studies have examined the effectiveness of hypermedia in middle school science classes with students who were not identified as LD. Oliver and Hannafin (2001), in a qualitative study of 12 eighth grade students using tools from Slotta and Linn’s (2000) “knowledge integration environment” (KIE) found that three tools improved students abilities to investigate, hypothesize, and analyze information in technology-based open-ended learning environments (OLEs): 1) organization tools, 2) questions that prompted reflection, and 3) bracketed information. However, they point out that students who lack understanding of key concepts and vocabulary (e.g., students with reading difficulties) struggled to frame the problem they were intended to solve. Land and Green (2000) obtained similar findings, noting that novice learners often fail to refine search strategies in OLEs due to the complex, resource-rich nature of electronic environments. They recommend that technology should be used in concert with opportunities for students to discuss their thought processes, defend their hypotheses, and compare their understandings to experts. These recommendations are supported by research in the field of special education (Fuchs, Fuchs, & Kazdan, 1999; Morocco, Hindin, Mata-Aguilar, & Clark-Chiarelli, 2001; Swanson, 2001).
In another study, Liu and Bera (in press) examined the effectiveness of Alien Rescue, an astronomy hypermedia program, with 110 middle school students. They conducted an analysis of student tool use over the course of a three-week, 5 stage, problem-based learning intervention. Their findings indicate that students who frequently accessed tools supporting cognitive load (e.g., databases and charts), cognitive processing (e.g., notebook and bookmark features), and hypothesis testing (e.g., data collection and graphic organizers) scored significantly higher on posttest measures than students who accessed the tools less frequently. Interestingly, the tools accessed by high achieving students in this study were identical to the strategies special educators teach students as a means of improving comprehension. While this study did not focus on students with LD, it provides evidence that (a) comprehension strategies, in the form of tools, can be incorporated into hypermedia programs, (b) regular education students who use the tools benefit from them, and (c) hypermedia programs can be used to monitor student performance and academic outcomes.

Unfortunately, no studies have specifically identified features of hypermedia programs that significantly improve scientific literacy for students with reading difficulties. MacArthur et al., (2001) conclude that the effects of electronic texts may depend on the individual students, the quality and type of enhancements, and the extent to which the students use the enhancements. They note that insufficient empirical data exists to draw conclusions about which enhancements might be most efficacious for students with reading difficulties and call for future research to examine the types of enhancements that are most appropriate for specific students in different educational settings. Land (2000) adds to this stating, “Although at face value the potential of these opportunities [electronic tools and resources] is compelling, the extent to which learners mindfully engage in them is not at all certain” (p. 61). Further research is needed to determine how the integration of technology-based tools affects scientific literacy for middle school students with reading difficulties. The proposed study is designed to address this need.

**Methodology**

*a) Questions/Hypothesis*

This study is based on related literature, current research, a pilot study, and an identified need by seminal figures in the areas of science, reading, technology and special education. Clearly, there is a need to improve our understanding of how students with reading difficulties can best be served in inquiry-based, technology enhanced, science classrooms. To address this need, the following questions are presented: **Guiding Question:** Can middle level science hypermedia programs improve science literacy for middle school students with learning disabilities in reading and poor readers?  

**Research questions:** 1) Is there a difference in comprehension when students with LD in reading and poor readers are presented with different reading levels in a hypermedia program (4th grade treatment vs. 8th grade control)? 2) To what extent do the cognitive tools in hypermedia affect students’ with LD in reading and poor readers’ comprehension of scientific concepts and processes?

It is hypothesized that students with reading difficulties in the treatment group, receiving hypermedia-based text at a reading level commensurate with their ability, will show statistically significantly higher comprehension rates than peers in the control group. Additionally, it is hypothesized that students with reading difficulties who utilize tools that support cognitive processes and share cognitive load will achieve higher comprehension levels of scientific concepts and processes.

*b) Procedures for collecting information*

All procedures for collecting information, including goals, objectives, activities, personnel responsible, and milestone dates are presented in Table 1 (Appendix A). Additional information is provided in the following section. Due to the internet-based nature of the program, schools will be required to have broadband access to the Internet and computers for each student participating in the study in order to meet the selection criteria.

Superintendents, directors of special education, and science directors at Connecticut middle schools will be contacted via a conventional letter that describes the study and solicits their participation. Conventional letters (See Appendix D) will be followed up with telephone calls and emails three weeks later. Schools that express interest in participating in the study will be evaluated by the student researcher to determine if the school’s infrastructure provides the necessary requirements for participation. Once superintendents, directors of special education, and science directors have given their written approval to adopt the three-week curriculum for all students, approximately four middle schools (N = 1200 students) will be selected to host the study. Of the 1200 students, approximately 140 students with reading difficulties (further described below) will be randomly selected by class to participate in the study.

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1 Poor readers will be defined as scoring below the 25th percentile on the Degrees of Reading Power (DRP) subtest of the Connecticut Mastery Test (CMT)
Seventh grade teachers who give voluntary written consent to participate in the study will be identified. All seventh grade students will be asked to give voluntary written assent. Legal guardians and local education authorities (for children with LD) will be contacted and asked to give voluntary written consent for each child who wishes to participate in the study. Once appropriate permissions have been obtained, demographic data will be collected for all students. All data will be stored in a secure location and destroyed one year after the completion of the study. The sixth grade results of the Degrees of Reading Power (DRP) subtest of the Connecticut Mastery Test (CMT) will be used to classify students’ reading ability. Students reading below the 25th percentile will be considered poor readers (Lyon et al., 2001). Students with LD in reading and poor readers will be randomly assigned to either the treatment or control condition. Power analysis indicates optimum group sizes of 68 ($f = .20$, $d = .57$) to achieve a power of .80.

**Design**

Research question one utilizes the following mixed factor design.

<table>
<thead>
<tr>
<th>Treatment Condition</th>
<th>DRP Score (Covariate)</th>
<th>Science Knowledge pretest</th>
<th>Science Knowledge posttest</th>
<th>Solutions Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment (4th grade reading level)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control (8th grade reading level)</td>
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</tbody>
</table>

Research question two will consist of an analysis of students’ use of Alien Rescue’s 13 tools over the course of the three-week intervention. Information regarding Alien Rescue’s tools is available in Appendix F (Hard Copy Only).

**Procedures**

A project assistant (PA) will be trained during the summer of 2005 to assist the student researcher in data collection including: 1) inspecting attendance records, 2) physically observe student-to-student and student-teacher interactions during the intervention, 3) collecting achievement and demographic data, 4) ensuring design implementation (treatment compliance), 7) assessing treatment fidelity, and 8) monitoring attrition rates.

Teachers using the Alien Rescue program in their classroom will participate in 2 six-hour trainings two weeks prior to the implementation of the intervention. During the training, teachers will learn how to use the hypermedia program, review the teachers manual, practice teaching a selected lesson to peers, and establish a minimum inter-rater reliability of .80 (teachers, researcher, and PA) when evaluating student assessments.

Students submit their solution forms during the last day of the intervention. The researcher and PA will collect the solution forms and score them with other participating teachers in the school. Each form will be scored by one teacher, the PA, and the student researcher to ensure inter-rater reliability. One week later, students will be given the online science knowledge test. This test is scored electronically. Results from the solutions form and science knowledge test will be entered into an SPSS database for analysis.

**c) Analysis**

To answer research question #1 “Is there a difference in comprehension when students with LD in reading and poor readers are presented with different reading levels in a hypermedia program (4th grade treatment vs. 8th grade control)?”, descriptive statistics will be computed. A Multivariate Analysis of Variance and Covariance (MANCOVA) will be conducted with treatment vs. control group as the between subjects independent variable, posttest and solution forms as the dependent variable, and DRP scores as the covariate. To answer research question # 2 “To what extent do the cognitive tools in hypermedia affect students’ with LD in reading and poor readers’ comprehension of scientific concepts and processes?”, descriptive statistics of tool use during the intervention will be computed. A cluster analysis will be conducted to group students based on how they used the thirteen tools. A MANCOVA will be performed with cluster membership as the independent variable, posttest and solution forms as the dependent variable, and DRP scores as the covariate. Post hoc tests will be conducted if significant differences are identified in either question. Outcomes will be reported using effect sizes bound by confidence intervals.

Additional information regarding the evaluation of this project is presented in Table 2 (Appendix B).

**Limitations**

While this study utilizes random assignment, it does have sampling limitations. Due to the requirements of an internet-based intervention, it is likely that only wealthy school districts will have the infrastructure to support the study. The impacts of socio economic status (SES), prior learning experiences, and other environmental factors may influence internal validity. The sampling technique may also impact the generalizability of the study. Additionally, the reliability of the science knowledge test ($r = .75$) should be .80 or higher. This limitation is reduced through the presence of the solutions form, which provides a second measure of academic achievement at a different time. A
final concern is treatment diffusion. Because students will participate in a dialogue with peers each day, it is unclear if the dialogue or the treatment will affect academic achievement. If analysis of individual classes indicates that one classroom of students in the treatment group scored significantly higher than other classrooms, treatment diffusion should be investigated.

d) Collaboration

This project is the result of a collaboration between researchers across disciplines at The University of Connecticut including special education, curriculum and instruction, and educational technology. The research will take place in approximately four middle schools throughout the state of Connecticut including University of Connecticut Professional Development Schools. The hypermedia program used in this research, Alien Rescue, is based on National Science Education Standards and the 2004 Connecticut Science Framework. This hypermedia program has recently been redesigned to meet the needs of this research project and was developed collaboratively with the student researcher, University of Texas, Austin, Texas A&M, the University of Louisiana, Lafayette, NASA, and science administrators in the Glastonbury Public School System.

4. Expected end product

This study will explicitly report the learning outcomes of students using hypermedia in instructional contexts. It will provide a detailed analysis of how often students access representational illustrations of topics, spatial organizers, mnemonic illustrations, and adjunct aids as they navigate through a hypermedia environment. The project will document students’ comprehension of scientific concepts and provide a summative report at the conclusion of the project.

Products from this study will include: 1) TNE report and presentation, 2) dissertation and presentation, 3) manuscripts submitted to professional educational journals (e.g., Journal of Research in Science Teaching, Learning Disabilities Research and Practice, Educational Technology Research and Development), and 4) presentation proposals to local, regional, and national conferences, such as American Educational Research Association (AERA), Council for Exceptional Children (CEC), National Science Teachers Association (NSTA), and the Association for Educational Communications and Technology (AECT).

5. Personnel

Supervising faculty member: Stan Shaw, Ed.D. is a Special Education professor in the Department of Educational Psychology at the University of Connecticut (UConn). Dr. Shaw is the Coordinator of the Special Education Program and Co-Director of the Center on Postsecondary Education and Disability at UConn. Since 1976, he has been Project Director for more than six million dollars in grant funds. Dr. Shaw has presented over one hundred and thirty papers at national and international conferences and published extensively on national, international, and local special education issues in peer reviewed journals. Dr. Shaw will supervise the student researcher and provide technical expertise for the project. See Dr. Shaw’s letter of support in Appendix E.

Student researcher: Matthew Marino is a doctoral student in special education at the University of Connecticut. He is a Professional Development Center Coordinator for the Neag School of Education. He has a Master’s degree in middle level curriculum and instruction and five years of experience as a middle school science and technology teacher. Mr. Marino has been Project Coordinator for more than thirty thousand dollars in grant funding. He has presented papers at several international conferences and has published manuscripts and a book chapter on middle level instructional strategies.

Associate Advisors: 1) Michael Coyne, Ph.D., Special Education Reading Advisor, 2) John Settlage, Ph.D., Science Advisor, 3) Robert Hannafin, Ph.D., Technology Advisor.

Project assistant: A project assistant with experience in the use of educational technology will be hired to assist the student researcher for a total of 200 hours as described in the procedures section.
References


