

Effects of Self-Evaluation Training on Achievement and Self-Efficacy
In a Computer-Supported Learning Environment

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Paper presented at AERA

April, 2005

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Abstract

Self-evaluation training contributes to achievement in traditional classrooms, i.e., those in which technology is not a main focus. We investigated the impact of self-evaluation training on student achievement and on computer self-efficacy in a computer-supported learning environment (grade 11 students using Geographic Information Systems software). We found that self-evaluation training had a positive effect on student achievement, accounting for 25% of the variance across three measures, a much larger proportion of the variance than could be attributed to initial self-efficacy (4%). The treatment effect was as large for females as for males and for those with low initial self-efficacy as it was for those with higher scores. However, self-efficacy increased more in the control than in the treatment group. Several interpretations of the latter finding are plausible: the negative effect of self-evaluation training on self-efficacy could be 1) a negative result of the treatment, 2) an artifact of pretesting (the treatment may have led students to recalibrate the metric they used in their self-appraisals), or 3) a positive outcome of the treatment (teachers may have used self-evaluation training to depress the inflated self-perceptions of some teenagers).

Keywords

Computers & Learning, Achievement, Student Attitudes

¹ An earlier version of this article appeared as Michelle Starling's Master of Education Research Paper for the Department of Curriculum, Teaching & Learning at the University of Toronto. Anne Hogaboam-Gray and Peter Gray contributed to the data analysis.

Effects of Self-Evaluation Training on Achievement and Self-Efficacy
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Teaching students how to evaluate their work has a positive effect on student achievement in traditional settings, i.e., those in which technology is not a central feature (e.g., Ross, Hogaboam-Gray, & Rolheiser, 2002; Ross, Rolheiser, & Hogaboam-Gray, 1999a). Although computer-supported learning programs frequently provide a self-assessment function, few studies have examined the effects of self-assessment on student achievement or on such student cognitions as beliefs about their ability to accomplish technology-embedded tasks. This study examined the effects of self-evaluation training on the achievement and computer-related self-efficacy of grade 9 students using Geographic Information Systems (GIS) software.

Motivation for the Study

In this section we will present our rationale for anticipating that self-evaluation training students will contribute to achievement in computer-supported learning contexts. We will review research on computer self-efficacy to argue that change in self-efficacy is an important outcome of instruction, as well as a contributor to instructional effectiveness. In so doing, we will identify antecedents of self-efficacy that need to be included in arguing for the pretest equivalence of our treatment and control groups.

Self Evaluation and Achievement

Klenowski (1995) defined self-evaluation as “the evaluation or judgment of ‘the worth’ of one’s performance and the identification of one’s strengths and weaknesses with a view to improving one’s learning outcomes” (p. 146). Klenowski argued there were three essential

elements to self-evaluation training: use of criteria negotiated by teacher and students, teacher-student dialogue that focuses on evidence for judgments, and ascription of a grade by students (alone or in collaboration with teachers). We define self-evaluation training as systematic instruction in each of these elements. For example, in Rolheiser (1996) we provided instructional strategies and tools for teaching self-evaluation in four stages: (i) involve students in defining evaluation criteria, (ii) teach students how to apply the criteria, (iii) give students feedback on their self-evaluations, and (iv) help students use evaluation data to develop action plans.

Many computer-aided learning packages include a self-evaluation component but the feedback students receive tends to be limited. In addition, researchers have not disentangled the effects of self-evaluation from other treatment dimensions. For example, Vollands, Topping, and Evans (1999) reviewed studies finding that Accelerated Reader, a computerized self-assessment system in use in 40 000 U.S. schools, had a positive effect on student literacy. The program administers a comprehension test keyed to self-selected books. Students receive a score which is the product of the number of items correctly answered and the difficulty of the text chosen. They are expected to use the score to select subsequent books that are within their Zone of Proximal Development (Vygotsky, 1978) but the feedback provides little direction on how to do this. There is also doubt whether the effects of the program should be attributed to self-assessment or to the rewards students receive for obtaining high scores. In contrast, the student achievement effects of self-evaluation training in traditional classrooms have been extensively investigated with positive achievement effects reported for language (Arter, Spandel, Culham, & Pollard, 1994; Hillocks, 1986; Klenowski, 1995; Ross et al., 1999-a), mathematics (Ross et al., 2002; Schunk, 1996), music (Sparks, 1991), and social skills (Ross, 1995; Ross, Rolheiser, & Hogaboam-Gray, 1999-b; Nelson, Smith, & Colvin, 1995).

Self-evaluation training contributes to achievement for the following reasons. Self-evaluation training (i) focuses student and teacher attention on the objectives to be learned; (ii) provides explicit indicators of success and failure; (iii) and provides students with challenging but attainable performance expectations. (iv) Students pay more attention to self-evaluation than to other forms of assessment (Ross, Rolhesier, & Hogaboam-Gray, 1998). (v) Self-assessment provides teachers with information, particularly concerning student beliefs and feelings about their learning, not otherwise available. (vi) Self-assessment increases student motivation through self-efficacy. Ross et al. (2002-a) describe the mechanisms through which self-efficacy mediates between self-evaluation and achievement. The effects of self-efficacy on student achievement have been amply demonstrated in a variety of fields (see reviews by Multon, Brown, & Lent, 1991; Pajares, 1996).

Self-Efficacy in Computer-Supported Environments

Studies of technology education have treated self-efficacy as an outcome of instruction, as well as a predictor of cognitive achievement. A key issue in current research is the exploration of why some people reject computer technology. Low computer self-efficacy is frequently cited as a central motivator of technology avoidance (e.g., Harrison & Rainer, 1992).

The biggest influence on self-efficacy is successful task experience—those who accomplish their goals are more likely to anticipate success with similar tasks in the future (Bandura, 2000). Participation in computer-supported course work increases the likelihood of successful task experience. Course work increases the learner's skill set and provides opportunities for students to see the positive effects of that skill set on the accomplishment of computer-based tasks. Computer-based course work contributes to higher computer self-efficacy (Chou, 1991; Klobas & Renzi, 2001; Neafsey, 1998; Tompson & Dass, 2000; Torkzadeh & Van

Dyke, 2002). These effects are more likely to occur if teachers explicitly attend to student cognitions. By helping students monitor their progress, teachers increase the likelihood that students will attribute their success to their ability and effort rather than to factors outside their control such as luck (Bandura, 2000). For this reason we anticipate that self-evaluation training will enhance students' computer self-efficacy beliefs as well as their achievement.

Students experience success and failure prior to taking particular computer courses. These experiences are the strongest influence on self-efficacy beliefs. We would anticipate that students who have had more experience would score higher on self-efficacy measures because self-efficacy influences goal setting (Bandura, 2000). Those who are successful on computer tasks will be more likely to seek out similar experiences than those who are less successful. Success and experience reinforce each other, creating a strong correlation between computer experience and computer self-efficacy. Researchers have demonstrated that computer experience predicts computer-related self-efficacy (i.e., the student's expectation the he or she will be able to perform a range of computer-related functions) (Coffin & McIntyre, 1999; Durndell & Haag, 2002; Ertmer, Evenbeck, Cennamo, & Lehman, 1994; Hasan, 2003). Negative prior experience depresses self-efficacy. For example, Salanova, Grau, Cifre, & Llorens (2000) found that increased experience and training both contributed to computer burnout (exhaustion and cynicism). However, the effects were moderated by self-efficacy. Those with higher computer self-efficacy were less likely to experience negative effects. These findings suggest that prior computer experience is an important criterion in determining the equivalence of treatment and control groups.

Some students have greater opportunities to acquire computer experience than others. Previous research has found that computer ownership increases computer experience (Levine &

Donitsa-Schmidt, 1998), thereby contributing to higher self-efficacy. Internet access is also likely to enhance opportunities for home use.

Parental modeling of successful computer practice is likely to have a positive effect on the computer self-efficacy of their children, through vicarious experience and through parental persuasion—two factors that contribute to self-efficacy, although not as strongly as successful experience (Bandura, 2000).

Finally, there is strong evidence that gender influences computer self-efficacy directly and indirectly through self-efficacy antecedents, such as experience. The size of gender differences in cognitions about computers and computer use is not large (e.g., Bannert & Arbinger, 1996 found that gender explained 5% of the variance in computer outcomes) and there is some evidence that gender differences are declining as computer use becomes institutionalized (Schumacher & Morahan-Martin, 2001). Although not all studies found evidence of gender differences, virtually every study that did reported that males are advantaged. Males are more likely to own a computer (e.g., Durndell & Lightbody, 1993), use it more often (e.g., Robertson, Calder, Fung, Jones, O'Shea, & Lambrechts, 1996), have greater computer experience (Bannert & Arbinger, 1996), and report more support from parents for computer use (Reinen & Plomp, 1997). Males are more confident about their computer abilities than females (Durndell & Haag, 2002; Murphy, Coover, & Owen, 1988).

These findings provide the foundation for treating computer self-efficacy as an outcome of instruction in computer-supported environments. This research also indicates that computer use, coursework, ownership, Internet access, parental use, and gender be included in arguing for the pretest equivalence of treatment and control groups.

Purpose and Context of Our Research

Our goal was to extend research on the effects of self-evaluation training to computer-supported learning environments. The research question of the study was: To what extent does self-evaluation training contribute to students' achievement and computer self-efficacy?

The context was a grade 9 Geography course in which students solved real-life geographic problems using GIS (Global Information Systems) software: ArcView 3.2 (ESRI Canada, 2002). ArcView is an automated mapmaker containing a database and database manager that stores, retrieves, manipulates and displays geographic data. Evidence about the effects of ArcView training on geographic knowledge is positive, albeit anecdotal (Audet & Paris, 1997; Solem, 2001). GIS is used in all Geography courses in secondary school because it emphasizes spatial concepts that are the basis of geographic understanding (Oldakowski, 2001). Students do not encounter ArcView prior to grade 9 and it is not available for home use. Although associated most closely with Geography, many disciplines draw on GIS (Audet & Abegg, 1996), so that the study findings have application beyond Geography courses.

Method

Sample

One hundred and sixty-four students in seven Grade 9 Geography classrooms participated in the study. Two teachers in one high school taught the treatment group; four teachers in three schools taught the controls. All students were from a single school district in central Ontario, Canada, representing 10% of the grade 9 students in the district. Students were almost exclusively white, less than 1% spoke a language other than English in their home, and 6% were receiving special education services.

Instruments

Achievement was measured with three instruments: At the end of the study all students completed an individual performance assessment over two 75-minute periods. Students used ArcView to create a map and MS Word to write a prose report of a problem solving task in which they described the importance of a Geographic problem (the lack of recycling in Canada), generated alternative solutions to the problem, identified advantages and disadvantages of each alternative, and provided a rationale for the solution they selected. The *Map Score* consisted of a 1-5 score based on computer application skills. Level one was given to maps with two or more substantive errors (e.g., map content errors) or four or more minor errors (e.g., features slightly out of proportion). Level five was given to a map completed correctly with more than one meaningful addition to the basic procedure (e.g., inclusion of an inset map or use of colour/shading to highlight an argument). The *GIS Report* score consisted of a 1-5 score based on four dimensions of problem solving: problem definition, data analysis, recommendation, and structural features of the report. The appendix contains the rubric for both measures. The third measure was *GIS exam*, a low inference test of GIS mapping skills in which each student created a map with specified features (e.g., ecozone boundaries), labeled the features, found relationships between ecozones and fresh water lakes and explained their importance, found and labeled a wildlife sanctuary, and exported the map to hard copy. Students received a score from 0-50 on the GIS exam.

The GIS Maps and GIS Reports were coded by two judges who were trained to 80% agreement. Each judge independently coded each map and report. Where there were differences they negotiated the score assigned. Inter-rater reliability was calculated in two ways. The proportion of perfect agreement between the two judges across the five-point scales was 61% on

the map and 59% on the Reports. A less stringent definition of agreement within one level of the scale produced agreement of 94% for the Maps and 99% for the Reports. Cohen's (1960) Kappa, a chance-adjusted measure of agreement, for the less stringent definition was .88 for the Maps and .98 for the Reports. The GIS exam was marked by classroom teachers using a low inference scoring sheet. Reliability could not be calculated because we had access only to the total scores.

At the beginning and end of the study, all students completed a computer self-efficacy scale in which they reported confidence in their ability to perform 25 computer application tasks (e.g., logging onto a networked computer, copying a disk). Students used a 1-6 scale anchored by very little confidence and a lot of confidence. Responses were averaged to produce a 1-6 score. The internal consistencies were high on pre- ($\alpha=.97$) and post-tests ($\alpha=.98$).

At the beginning of the study all students responded to survey items concerning gender, home ownership of a computer, Internet access, hours of student computer use, and parent use of computers.

Treatment Conditions:

Students in both treatment and control groups worked on computer-supported units once per week for four months. Each of the six units was based on a public policy issue (e.g., developing a fire management policy for British Columbia forests). Students constructed maps, tables, and charts representing aspects of the problem (e.g., forested regions, areas of fire, causes of fire, effects of selected policies). Data were drawn from the ArcView database and from other sources. Students completed individual assignments but worked in pairs (which produces higher learning than working alone: Berg, Brandstorm, & Sutter, 1995; Hooper, Temiyakarn, & Williams, 1993; Mevarech, Silber, & Fine, 1991). Students were paired on the basis of their

pretest self-efficacy (highs with lows). Students in all conditions used the same set of student tasks, learning materials, hardware and software.

Students in the treatment, but not the controls, were trained in self-evaluation procedures outlined in Rolheiser (1996). Students and teachers developed rubrics representing high and low performance on a GIS project and on working together as a partnership. The rubrics, unique to each class but sharing common features, were displayed in the classroom and were used by students to assess their projects and their collaboration. Teachers gave students feedback on their performance using the same rubrics. Students also completed short instruments assessing project progress which they shared with their partners to set immediate goals. Students in the control condition were evaluated solely by the teacher.

Teachers in both treatment and control conditions attended three half-day in-services, two before the start of the semester and a third near its end. At sessions 1 and 2 all teachers experimented with GIS software, reviewed GIS exercises, and developed strategies for assisting students through the activities. The third session focused on solving problems that arose and debriefing teachers on their experiences. At each session, the treatment teachers met separately for one hour on strategies for teaching self-evaluation. During this hour control group teachers continued to focus on the classroom use of GIS software.

Analysis Procedures

After determining the reliability of study variables and the pretest equivalence of the groups, data were entered into a multivariate analysis using GLM (General Linear Modeling) in SPSS, which combines linear regression with analysis of variance. The dependent variables were GIS map, GIS report, GIS exam, and computer self-efficacy. The independent variable was experimental condition, and the covariate was pretest computer self-efficacy.

Results

Table 1 displays the means and standard deviations of the variables in the study. Table 2 shows part of the correlation matrix. The student outcome variables were significantly correlated. This indicates that a multivariate procedure is required to control multicollinearity. Table 2 also shows that none of the student background variables consistently predicted the outcome variables. However, we decided to include pretest self-efficacy as a covariate in the multivariate analysis on theoretical grounds. This decision was confirmed when the GLM analysis indicated that self-efficacy 1 was a significant covariate for two of the four outcome measures. Not shown in Table 2 is that pretest self-efficacy correlated with hours of computer use ($r=.31$, $p=.001$, $n=158$) and gender ($r=-.25$, $p=.012$, $n=162$), as expected from previous research. Table 3 shows that the groups were equivalent on the pretest measures.

Tables 1, 2, 3 and Here

Tables 4 and 5 examine the effects of the treatment. Table 4 shows the effects of the treatment when all the student outcome variables are combined. It demonstrates that the treatment had a significant effect, after controlling for the effects of pretest self-efficacy. The multivariate model explained 84% of the variance in the outcome scores. Both the treatment and pretest self-efficacy had significant effects. The treatment accounted for 22% of the variance across outcomes, a large effect according to Cohen's (1988) criteria for interpreting effect sizes.

Table 4 Here

Table 5 displays the univariate effects. The covariate, pretest computer self-efficacy, had a significant effect on one of the achievement outcomes. Students who had greater confidence in their ability to complete computer tasks had higher scores on the GIS Map. There were no differences on the other achievement measures. Students with higher self-efficacy on entry to the

program had higher self-efficacy on the posttest. Table 5 shows that after controlling for the effects of pretest self-efficacy, students in the treatment group scored higher than students in the control group on all the achievement measures: the Map, the GIS Report, and the GIS exam. The partial eta squared column in Table 5 shows that the treatment had a greater impact on each of the achievement outcomes than did pretest computer self-efficacy. Table 5 also shows there was a significant treatment effect on posttest computer self-efficacy. In this instance the treatment effect was a tenth of the impact of entry level self-efficacy. Table 6, which summarizes the means for each experimental condition on the outcome variables, shows that members of the treatment group scored higher than the controls on posttest achievement and scored lower than controls on posttest self-efficacy. The univariate effects of the treatment ranged from small (computer self-efficacy, GIS map, and GIS exam) to medium (GIS Report).

Tables 5 and 6 Here

We also investigated interaction effects. The analysis (not shown) indicated that the interaction of treatment with pretest self-efficacy and the interaction of treatment with gender were not statistically significant; i.e., the treatment was equally effective regardless of students' gender or computer self-efficacy on entry to the program.

Discussion

The study makes three contributions to academic knowledge. First, the study demonstrates that teaching students how to self-evaluate makes a positive contribution to their achievement. The effects were consistent across three domains of learning: spatial reasoning (represented by the computer-supported mapping score), solving authentic problems (represented by the GIS report), and basic geographic knowledge and skill (represented by the GIS exam). The only previous study of self-evaluation training in undergraduate computer classrooms

known to us (Ertmer & Schunk, 1997) found no achievement differences. Self-evaluation in that study may have had a weak effect because (i) it was only done once, (ii) undergraduates in the other experimental conditions may have self-assessed even though it was not required, and (iii) students were given no explicit training in how to evaluate beyond the instruction to do so.

The credibility of our finding of positive effects for self-evaluation training is weakened by the use of a quasi-experimental rather than true experimental design. The most serious threat to internal validity in this design, pre-existing group differences, was mitigated by the demonstration that the treatment and control groups were equivalent on variables associated with outcomes in computer-supported learning environments in previous research (i.e., self-efficacy, gender, computer ownership, computer use, Internet access, and parental use of computers). We also used the most powerful of these factors, pretest self-efficacy, as a covariate in the analysis. In addition our results confirm previously reported effects of self-evaluation in classrooms in which instructional use of computers was not a focus (Arter et al., 1994; Hillocks, 1986; Klenowski, 1995; Nelson et al., 1995; Ross, 1995; Ross et al., 1999-a; 1999-b; 2002-a; Schunk, 1996; Sparks, 1991). The triangulation of results between technology aided and traditional settings suggest that our finding is sufficiently robust to generalize to other computer supported learning environments.

The second contribution of our study is that it demonstrates that students' expectations about their ability to accomplish computer-supported tasks significantly influence their learning. Although the meta-analyses of Multon et al. (1991) and Pajares (1996) demonstrate the influence of self-efficacy on learning in traditional settings, few studies have demonstrated the same link in computer-supported contexts. Our study provides evidence that student beliefs about their abilities in computer domains influence how much they learn, even after the effects of the

treatment have been controlled. On a positive note, there were no significant interactions: the treatment was equally effective regardless of gender or pretest self-efficacy.

The third contribution of our study is the finding that although both groups developed more positive expectations about their ability to perform computer tasks, the self-efficacy of control students increased to a greater degree than the self-efficacy of treatment students. This could be viewed as a negative outcome of self-evaluation training because computer self-efficacy, confidence and anxiety are so highly correlated as to be almost synonymous. For example, computer confidence and anxiety load on the same factor (Loyd & Loyd, 1985; Moroz & Nash 1997a; Pope-Davis & Vispoel, 1993). This suggests that self-evaluation training might increase rather than decrease the problem of computer phobia.

Other interpretations are equally plausible. In previous research we found that self-evaluation training increased the accuracy of self-evaluations; i.e., the gap between teacher judgments and student self-appraisals narrowed (Ross et al., 1999-a). Increased accuracy can be viewed as a change in the underlying metric that treatment group students used when assessing their abilities. This recalibration or response-bias shift during a treatment was demonstrated by Howard (e.g., Howard & Dailey, 1979) and more recently by Cantrell (2003). The observed effect of the treatment on self-efficacy might be a testing artifact. The treatment effect on self-efficacy could also be a planned outcome of teachers. Lindsley, Brass, & Thomas (1995) argued that upward and downward spirals of self-efficacy beliefs are both bad, leading to over- or under-confidence. Each cycle depresses subsequent performance. Lindsley et al., writing in an organizational context, argued that it is the task of the leader to prevent upward and downward spirals. We could extend the argument to teachers. The negative effect of the treatment on self-

efficacy could be because teachers used the feedback stage of self-evaluation training to lower self-efficacy beliefs of teenagers who held inflated views of their capacity to use computers.

In summary, the meaning of our third finding is not clear. Self-evaluation training depressed self-efficacy. But this may not be positive if it increased the accuracy of self-appraisal. Those with inflated views will eventually crash into a wall of reality. Given the importance of self-efficacy in computer-supported learning environments, further research is required.

Conclusion

The most important outcome of our study is the finding that self-evaluation training contributes to student learning in computer-supported learning environments. The treatment accounted for 25% of the variance in achievement across measures, compared to 4% of the variance explained by pretest computer self-efficacy. In addition the treatment effects were as large for females as for males and for students with low expectations about their ability to perform computer tasks as they were for students with higher expectations.

It is important to recognize that the effects of the treatment were attributable to training in self-evaluation, not to self-evaluation itself. Fuchs, Fuchs, Karns, Hamlett, Katzaroff, and Dutka (1997) found that simply providing students with the opportunity to self-evaluate without additional training had negative effects. A treatment that provided only self-evaluation opportunities could reinforce the belief of students with low expectations that they are technologically illiterate. To be an effective part of an instructional design the teacher needs to identify instructional goals, clarify appraisal criteria, give students feedback on the accuracy of their self-appraisals, and guide students in how to use self-evaluation data to set learning priorities. We are optimistic that teachers who incorporate student self-evaluation into their instructional design will be rewarded.

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Table 1 Means and Standard Deviations of Variables in the Study

	N	Mean	SD
GIS Exam	161	34.12	9.32
Map Score	160	3.19	1.21
GIS Report	153	2.46	.911
Self-efficacy 1	164	5.04	.59
Self-efficacy 2	160	5.21	.61
Gender	162	56% female	-
Own computer	162	98%	-
Internet access	158	97%	-
Hours of use	158	<1 hr=21% 1-2 hrs=38% 2-3 hrs=26% 3+ hrs=15%	-
Parents' use computer	156	85%	-
Age	162	13 yrs=1% 14 yrs=86% 15 yrs=12%	-

Table 2 Correlation Matrix of Independent with Dependent Variables (N=164)

	GIS Exam	Map	Report	Self-efficacy 2
GIS Exam	-			
Map	.20*	-		
Report	.26**	.29**	-	
Self-efficacy 2	.13	.19*	.09	-
Gender	-.20**	.04	.14	-.24**
Has computer	.13	-.04	-.07	.12
Internet access	.00	.10	.04	.27**
Hours of use	.03	.04	-.09	.20*
Parents' computer use	.03	.14	.02	-.04
Age	-.01	.01	.04	.05
Self-efficacy 1	.13	.14	.07	.57*

Table 3 Evidence of Pretest Group Equivalence: Results of t-tests

Variable	Treatment			Control			t-tests
	N	Mean	SD	N	Mean	SD	
Self-efficacy 1	68	5.03	.568	88	5.05	.619	$T(154)=-.670, p=.867$
Gender	68	1.57	.498	86	1.53	.502	$T(152)=.476, p=.813$
Own computer	68	1.03	.170	86	1.02	.152	$T(152)=.234, p=.815$
Internet access	66	1.05	.210	84	1.01	.109	$T(92.27)=1.179, p=.241$
Hours of use	66	2.36	1.002	84	2.29	.964	$T(148)=.483, p=.630$
Parents' use	65	1.15	.364	84	1.15	.364	$T(147)=-.015, p=.988$
Age	68	14.12	.406	86	14.09	.292	$T(117.51)=.421, p=.674$

Table 4 Results of Multivariate Tests

Effect	F	df	p	Partial eta squared
Intercept	13.122	4,137	.001	.277
Self-efficacy 1	18.221	4,137	.001	.347
Treatment	9.469	4,137	.001	.217

Table 5 Results of Univariate Tests

Effect	F	df	p	Partial eta squared
Corrected model				
.Map	3.986	2,143	.021	.054
.GIS Report	12.510	2,143	.001	.152
.GIS exam	3.014	2,143	.052	.041
.Self-efficacy 2	40.764	2,143	.001	.368
Intercept				
.Map	3.076	1,143	.082	.022
.GIS Report	10.230	1,143	.002	.068
.GIS exam	17.959	1,143	.001	.114
.Self-efficacy 2	40.180	1,143	.001	.223
Self-efficacy 1				
.Map	4.000	1,143	.047	.028
.GIS Report	.885	1,143	.348	.006
.GIS exam	.905	1,143	.343	.006
.Self-efficacy 2	73.835	1,143	.001	.345
Treatment				
.Map	4.452	1,143	.021	.045
.GIS Report	24.606	1,143	.001	.141
.GIS exam	5.367	1,143	.006	.062
.Self-efficacy 2	5.068	1,143	.032	.038

Table 6 Means and Standard Deviations of Outcome Variables by Experimental Condition

Outcome	Treatment	Mean	SD	N
Map	Treatment	3.42	1.39	64
	Control	3.03	1.24	79
	Total	3.20	1.21	143
GIS Report	Treatment	2.87	.94	64
	Control	2.18	.75	79
	Total	2.49	.90	143
GIS Exam	Treatment	36.47	9.49	64
	Control	32.97	8.95	79
	Total	34.53	9.33	143
Self-Efficacy 2	Treatment	5.11	.62	64
	Control	5.34	.57	79
	Total	5.24	.60	143

Appendix: Rubric for Scoring GIS Maps and GIS Reports

	1	2	3	4	5
Map	More than 2 substantive errors or several minor errors (4 or more)	1 substantive error and 1 minor (3 minor errors)	Follows procedure accurately with up to one major error (2 minor errors)	One meaningful addition to the basic procedure or 2 minor additions	More than one meaningful addition to basic procedure

<p>Additions</p> <p>Major</p> <ul style="list-style-type: none"> • Different background • Inset map • Changes to colour/shading to highlight and contrast <p>Minor</p> <ul style="list-style-type: none"> • Borders around legend or other map elements • Change font in title • Change compass rose • Arrange features attractively 	<p>Errors</p> <p>Substantive</p> <ul style="list-style-type: none"> • Did not include information required • Information wrong does not pertain to the map • Proportion of map is too large or too small • .shp error (does not reflect map content) • missing a map = 2 substantive error <p>Minor</p> <ul style="list-style-type: none"> • sloppy placement • did not put border on map or compass arrow • spelling • uniformity errors, features slightly out of proportion • miles to km • .shp not removed but still reflects content
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Overall map level: _____

Report	1	2	3	4	5
Problem	Identifies overly general problem based on topic not task requirements	Identifies related problem that differs from task requirement.	Identifies problem from task requirement with minor omissions.	Identifies problem that matches the task requirement	Reinterpretation of problem while retaining integrity of the task.
Analysis	Unsupported or supported by incorrect information	Supported by student opinion or common knowledge. Generalized information from background section.	Some explicit map data that supports problem analysis Or Some other explicit geography data to support problem analysis	Both map and other geography data to support the problem analysis	Added map and other geography data to support solution
Recommendation	No recommendation or recommendation is unproductive.	Recommendation does not match problem of task, but is productive.	Recommendation that matches the task requirement and is productive.	Recommendation with thinking about implications	Recommendation with data about probable implications
Structure	No headings No positive implications No negative implications No referencing	Follows structure with 3 omissions.	Follows structure with 2 omissions	Follows structure with one omission	Headings More than one solution Negatives of each solution Positives of each solution Complete Referencing

Overall report level: _____

ID # _____ Marker: _____