The Effectiveness of Interactive Maps in Secondary Historical Geography Education

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Social Studies, including history and geography, is a core part of most state curriculum standards for K-12 education, and for the most part is in need of improvement. Among the technological solutions that have been developed, interactive maps show promise in making the complexities of the social sciences (especially historical geography) more interesting to students, and easier to visualize and understand, without demanding significant investments by schools. A two-group experiment examined this potential for the 7th Grade Utah Studies curriculum. After completing an exercise to analyze possible historical and geographical causes of settlement patterns in Utah, students using interactive maps showed significantly better improvement between a pretest and posttest than students using paper maps. Although some of the test results were inconclusive and highlighted technological and resource obstacles to the widespread adoption of interactive mapping in the classroom, it has been shown to help students learn social studies in a deeper, more engaging manner.

Keywords: interactive cartography, web cartography, maps in education, social studies education, Utah history

INTRODUCTION

The social sciences do not enjoy a high status in today's U.S. classrooms. Indeed, geography, history, and other social sciences receive considerably less attention in classrooms than other subjects (Leming et al., 2003), at a time when it is increasingly more important for students to understand the world around them. Most U.S. students rate social studies as one of the least interesting and most irrelevant subjects in their coursework (Leming *et al*., 2003; Shaughnessy and Haladyna, 1985). According to Leming *et al*. (2003),

Not only is the level of public understanding of our history and cultural traditions alarmingly low, but the willingness of young people to participate in our common political life is also declining. Students rank social studies courses as one of their least liked subjects and social studies textbooks are largely superficial and vapid (i).

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This shallow content may be difficult to understand, and geographic concepts may be so isolated (without context) that students fail to see the relevance of the subject to their lives (Tyson and Woodward, 1989). Social studies education has focused primarily on rote memorization of events and places, rather than focusing on using techniques that address distinct learning styles and higher-order thought processes. This focus likely contributes to the negative attitudes children often express about the subject (Coyle *et al*., 1996; Shaughnessy and Haladyna, 1985).

The typical social studies curriculum standard dictates the teaching of both geography and history, for good reason. Our past is a tapestry of

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interwoven spatio-temporal patterns and processes. A true understanding of history requires geographical knowledge, and vice versa. However, it can be difficult for students to learn and appreciate the wonders of historical geography using traditional educational techniques (textbooks, lectures, worksheets, etc.) because of necessity these texts tend to separate history education and geography education. Social studies classes have a tendency (often due to the educational background of the teacher) to focus on history with only passing references to geography, rather than being integrated (Gregg and Leinhardt, 1993).

Because of the aforementioned shortcomings of social studies education, there is good reason to develop new ways of teaching that would enhance the subject and excite students**.** New teaching tools can have a profound impact in the classroom, especially if they are focused directly on the most significant problems in current education. Subjects that are difficult to teach using the traditional textbook method benefit from additional teaching resources that enhance the learning process. This article investigates the use of one of these tools, the interactive map, that may help in learning social science concepts.

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Potential Solutions

Over the past several decades, many techniques have been developed to enhance K-12 education. In particular, four technological solutions have a particularly high potential for success in historical geography: paper maps, interactive media, geographic information systems (GIS), and interactive maps.

Paper Maps, the oldest of the possible solutions, enhances social studies learning when the subject is spatial in nature. Maps have been used in education for many years. Although much of the research into maps and education has focused on the development of map reading skills for their own sake (e.g., Blaut and Stea, 1971; Boardman, 1989; Freundschuh, 1990), a few studies have shown that both thematic and reference maps can help students learn geographic facts and concepts (e.g., Bailey, 1979; Boardman, 1985; Trifonoff, 1995). Maps can increase conceptual organization and memory retention, since people tend to remember visual symbols and patterns (Rittschof and Kulhavy, 1998; Griffin and Robinson, 1997; Kulhavy *et al*., 1993; Abel and Kulhavy, 1986). Thus, maps can enhance children's understanding of the spatial aspects of cultures, environment, and economy (Bailey, 1979; Joyce, 1987; Inbody, 1960). One difficulty is that the maps in textbooks are often designed poorly and not used effectively (Gerber, 1992), especially for regional history textbooks with smaller circulation and thus less money to spend on design. Another obstacle is that because historical geography studies time as well as space, static maps may not be the ideal form of representation.

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Interactive Media resources (such as videos, the internet, and CD-ROM's) have been useful for enhancing classroom learning, especially when students are able to use them at their own pace (Giardina, 1992). In addition, computerized learning activities can adapt to different class sizes (Schick, 1993), as long as enough computers are available. These benefits are becoming more important as school classrooms are becoming more crowded (Ready *et al*., 2004; National School Boards Association, 1999; O'Neil and Adamson, 1993). These media are also much more interesting to young people (Olson, 1997), and if they enjoy the learning activity, they are more likely to maintain focus long enough to learn the concepts being taught (Calvert, 1993-1994). Several studies have shown the need for technology in school social studies classes (Baker and White, 2003; Wilton, 1999; Noonan, 1998; Fitch, 1997), as this resource can be used to stimulate otherwise disinterested students in classrooms to become active participants in learning social studies. However, most media are not intended to portray spatial concepts, and are therefore not enough to help students understand social studies.

Geographic Information Systems (GIS) combine the benefits of paper maps and interactive media by enabling students to explore, analyze, and make decisions about spatial problems in an interactive and challenging manner (Northon, 2003; Patterson *et al*., 2003; Audet and Ludwig, 2000). Keiper (1999) found that GIS created "a shift from learning about geography to learning to do geography. (p. 57)" However, very few schools have incorporated GIS into the classroom (Baker and White, 2003; Patterson *et al*., 2003; Kerski, 2001; Audet and Paris, 1997). One of the problems of implementing GIS in classrooms is that teachers have to invest significant time in learning the software and developing lesson plans and exercises, and it requires valuable class time for students to learn as well. In addition, the costs of the software and high-end computers may be prohibitive, although hardware costs are decreasing, and GIS vendors are offering lower prices and system wide licenses to districts and even states such as Utah (Audet and Ludwig, 2000). Gradually, GIS technology is becoming a practical tool for teachers (Broda and Baxter, 2003), at least in technology-oriented classes. This rarely includes social studies, however.

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Interactive Maps are not based on GIS software, and should provide the advantages of GIS to learn about spatial topics without as much investment of time and money. These are standalone map-centered programs that respond onscreen to user activity and help promote information exploration and understanding (Andrienko *et al*., 2002; Audet and Ludwig, 2000; Olson, 1997; National Research Council, 1997; Krygier *et al*., 1997). Most schools today have Internet access, making this form of map cost-effective and familiar to today's web-savvy students. These maps are more flexible in their use than paper maps, since they allow users to explore data and visualize and analyze visual patterns on the computer screen. The potential of the interactive process is reinforced by several studies that have found paper maps to be especially educational when students are involved in creating them rather than just reading them (Sullivan, 1993; Bausmith and Leinhardt, 1997; Knowles 2000). The interactive map also solves the problem of teaching historical geography because it can have both a temporal and spatial dimension. Due to these advantages, interactive maps could help improve classroom curriculum in many different subjects.

Thus, it is worthwhile to test the efficacy of interactive maps in improving the learning process. Although some studies have focused on the benefits of integrating interactive maps in the classroom, the research has generally been focused on the natural sciences and physical geography (Audet and Ludwig, 2000; Linn, 1997; Olson, 1997; Murayama, 2004; Pederson *et al*., 2005). The few studies that have focused on human geography topics (e.g., Linn, 1997; Keiper, 1999) have generally had inconclusive results, and interactive map use to teach historical geography in particular has not been studied.

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The purpose of this research is to evaluate the ability of interactive maps to improve the learning and attitudes of students in social studies in secondary schools. We hypothesize that interactive maps create not only a more enjoyable learning environment than traditional paper maps, but also facilitate the development of a more effective teaching technique. We also hypothesize that the use of interactive maps promotes more positive learning attitudes, and should help students understand basic concepts of geography and history and analyze how geographical factors have contributed to Utah's history.

Experiment Design

To study the role of interactive maps in education, we used an experimental research design, focused on testing students' learning during a short unit on the history and geography of Utah settlement. We chose this topic because it is part of the state Utah Studies curriculum (and thus would be taught anyway) and it is well suited for showing how a variety of factors interact spatially and contribute to changing spatial patterns. Simply asking students to memorize facts would not really promote effective learning, as true geography involves being able to link spatial phenomena and explain why certain phenomena occurred in a particular place. To really learn, students should be able to *understand, apply*, and *analyze* concepts about how various factors affected Utah settlement.

Specifically, we used a quasi-experimental, pretest-posttest nonequivalent control group design to test the effect of interactive maps on learning and attitudes about this topic. This design has been used effectively in other tests of maps and GIS in education (e.g., Baker and White, 2003; Linn, 1997). The subjects were six 7th grade Utah Studies classes at a local junior high school, in which 145 students were asked to complete tests and an exercise using map resources to answer questions that required them to locate, analyze, and synthesize geographic and historical information.

". . . students were asked to complete tests and an exercise using map resources to answer questions that required them to locate, analyze, and synthesize geographic and historical information."

A three-step procedure was used for the test. In the first step, during a 45-minute class period students were given a pretest with no materials, or help, to answer questions. In the second step, on the second-class day, the students were given an exercise (identical to the pretest), but this time with map resources to help them learn. Students still worked individually, but were allowed to get help from peers, the teacher, and the researcher. The control group was given paper maps, while the experimental group was given an interactive map. Pederson *et al.* (2005) took a similar strategy to discriminate the effectiveness of paper and (static) electronic maps.

In the last step, during a third class period that was twice as long as the first two class periods (1½ hours), students were given a posttest (similar in form to the pretest but slightly longer with different questions) and allowed to use the paper maps or the interactive map, but without help. After the tests, students completed an attitude survey that assessed their impressions of the unit and the learning materials used. We were therefore able to isolate the type of map resource as a factor in improving test scores and student attitudes. A table illustrating the above experimental design is shown in Table 1.

Group	**Pretest**	**Treatment**	**Posttest**
Experimental	Test 1	Test 1 **Interactive map** Assistance	Test 2 **Interactive map** Attitude survey
Control	Test 1	Test 1 **Paper maps and tables** Assistance	Test 2 **Paper maps and tables** Attitude survey

Table 1. Overview of Experiment.

Test Instruments

The paper and interactive maps used in the experiment displayed the same information about Utah's settlement patterns over time (i.e., settlement/abandonment dates, census populations), along with reference information and related factors, including mining, railroads, precipitation, terrain, streams, and roads. The railroads and towns layers modeled temporal change, derived from a historical GIS of Utah. Both types of maps also used identical cartographic designs, such as proportional circles for the town populations.

The control resources consisted of a set of 16 maps, one for each decade from 1850-2000; each student was given his or her own set of maps to use. The paper maps were created using ArcGIS software and printed in color so they could be comparable to the interactive map (see Figure 1). The control students were also given printed tables listing Census data so they would have exact populations for each town.

"The paper and interactive maps used in the experiment displayed the same information about Utah's settlement patterns over time . . ."

The interactive map was created using Scalable Vector Graphics (SVG) and JavaScript, and following the recommendations of Crampton (2000) and Loben and Patton (2003), included several basic interactivity tools. *Brushing*, as shown in Figure 2, allowed users to move their cursor over a town on the map, causing it to be highlighted, and its name, county name, settlement date, and population for the selected Census year to be listed. *Toggling* (Figure 3) let users turn the thematic and reference layers on and off, including railroads, precipitation, terrain, current roads, mineral deposits, and streams. As layers were turned on, legends appeared to the right of the layer to explain the layer symbology. *Zooming* (Figure 4) was also available for focusing on a specific county.

The interactive map also included tools for exploring change over time. When the user selected a specific year from the drop-down menu, as shown in Figure 5, the city and railroad layers changed to match the chosen date. Alternatively, users could select the "Animate Map" button to watch the changes (in towns and railroads) over the entire history of Utah (1850-2000). The combination of these tools allowed users to isolate specific areas of interest and analyze a variety of physical and cultural geography factors contributing to the changing spatial patterns of settlement[1].

"The tests focused not on rote memorization, but on helping students to identify, understand, and analyze spatial relationships . . ."

The pre- and posttests were then based on the information on the maps and the learning objectives of the curricular unit. The two tests had parallel forms, so the students were presented with novel, but similar, problems. The exercise given to teach them to use the maps was identical to the pretest. Because the score improvement was calculated solely on pre- and posttest scores, students' remembering questions and answers from pretest to exercise did not affect the experiment results. The pretest contained fewer questions than the posttest because students had a shorter class period to complete the pretest.

The tests focused not on rote memorization, but on helping students to identify, understand, and analyze spatial relationships in explaining the distribution of Utah settlements over time using hypothetical attractors such as climate, terrain, water, minerals, roads, and railroads. A combination of question types was therefore used to assess different types of problem solving. The matching items required students to compare city sizes for two consecutive decades and identify the decade during which a settlement was established, thus focusing on fact-finding and *conceptual understanding* in Bloom's revised taxonomy (Anderson and Krathwohl, 2001). A section of multiple-choice questions required students to analyze data and patterns to identify possible reasons for settlement in certain

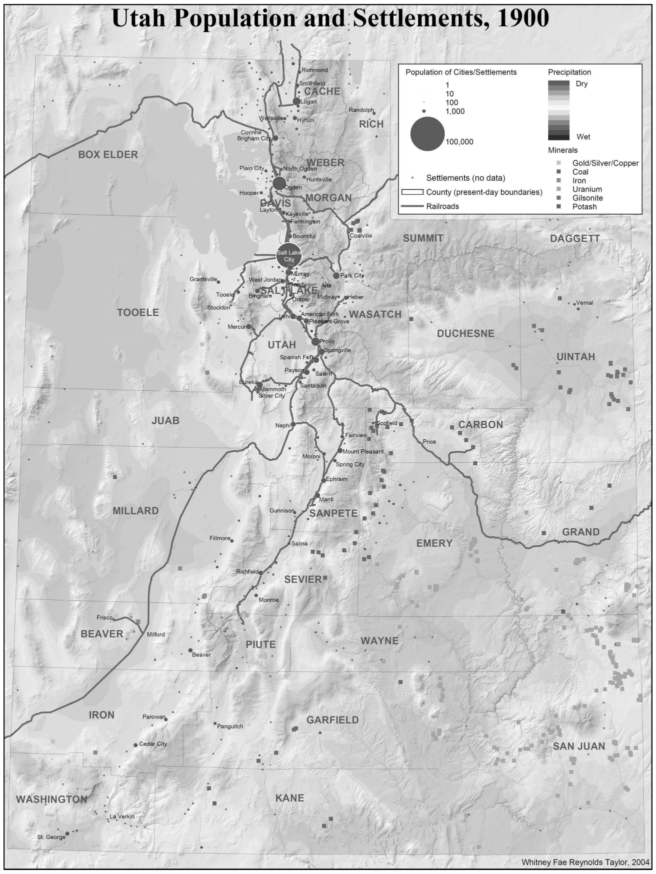

Figure 1. Sample paper map. (see page 77 for color version)

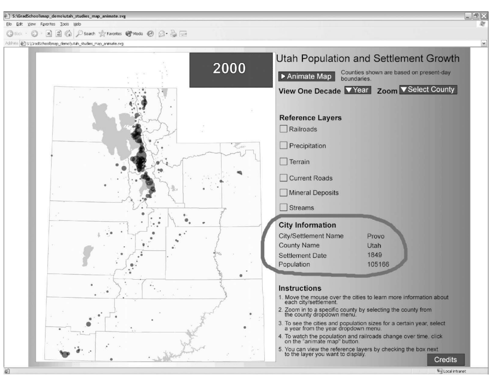

Figure 2. Brushing to view city data in the interactive map. (see page 77 for color version)

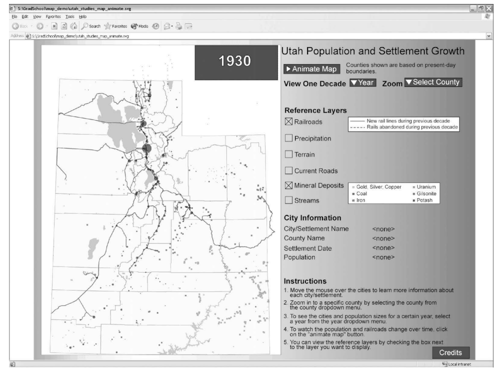

Figure 3. Toggling layers on and off in the interactive map. (see page 77 for color version)

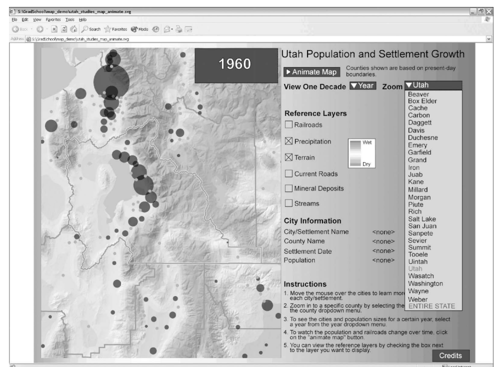

Figure 4. Zooming on a county in the interactive map. (see page 77 for color version)

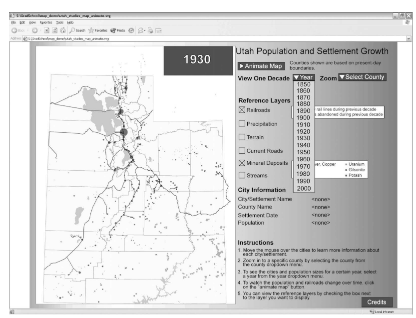

Figure 5. Selecting a year in the interactive map. (see page 77 for color version)

areas, focusing on *inference, comparison*, and *explanation*. Although multiple-choice test items are problematic because students can frequently guess the correct answer (Anderson and Krathwohl, 2001), it was chosen because it is an effective way of assessing conceptual knowledge. The short-answer portion of the test asked students to *exemplify, summarize, infer, compare*, and *differentiate* factors that may contribute to settlement patterns, and changes in railroading over time.

Before the experiment, the test questions and maps were piloted with several non-test students of the similar ages, to ensure that the questions were appropriate in wording and difficulty for the target age. The students were asked to think aloud while they answered the questions, and this feedback helped us revise the questions and eliminate any questions that were too difficult for them to understand. The following are a few sample questions from the posttest:

Matching: Match each city in Utah with the decade during which it was settled. Write the letter designating the decade for each city on the blank next to each city. Each decade may be used once, more than once, or not at all.

____ 1. Scofield, Carbon County	a. 1871-1880
____ 2. Hurricane, Washington County	b. 1881-1890
____ 3. Vernal, Uintah County	c. 1891-1900
____ 4. La Verkin, Washington County	d. 1901-1910
____ 5. Sunnyside, Carbon County	e. 1911-1920
	f. 1921-1930

Multiple Choice: Which one of the following factors best explains why the population of Park City (Summit County) is growing and Eureka (Juab County) is declining even though the mines near both cities closed many years ago?

a. Date railroad was pulled up
b. Stream flow
c. Closeness to other towns
d. Precipitation

Short Answer: Wayne County has over twice as much area as Cache County. However, despite the difference in area, Cache County has historically had a larger population than Wayne County. Name two of the physical geography factors that have contributed to this trend.

"After students completed the posttest, they were asked to fill out a survey."

After students completed the posttest, they were asked to fill out a survey. The first part asked for information on demographic factors that have been shown to have an extracurricular effect on learning (Bangert-Drowns and Pyke, 2002; Montello *et al.*, 1999; Proctor and Richardson, 1997; Calvert, 1993-1994; Lockheed *et al.*, 1989), including gender, past social studies performance, and parents' education level. These were used as control variables in the analysis. The second part was an attitude assessment, in which students were asked to identify their impressions of the material, using a bipolar adjective scale (Burke, 1989). This section was divided into attitudes about the unit in general and attitudes about the map resources they used. Two opposite adjectives were listed for each item (e.g., confusing vs. understandable, important vs. unimportant, enjoyable vs. unpleasant), and students marked their opinion on a scale between them. A score of five was given for ratings closest to the favorable adjective in each pair, and one for ratings closest to the unfavorable adjective. The order of negative and positive adjectives was reversed on some questions to prevent students from marking a single column for all the adjectives without reading. Each student's ratings of all bipolar adjectives were summed to get his or her composite rating of the unit and the map(s) used.

Results

The test results were scored, and then analyzed using multiple linear regression. The primary independent variable was the type of map used (paper or interactive). The demographic data (gender, past social studies grades, and parents' education) were also used as independent variables to account for their possible effect on student ability. The dependent variables included the improvement from pretest to posttest, calculated by subtracting the percent correct for the test as a whole and for each question type, and the attitude ratings. Table 2 summarizes the variables used in the analysis.

Variable	Measurement	Source
Dependent Variables		
Overall Score Improvement	Posttest percent – Pretest percent	Tests
Matching Improvement	Matching posttest percent – pretest percent	Tests
Multiple-Choice Improvement	Multiple-choice posttest percent –pretest percent	Tests
Short-Answer Improvement	Short-Answer posttest percent – pretest percent	Tests
Unit Attitude Score	Add scores for bipolar adjectives	Survey
Map Attitude Score	Add scores for bipolar adjectives	Survey
Independent Variables		
Gender	Male (1) or Female (0)	Survey
Past Social Studies Grade	Grades A (1) – F (5)	Survey
Father's Education Level	Degree Attained (1 = High School; 5 = Doctoral	Survey
Mother's Education Level	Degree Attained (1 = High School; 5 = Doctoral	Survey
Map Used	Interactive map (1) or Paper maps (0)	Survey

Table 2. Independent and Dependent Variables, Measurement, and Data Sources.

The map type, past social studies grades, gender, and parents' education were thus used as predictors of the improvement scores from the pre- and posttest and the two attitude scores. The map-type coefficient in each regression model, an indicator of the maps' effect on students' learning and attitude, was then tested for significance.

Before reporting the analysis results, a limitation in data collection more than likely has affected the scores needs to be explained. Time was limited on the posttest, and some students in the experimental group did not have enough time to complete the short-answer section of the test because of the slow computer speed. Only 20 percent of the interactive-map students completed the short-answer section on the posttest, compared to 98 percent of the paper-map students. To account for this, the percentage correct on the short-answer section was based on the number of questions the students completed. For example, if a student completed four of the three-point short-answer questions and three were correct, the short-answer score would be 75 percent. Because the short-answer questions were not ordered by difficulty level, this solution to the problem was practical.

The score improvement for the different dependent variables varied. Table 3 summarizes the descriptive statistics for the control and experimental groups for the test-score dependent variables used in this research:

Variable	Group	Pretest Mean	Posttest Mean	Difference** Mean
Overall Test	Experiment Control	5.3/26 (20.5%) 5.4/26 (20.7%)	19.9/30.2* 19.2/40 (47.9%)	45.2% 26.5%
Matching	Experiment Control	2.6/5 (52%) 2.8/5 (56%)	9.1/10 (91%) 7.1/10 (71%)	38.4% 13.9%
Multiple Choice	Experiment Control	2.1/5 (42%) 1.8/5 (36%)	5.6/9 (62.2%) 5.8/9 (64.4%)	20.4% 28.2%
Short Answer	Experiment Control	0.7/16 (4.4%) 0.9/16 (5.6%)	4.8/11.2* (42.9%) 6.2/21 (29.5%)	40.1% 23.8%

* students did not finish the posttest section

** difference includes only students who completed both the pretest and posttest

Table 3. Test Descriptive Statistics

"A few students scored in the "A" range in both the control and experimental groups, and most students in both groups would have received a passing grade for this unit."

Overall, the students did fairly well on the posttest. The average posttest score for the students using the interactive map was 66.0 percent, whereas the average posttest score for the students using the paper maps was 47.9 percent. Although these averages are a little lower than what would be desirable for a normal test, they are good considering the condensed amount of time the students had to learn the material and concepts in the unit. In addition, this result may be attributed to the fact that the test questions required them to stretch themselves and do things beyond the recall level. A few students scored in the "A" range in both the control and experimental groups, and most students in both groups would have received a passing grade for this unit.

The experimental group's mean improvement for the *matching* section was 38.4 percent, whereas the control-group mean improvement for that section was 13.9 percent. The experimental group's mean improvement for the *multiple-choice* section was 20.4 percent, whereas the control-group mean improvement for that section was 28.2 percent. Finally, the experimental group's mean improvement for the *short-answer* portion was 40.1 percent, and the control group's mean improvement for that portion was 23.8 percent. Multiple regression analysis was then performed with overall score improvement as the dependent variable. Table 4 displays the results of the full regression model.

Independent Variable	Slope	t-value	Significance Level
Map type	17.677	5.729	<0.001**
Sex of student	0.609	0.193	0.847
Past social studies grade	-2.641	-1.141	0.257
Father's education	1.870	1.312	0.193
Mother's education	1.144	0.625	0.534

**significant at the $p = 0.05$ level, total degrees of freedom (df): 109

Table 4. Dependent Variable: Overall Improvement.

The full regression model indicated that the students in the experimental group improved an average of 18 percent better than the control group in overall score (controlling for demographic factors), which was a significant difference. None of the other independent variables were found to be significant in this model. These results indicate that the map type students used impacted their ability to answer the test questions accurately.

The key to understanding the difference between the two groups can be seen by analyzing the map-type variable for not only the full regression model, but also the models for each test section. Table 5 summarizes the results of the map-type variable for each regression model.

Dependent Variable	Slope	t-value	Degrees of freedom	Significance Level
Overall Improvement	17.677	5.729	109	<0.001**
Matching Improvement	24.233	4.743	109	<0.001**
Multiple-Choice Improvement	-5.408	-1.096	109	0.275
Short-Answer Improvement	15.065	3.876	101	<0.001**

**significant at the p = 0.05 level

Table 5. Independent Variable: Map-type.

On the regression models for the individual sections, the experimental group was significantly better ($p < 0.001$) in both the matching section and the short-answer section. However, the students using the interactive map actually improved less than the control group on the multiple-choice questions, although not significantly less.

The two sections of the attitude survey were analyzed separately. The first section (ten adjective pairs) assessed students' attitudes for the unit as a whole, and the second section (five adjective pairs) focused on students' attitude for the map(s) used for the unit. Multiple regression analysis was then performed with the map and unit attitude scores as dependent variables and the same independent variables as before. Table 6 displays the descriptive and regression statistics for both the control and the experimental groups. In both parts, the scores were not significantly different.

Dependent Variable	Group	Mean	Slope	t-value	Degrees of freedom	Significance
Unit Attitude	Experimental	32.91/50	-0.930	-0.651	112	0.517
	Control	33.26/50				
Map Attitude	Experimental	17.93/25	-1.231	-1.458	112	0.148
	Control	18.79/25				

Table 6. Attitude Statistics.

The demographic variables (gender, past performance, and parents' education) also yielded regression coefficients in each model, but none had a consistently significant influence.

Discussion

The results illustrated that introducing interactive maps enhanced the success of some learning objectives, but some results were inconclusive. Based on anecdotal evidence and a review of patterns in the test results, there are several possible reasons for the varying results from each test section.

Matching: The matching questions asked students to report the settlement date for a given city and indicate whether a city increased or decreased its population during a given decade. Students using the paper maps may have had difficulty with these questions because they had a lot of information in the maps and tables and may have become confused. The students had been asked to use the maps whenever possible to determine whether a settlement grew or not, and during which decade a settlement started (i.e., which map it first appeared on), and use the Census tables only when necessary. However, they may have used the tables exclusively, which could be problematic. For example, the example question above asks about Scofield, which was settled in 1879, and thus appears on the 1880 map, even though it did not get counted in the Census until 1890. A student that used only the Census table (which shows a 0 for Scofield for 1880) would get this question wrong. A more complete table (e.g., with a column for settlement date) would certainly have raised the scores of the control group, but this would only have validated the usefulness of the table, not the paper maps. Students who used the interactive map, conversely, had access to all the information they needed to answer the question in one location via the brushing tool, in which Scofield explicitly states a settlement date of 1879 and a lack of an 1880 Census population, reducing confusion.

"The results illustrated that introducing interactive maps enhanced the success of some learning objectives, but some results were inconclusive."

Short Answer: The short-answer portion of the test asked students to isolate certain features that may have contributed to settlement patterns and changes in railroading over time. Through toggling, the students using the interactive map were better able to isolate different contributors, such as precipitation, elevation (terrain), minerals, and streams, which likely contributed to the significant difference between the two groups. Students using the paper maps had the same information, but it was all on the maps simultaneously. In addition, they were not able to see a more detailed view of certain counties by zooming, as the students with interactive maps were able to do.

Multiple Choice: The multiple-choice questions asked students to analyze data presented on the map and study the patterns to identify potential reasons for settlement. The lack of a significant difference between the two groups for the multiple-choice portion of the test may be attributed to the speed of the computers used by the students. Although the interactive map was able to run on the computers, it ran slower than anticipated because the computers were relatively old. As a result, we observed several students becoming frustrated with the delays and guessing on the multiple-choice questions rather than waiting for the map to update. Guessing is always a danger when using multiple-choice test items (Anderson and Krathwohl, 2001). Thus, this form of question may not have been the best for the students with interactive maps, who needed to patiently wait for their map to update before responding. That said, they scored about the same as the students with paper maps, so they were not guessing on everything, assuming that the students with papers maps were not guessing either.

"The lack of a significant difference between the two groups for the multiple-choice portion of the test may be attributed to the speed of the computers used by the students."

Unit and Map Attitudes: The lack of significant results for the attitude assessment is not unique to this study; Pedersen *et al*. (2005) also found equivocal levels of satisfaction between paper and electronic maps. In our case, this appears to have been due to the relationship between the adjectives used in the assessment and the different student experiences. While in the classroom, we observed two very different levels of enthusiasm for the two map groups. The students using the paper maps quickly got bored using the maps for the different tests and exercises. The students in the experimental group were excited to try the new computer maps, but gradually got frustrated with the slow computers, a common problem in studies dependent on technology (Yang, 2001; Hara, 1998; Proctor and Richardson, 1997). In both of the groups, students complained about answering the same types of questions over and over, even though the parallel pretest/exercise/posttest structure was necessary for the experiment. Thus, the lack of significant differences for any of the adjectives may have been due to blanket attitudes: students that were generally pleased with the unit appear to have selected all the positive adjectives, students who had a generally negative attitude (for whatever reason) selected all the negative adjectives, and students who didn't care answered all the attitude questions neutrally, without carefully considering the nuances between each one.

"The students in the experimental group were excited to try the new computer maps, but gradually got frustrated with the slow computers, a common problem in studies dependent on technology."

Conclusions

The results of this study show that interactive maps offer modest learning benefits over traditional paper maps. However, some types of learning objectives and some types of concepts have more to gain from interactivity than others. Specifically, interactive maps seem well suited for conceptual learning that involves *finding*, *comparing, exemplifying*, and *explaining* geographic information and patterns. It is not as advantageous for memorizing facts or evaluating fairly simple patterns that can be adequately expressed on paper maps or other media. Unfortunately, the attitude assessment was inconclusive, and additional research is needed to see whether students prefer interactive-map learning to paper-map learning.

Findings of insignificant to modestly significant learning and attitude gains for interactive maps (and GIS) have been fairly common in similar studies (e.g., Linn, 1997; Pedersen *et al*., 2005; Keiper, 1999; Baker and White, 2003; West, 2003). One common factor, though not always recognized by the authors, is the quality of the tested materials. One must assume that the interactive map is a high quality, representative example of the genre. In this case, the Utah settlement interactive map was later refined for a different project, and the significant improvements in usability and performance made us wonder if we would have had stronger results with the newer version.

". . . interactive maps seem well suited for conceptual learning that involves finding, comparing, exemplifying, and explaining geographic information and patterns."

One of the main limitations of this study was the level of technology available at the school. Although the interactive map was tested on the classroom computers before the experiment, they were slower than the ones used to design the interactive map, making the map run much more slowly than desired. The subsequent frustration appears to have impacted both the test scores and the attitudes of the experimental group. However, this obstacle is not only at this location; budget limits often lead to schools having older, less powerful computers than in the office (and often, in the home). This is a limitation to which educational technology researchers, teachers, and students must adapt (Keiper, 1999). For example, Proctor and Richardson (1997) suggest creating paper materials (similar to our control materials) as a fallback, perhaps even making the computer-based tools optional for completing assignments.

Another limitation was that because the learning unit was experimental, the teacher gave grade points merely for students' participating, regardless of their scores—only if they "tried their best." The lack of significance for various sections could therefore be partly attributed to students who did not really care how well they performed. This lack of motivation is often a difficult obstacle in human-subjects testing, including similar studies in geographic education (Proctor and Richardson, 1997; Pedersen *et al*., 2005). In the case of this study, the teacher could not use the test scores for grading because we expected that the control group would get lower scores regardless of their ability.

". . . students who used the interactive map visibly showed more enthusiasm as they worked on the unit . . ."

Although the attitude assessment results were inconclusive, we made several anecdotal observations that suggest that the teacher and students liked the interactive maps more than was indicated by the results, and may be widely accepted once school technology improves. The teacher was eager to try something new with the unit and was excited about the things presented therein and the new tools used. The students who used the interactive map visibly showed more enthusiasm as they worked on the unit (exercises and tests) than the students who used the paper maps (who complained of boredom from doing the same task repeatedly). Several of the students using the interactive map commented that the map was really interesting and fun to use, but then complained of the length of time they had to wait for the computer to update with changes. A revised assessment instrument (to somehow avoid blanket answers), and interactive maps tailored to the performance of the school computers, may have significantly changed the results.

Although using these teaching tools in the classroom can benefit social studies education, creating interactive maps is not something teachers can easily do themselves; it took several months of programming to create the maps used in this study. Creating these maps still requires third parties who are willing to volunteer their efforts to improve social studies education in schools.

Future Research

"Future research should focus on creating interactive maps that accompany a wide variety of topics in social studies curriculum to help students learn about an assortment of concepts with the interactive maps."

The limitations of this study illustrate the need for future research in this arena. For this study, the time to create the interactive map was limited, so only one interactive map could be created before the experiment deadline. Future research should focus on creating interactive maps that accompany a wide variety of topics in social studies curriculum to help students learn about an assortment of concepts with the interactive maps. As students become more accustomed to using the computers and map interactivity in their classes, they may be able to analyze more complex changes in the subject, and focus less on the mechanics of using the tools. In addition, efforts should be made to encourage more teachers to accept new teaching resources in their classrooms so that the maximum potential of using these resources can be achieved.

Based on the anecdotal positive response students had toward using the computer maps in this study, further research into attitude differences is warranted, although obtaining a clear understanding of student feelings is difficult. Also, we were not able to study how well students *retain* what they learn using interactive maps over a longer term; this would require a longitudinal study. In addition, this study was focused on a relatively small area and a regional subject applicable to the state level, but future studies should include implementation interactive maps of various size spaces and regions.

Best Practices

For those educators who wish to design and use interactive maps, we suggest several guidelines learned in the course of this research:

- Design maps that are appropriate for the level of technology available, even if this means leaving out functionality that could be very useful or engaging. Assuming that school computers will soon become much more powerful denies the realities of budget issues in today's schools.
- Keep the interface simple and applicable to the target age, and include instructions in the software.
- Schools have limited budgets, and commercial interactive and web-mapping software can be prohibitively expensive, but software exists that can be free to develop or distribute high-quality interactive maps.
- When teachers use these maps in their instruction, they should create their own learning exercises around the maps that help emphasize the concepts they see as most important, rather than altering their curriculum to match the available resources.
- Design learning activities that require students to thoughtfully examine geographic and historical patterns, and discourage guessing.
- Collaborate with other educators who are interested in using the maps to better meet their educational needs.

". . . interactive maps can be utilized in subjects with a spatial dimension to aid learning."

Our research has shown that interactive maps can be utilized in subjects with a spatial dimension to aid learning. Interactive maps in social studies classes can create a more dynamic learning atmosphere, therefore enhancing knowledge acquisition. By using interactive maps as an additional resource in their teaching curriculum, teachers can effectively improve student learning, at least for some types of topics and learning objectives. Although the results of this study on student attitudes were inconclusive, there was enough anecdotal evidence to suggest that interactive maps have the potential to excite students about learning. As the technology available to students improves, and development tools become more prevalent and easier to use, the opportunity to design and use interactive maps in the classroom will increase greatly. Current and future teachers are encouraged to take advantage of available geographic technology to enhance their classroom instruction. Doing so will enhance the teaching of physical and human geography, while improving students' mapping and computer skills.

". . . enough anecdotal evidence to suggest that interactive maps have the potential to excite students about learning."

[1]The interactive map used for this study, as well as a version modified after the study was completed are available from the authors.

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