Field-based technology in Idaho middle school science classrooms: An evaluation of performance and attitude data from students

Martin G. Horejsi and Albert Strickland
Idaho State University

Abstract

A situation of unequal distribution of educational computing equipment arose during the implementation of a Goals 2000 grant that led to the ability of the researcher to inspect how the difference of available technology affected content knowledge and attitudes. The additional technologies included portable computers, probeware, digital cameras, multimedia programs, and a greater deal of computer support. Statistical analysis of the data yielded a significant difference in content knowledge in several areas between the non-technology classes (control group) and those who received the additional technologies (experimental group).

Introduction

A unique opportunity arose recently when a Goals 2000 grant funded a technology integration effort into two middle school earth science classes. What really stands out in this research opportunity is that it was a rare situation in education where the same teachers would be teaching the same material to the same-age students on the same days, except each teacher would have one class that has special access to more advanced technologies. These technologies included portable computers, probeware, digital cameras, multimedia programs, and a greater amount of computer support.

This research project explores the relationship between the technology integration effort and its direct impact upon the performance and attitudes of middle school earth science students. Specifically, this study attempted to ascertain if the use of more advanced technologies impacted student achievement and attitudes in science.

Background

For the learner to attain and retain the necessary information for successful use of the Internet, the material presented in the training must be meaningful (Ausubel, 1968). This means that not only the learner's perception of the presented material is important, but also that the presented material is tied directly to the learner's pre-existing knowledge. Ausubel (1968) concludes that for successful reception and retention of presented material, the training paradigm must meet three conditions; 1) the learner must judge the presented material as relevant; 2) differences between past and currently presented material must be reconciled; and 3) the learner must be given a path toward either reconciliation or self-discovery of meaning for the new material. The accomplishment of the first two steps is under the control of the learner. The last step, however, must be provided to the learner by the teacher in the form of an activity or problem to be solved using the new skills or knowledge

Early research of learning by discovery may point in the direction of success. However, Ausubel (1968) states that many of the findings are inconclusive, and perceived success actually diminishes as the age of the learner increases. Given this assumption, teaching the use of the Internet, probeware, and multimedia creates a problem in that the nature of the technology itself is fluid. Even back in 1995, Zakon noticed that the Internet changes day to day, something that is even more obvious today. The dynamic nature of the Internet makes technology training more of a skill acquisition, rather than a mastery of the medium (Kovacs 1995). For this reason, this project looked at the application of several technologies in tandem. The technologies in focus are considered beyond the usual technology complement found in many classrooms.

Methodology

Population

A school district in southeast Idaho received a Goals 2000 grant from the state government to implement specific technologies into middle school earth science classrooms. The population under study was eighth grade earth science students in that school district. Lowery (1997) describes upper elementary science students as good observers who are now ready to learn about cause and effect, and how to record data describing their relationships. Unfortunately, as reported by Bybee (1993), there are many reports offering reasons why the American public has lost confidence in our current science and technology education programs. One main target of criticism about education is with middle school science teaching. For this reason, the Goals 2000 grant targeted the sixth through ninth grades for technology integration. While the grant will eventually incorporate other grades, only two eighth grade classes were examined in detail for this study.

The participants in the treatment group were the students in one of the classes selected by each of the participating teachers. The control group students were also the students in one of the teacher's classes, but not any of the same students as those in the treatment group. The two teachers selected their experimental groups by choosing one of their overlapping periods where they both were teaching at the same time. The teachers felt that if they were both teaching their experimental groups at the same time, they could combine classes for some projects, and it would make scheduling the fieldtrips easier. The selection of the control groups was a personal decision of the each teacher. One teacher selected the first period of the day for his experimental group, while the other teacher selected the last period of the day for his control group.

Treatment

The training of the teachers and students took place throughout the year as more technologies were incorporated into the science classes. In all cases, the teachers were trained in the use of the specific technology prior to the training of the students. Additionally, the students were trained exclusively by their teacher.

Teacher Training. The teachers participating in the grant were given several hours of training on the use and troubleshooting of the probeware. Previous technology training unrelated to the Goals 2000 grant gave the teachers the necessary skills to operate the other pieces of additional technology implementation of the grant required. Once the teachers participating in the grant received training and the additional technologies, they began training the students in the experimental group how to use the equipment.

Student Training

The teachers began the grant with the use of eight portable computers. The portable computers operated in a similar manner to the desktop models the students already had access to in the classroom, but the probeware was new to the students.

Probeware Training

One particular probe was used by the students to learn the operation of the computer/probe interface. The probe was called an exercise heart rate monitor. The exercise heart rate monitor allowed the student to measure and graph their own heart rate over time while doing various activities. While this probe was used extensively at first, it was not the focus of data collection for the project. Instead, it was just used for training purposes.

When each teacher believed the students understood the operation of the portable computer, and the exercise heart rate probe, each introduced the other probes available to the students for scientific data collection. At that point, the students practiced using the probes both inside the classroom, and outside the school. The teachers even had some of the students practice using the portable computers inside a dark closet to simulate using the equipment in a cave like what they might find at the Craters of the Moon area-one of the possible fieldtrip locations.

Digital Camera Training

The teachers then trained their students to use digital cameras. The students practiced taking digital pictures inside and outside the school building. The cameras were also used in dark situations (such as a closet) to simulate environments students might find in the field.

Multimedia Development

Multimedia-capable computers were already in the classroom, but the multimedia software on the computer was only available for use by the experimental groups. A program called HyperStudio allowed the students to build multimedia programs showcasing the materials the students generated with the digital cameras and probeware.

Field Applications of the Technology

While most of the activities applied the additional technologies in the classroom, outdoor activities did supplement the indoor work. The most ambitious of the outdoor activities involved two fieldtrips to Craters of the Moon National Monument in south central Idaho. The first trip took place in shortly after school started, and after the teachers and student received the additional technologies. Since the additional technology was new to the students, taking digital images with the cameras dominated the outdoor activities. The captured images provided a large amount of material to work with once back in the classroom.

The second fieldtrip to the Craters of the Moon area occurred near the end of the school year. A late snowfall kept much of the Craters of the Moon area closed to the public until the middle of May. During the second trip to the area, students used the portable computers and probes to take temperature and light measurements in several caves; including lowering a 100-foot temperature probe into a volcanic cone to measure the drop in temperature per meter of depth. Hundreds of digital pictures were taken using the digital cameras. The students wrote detailed notes about all the pictures they took, as well as their methods of data collection using the probes.

Presentation of Student-Collected Materials

Once back in the classroom, the students applied their digital photographs to the HyperStudio multimedia program. Even though school was ending within one week of returning from the Craters of the Moon fieldtrip, the students were excited to produce a quality multimedia project because their teachers were going to present it to an audience at a national conference. Using computers and multimedia to share their pictures and information, the HyperStudio project became the capstone of the year’s work for the students.

The multibranching navigation possible with HyperStudio allowed the students to pair-up and produce a section of what would become a much larger multimedia project.

The teachers worked together to build a navigation system that allowed the user of the program to select one of many different choices. The program contained special moving pictures offering 360-degree spinning views of the students working with the probes. The program also allowed the virtual rotation of objects, for example providing a 360-degree view of a single rock.

Data Collection Method

The data collected during the first year of the implementation of the grant included the geology pretest and posttest raw scores of the students in the experimental groups. A survey addressing technology attitudes was administered to the students in the experimental group both prior to the treatment and following the treatment. A geology posttest was also given to one additional class of the two participating teachers. The additional student performance on the geology posttest served as the control group in the posttest-only control group experimental design.

Development of the Instruments

Three instruments were developed or modified for use in the Goals 2000 grant. Two instruments were both geology-oriented multiple-choice tests, and one instrument was a survey designed to collect data on attitudes about educational technology.

The Geology Pretest and Posttest Instruments

The geology pretest and posttest each contained of 45 multiple-choice questions selected from a pool of questions created by a panel of experts in the field. The final geology pretest and posttest each contained 45 questions selected to reflect the students' knowledge of general science concepts, and geologic terminology with specific reference to the geology of the Craters of the Moon National Monument.

The Technology Attitude Survey for Students

The Technology Attitude Survey instrument was developed through the modification of existing instruments already in use in other projects targeting similar content. The posttest-only control group design was selected project because the data generated by the Goals 2000 grant were collected in such a manner that other experimental designs were not practical. While the posttest-only control group design has limitations (Gall et al., 2005), the design is strong enough to provide experimental insight into the effects of the additional technologies on the students' geology knowledge.

Student Technology Attitude Survey

A pretest-posttest experimental design was employed for the attitude survey responses by the students in the experimental group. The experimental design addressed only the attitudes held by the experimental group.

Reliability Coefficient for the Geology Test Instruments

The reliability of the geology test instruments was established through a Guttman Split-half analysis. The reliability coefficient of 0.73 was generated using the general geology pretest and posttest scores from the experimental groups of both teachers 1 and 2. It was decided that a reliability coefficient of 0.60 or greater would constitute a reliable instrument usable for this study.

The Results of the Posttest-only Control Group Design

A question of primary focus of this project was to see if a change in student performance on a geology knowledge assessment could be attributed to the inclusion of additional technologies into the existing curriculum. It was found that the difference between the two sets of scores is significant. Therefore, the use of the additional technologies did significantly raise the students' scores on the geology measure.

Analysis of the statistics indicate that the additional technology did significantly improve the student performance in geology as reported by the improvement in posttest geology measure compared to the pretest measure. For this test, an F ratio of 30.1 was found for the change in mean score of the experimental group when comparing their pretest scores with their posttest scores. The significance of F at $< .0001$, with alpha=.05, is a statistically significant improvement in the treatment group students' geology test scores due to the treatment.

The comparison of posttest means between the treatment and the control groups for teacher 1 is 9.91. This value represents the average number of points a student in the teacher 1 experimental group scored over a student in the teacher 1 control group. About half that amount, at 4.25, was found between the teacher 2 experimental and control groups.

The control groups followed a similar curriculum to each other so it should not be unexpected to find similar posttest means between the two groups. In fact, the difference between the two groups is less than one point with an actual difference of 0.74 points. This small difference between control group means indicates a similar performance on the posttest even though each control group worked for a different teacher.

Table 1. Descriptive Statistics for the Geology Pretests and Posttests from both Teachers 1 and 2

Population	Mean	Std Dev	Min	Max
Geology pretests from both Teachers 1 and 2	19.95	4.86	10	32
Geology posttests from both Teachers 1 and 2	26.60	5.93	14	38
Control group geology tests from both Teachers 1 and 2	19.69	7.11	10	33

The descriptive data in Table 1 indicates several possible trends. First, the 1.07 point increase in the standard deviation of the pretest and posttest means (from 4.86 to 5.93), with the larger standard deviation with the posttest, indicates the scores by experimental groups spread out more than they did with the pretest. This is also supported by the growth in range from a 22 point spread to a 24 point spread between the experimental measures. This finding may offer insight into a disproportionate reception of the additional technologies as learning tools by the students.

A similar range is found with the control group's mean scores. A 23 point spread was found between the high and low scores on the control group geology test. However, the standard deviation was found to be 7.11 indicting the control group scores to be the most spread out of all three sets of scores. The standard deviation of 7.11 indicates that 68% of the mean scores of the students in the control group would be found between the scores of 13 and 27.

Unfortunately, there is no comparison possible between pretest means and the control group mean even though the means are similar. This is because different groups taking the test at different times during the experiment generated the two means on different test instruments.

Geology Test Frequency Distributions

The frequency distribution of scores reported by the students in the experimental groups are found in Tables 2 and 3. The highest frequency of a particular score with the six students who all scored 19 on the pretest. There were also six scores where one student each scored that particular score. Also, four scores were posted by 10% or more of the students.

Table 2. Frequency Distribution for the Geology Pretest from the Combined Experimental Groups of both Teacher 1 and Teacher 2

Value	Frequency	Percent	Percent	Percent
10	3	7.50	7.50	7.50
11	1	2.50	2.50	10.00
15	1	2.50	2.50	12.50
16	3	7.50	7.50	20.00
17	1	2.50	2.50	22.50
18	3	7.50	7.50	30.00
19	6	15.00	15.00	45.00
20	5	12.50	12.50	57.50
21	4	10.00	10.00	67.50
22	4	10.00	10.00	77.50
23	1	2.50	2.50	80.00
24	1	2.50	2.50	82.50
25	2	5.00	5.00	87.50
26	2	5.00	5.00	92.50
28	2	5.00	5.00	97.50
32	1	2.50	2.50	100.00
Total	40	100.00	100.00	

The frequency distribution found in Table 2 expands upon the mean scores by showing the relationship between the score and number of students who reported that score. The largest number of students with the same scores was, as would be expected, clustered around the reported mean of 19.95. The range of scores on the pretest is from 10 to 32. In contrast, the range of the posttest scores is 20 to 38 as reported in Table 3.

Table 3. Frequency Distribution for the Geology Posttest Scores from the Combined Experimental Groups of both Teacher 1 and Teacher 2

Value	Frequency	Percent	Percent	Percent
20	2	5.00	8.30	8.30
21	1	2.50	4.20	12.50
23	1	2.50	4.20	16.70
24	4	10.00	16.70	33.30
25	2	5.00	8.30	41.70
26	2	5.00	8.30	50.00
28	1	2.50	4.20	54.20
30	2	5.00	8.30	62.50
31	2	5.00	8.30	70.80
32	1	2.50	4.20	75.00
34	4	10.00	16.70	91.70
36	1	2.50	4.20	95.80
38	1	2.50	4.20	100.00
Total	40	100.00	100.00	

The posttest frequency distribution for the experimental group students in Table 3 produced a different distribution compared to the pretest. The mean score of 26.6 points is not well represented as compared to the mean of the pretest. Instead, there appears to be two spikes surrounding the mean, one at 24 points, and one at 34 points. While the mean of the posttest was significantly higher than the mean of the pretest, a different score distribution is present. This observation is statistically supported by the increase in standard deviation from 4.86 on the pretest to 5.93 on the posttest. The frequency distribution of the scores reported by the control groups show a picture similar to the posttest scores by the treatment group.

The spread of scores for the control groups illustrated in Table 4 offer insight into the larger standard deviation of the control groups compared to experimental groups reported in Table 2 and Table 3. The standard deviation calculated for the control group geology measure is 7.11, or 1.14 points higher than the highest treatment group posttest standard deviation.

Table 4. Frequency Distribution for the Geology Test Scores from the Combined Control Groups of both Teacher 1 and Teacher 2

Value	Frequency	Percent	Valid Percent	Cumulative Percent
10	2	5.00	5.10	5.10
11	1	2.50	2.60	7.70
12	2	5.00	5.10	12.80
13	4	10.00	10.30	23.10
14	5	12.50	12.80	35.90
15	3	7.50	7.70	43.60
18	3	7.50	7.70	51.30
19	3	7.50	7.70	59.00
20	1	2.50	2.60	61.50
21	1	2.50	2.60	64.10
23	1	2.50	2.60	66.70
24	1	2.50	2.60	69.20
26	3	7.50	7.70	76.90
27	1	2.50	2.60	79.50
28	2	5.00	5.10	84.60
29	1	2.50	2.60	87.20
30	1	2.50	2.60	89.70
31	2	5.00	5.10	94.90
32	1	2.50	2.60	97.40
33	1	2.50	2.60	100.00
Total	40	100.00	100.00	

The range of scores for the control group on the posttest is 10 to 33. The score reported most often by the control group was 14, and half the scores of the students, 10 out of 20, were represented by only one student.

The Geology Test Constructs

The geology instruments contained two constructs. The questions in construct 1 addressed topics in igneous geology while construct 2 encompassed general earth science and biology. Table 5 shows the percentage of correct responses sorted by the constructs as reported by the students in both the treatment groups and control groups.

Table 5. Proportion of Correct Responses by Geology Constructs by Teacher and Test

Test by Teacher	Construct 1	Construct 2
Experimental pretest Teacher 1	0.50	0.44
Experimental pretest Teacher 2	0.42	0.39
Experimental posttest Teacher 1	0.63	0.65
Experimental posttest Teacher 2	0.51	0.54
Control posttest Teacher 1	0.46	0.41
Control posttest Teacher 2	0.45	0.45

The proportions of correct responses shown in Table 5 offers some insight into the areas where the students scored higher and lower. Since the success of the performance on each construct is reported here as a percentage, the differing number of questions within each construct is less intrusive.

It should be noted that in both experimental groups, the proportions of correct answers were higher within both constructs on the posttest. Tables 6 and 7 show the comparisons for each treatment group and with the two geology test constructs.

Table 6. Change in Proportion of Correct Responses by Geology Construct for Teacher 1

Teacher 1 students	Construct 1	Construct 2
Experimental group pretest	0.50	0.44
Experimental group posttest	0.63	0.65
Change in performance	0.13	0.21

Table 6 shows the relationship and change between the correct answers by construct given by the students in teacher 1's class on the geology pretest and posttest. It is important to note that the students showed gains in both constructs. Also, there was a larger gain within construct 2 that covered general earth science and biology. Similar gains are shown in Table 7 for the experimental group working for teacher 2.

Table 7. Change in Proportion of Correct Responses by Geology Construct for Teacher 2

Teacher 2 students	Construct 1	Construct 2
Experimental group pretest	0.42	0.39
Experimental group posttest	0.51	0.54
Change in performance	0.09	0.15

Table 7 shows the relationship and change between the correct answers by construct given by the students in teacher 2's class on the geology pretest and posttest. Like the students in teacher 1's experimental group, gains were shown in both constructs. In addition, as with teacher 1's experimental group, the larger gain is found with construct 2. While the overall gains for teacher 2 were not as great as with teacher 1, the difference between the changes within the constructs is similar. The experimental group working for teacher 1 reported a posttest difference between constructs of .08 (0.21-0.13). Teacher 2's experimental group posted a difference of .06 (0.15-0.09).

Technology Attitude Survey for Students

A 20-item Likert-type survey instrument was administered to the students in the two experimental classes prior to treatment. The Technology Attitude Survey for Students allowed for possible responses to range from the number 1 indicating a strong disagreement with the statement to the number 4 indicating a strong agreement with the statement. Six of the questions on the Technology Attitude Survey given to the students were reversal questions meaning that a low numbered response actually indicated a positive increase in attitude toward technology. The data presented in the tables in this chapter represent modified data where the reversal questions have been corrected to indicate a parallel direction between increase in attitude and increase in response number. A Technology Attitude Survey was also given to all the students in the treatment groups. The pre-treatment scores on the survey provided data used to explore the homogeneity of the students involved in the treatment groups (see Table 8). Prior to the statistical analysis of the data, it was decided that an F probability of .20 or larger would represent enough of a similarity between group means as to allow the researcher to infer homogeneity about technology attitudes by the students in the experimental groups.

Table 8. Analysis of Variance for Pre-Treatment Technology Attitude Scores

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.0100	.0100	.1086	.7435
Within Groups	40	3.7011	.0925		
Total	41	3.7112			

*p<.05

The F ratio of .1086 was found providing a significance of .7435. This probability is much greater than the alpha level of .05. Therefore, the researcher concludes that no significant differences are present between the students in the experimental groups with regard to attitudes about the use of technology.

At the end of the school year, the students again completed the Technology Attitudes Survey. The results were compared to their earlier reported score on the same survey. Table 9 presents the findings of an ANOVA used to compare the student attitude scores prior to treatment and following treatment.

Table 9. Analysis of Variance Comparing Pre-Treatment and Post-Treatment Technology Attitude Scores

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	1	.1602	.1602	2.2057	.1415
Within Groups	78	5.6653	.0726		
Total	79	5.8255			

*p<.05

The results of the ANOVA comparing pre-treatment and post-treatment change in attitude about technology indicates that no significant change took place due to the treatment. An F value of 0.1415 was found which is in excess of our alpha of .05. Therefore, the researcher failed to reject our null hypothesis that the introduction of additional technologies into the earth science curriculum did not significantly affect the student's attitudes about technology.

The eighth grade population involved in the treatment may have matured during the year-long treatment causing the interpretation of the survey questions to change. Therefore, it is reasonable to assume that the interpretational understanding of the survey questions may have changed over time along with or without the student's attitude changing.

Table 10 shows the descriptive statistics for the Technology Attitude Survey given to the students working for teachers 1 and 2. The descriptive results are given for both the student survey taken prior to treatment and after the treatment. The pre-treatment and post-treatment raw data collected from the students on the survey instruments was compiled in spreadsheet form for study.

The students in both classes reported a decrease in standard deviation, and an increase in maximum score. In contrast, the students in Teacher 1's class reported a slight decrease, 3.14 to 3.13, following the treatment. Teacher 2's students reported an increase in attitude score, from 2.93 to 3.13.

Table 10. Descriptive Statistics of the Technology Attitude Surveys

Population	Mean	Std Dev	Min	Max
Teacher 1 pre-survey	3.14	0.28	2.46	3.46
Teacher 1 post-survey	3.13	0.24	2.71	3.58
Teacher 2 pre-survey	2.93	0.31	2.38	3.43
Teacher 2 post-survey	3.12	0.21	2.71	3.59

The change in technology attitudes following the treatment for the students working for teacher 1 appears to indicate a possible saturation level of technology in this classroom. As is indicated by specific responses by the students on question 20 (see Table 11), an actual drop in the mean by the students in the class of teacher 1 should not be unexpected. While the drop in mean is slight with only a 0.01 point decrease, it stands in contrast to the increase of 0.19 found with the students working for teacher 2. The reason for this difference may be due to the high means reported by the students in the class of teacher 1 compared to teacher 2. The difference between pre-treatment survey means by the classes of teacher 1 and teacher 2 was found to be 0.21 with the students in teacher 1's class reporting the greater means.

The students in teacher 2's class reported an overall increase in positive attitude toward technology (from 2.93 to 3.12), and their post-treatment survey standard deviation decreased by 0.1 indicating a lesser spread of reported scores (from 0.31 to 0.21). A decrease in standard deviation was also found with the students working for teacher 1.

While the mean remained relatively static (3.14 to 3.13) there was a change in standard deviation of 0.04 from a pre-treatment value of 0.28 to a post-treatment value of 0.24.

Another point of interest with the student technology attitude data is the similarity in mean and range between the post-treatment survey responses of both classes. The post-treatment mean of the teacher 1 group is 3.13, while the value for teacher 2's group is only 0.01 less with a reported mean of 3.12. This is in contrast to the 0.21 difference reported prior to treatment. The post-treatment range of scores for the student working for teacher 1 is 2.71 to 3.58 while the same range for teacher 2's group is 2.71 to 3.59, and a difference of only 0.01 across the entire range.

The raw data appearing in Tables 11 and 12 compare the pre-treatment and post-treatment technology attitudes reported by the students. Corrections have been made for the six reversal questions where a decrease in response number indicates a positive increase in attitude toward technology in education.

Table 11 shows the five largest changes in attitude reported by the students working for teacher 1 occurred with questions 2, 8, 18, 19, and 20. Survey question 2 asked if the student believed word-processing is the best use of computers. This result shows an important improvement change in the students' technology most likely due to the increased exposure of different technologies normally unavailable to students in the eighth grade.

Table 11. Comparison of Student Pre-Treatment and Post-Treatment Technology Attitude Scores for Teacher 1

Question number	Experimental group, teacher 1, pre-treatment Technology Attitudes	Experimental group, teacher 1, post-treatment Technology Attitudes	Difference between pre and post treatment Technology Attitudes
1	3.31	3.33	0.03
2	2.46	2.71	0.25
3	3.42	3.58	0.16
4	3.42	3.29	-0.13
5	2.96	2.83	-0.13
6	3.35	3.21	-0.14
7	2.77	2.92	0.15
8	3.31	3.00	-0.31
9	3.31	3.17	-0.14
10	3.27	3.21	-0.06
11	2.77	2.96	0.19
12	2.96	2.96	0.00
13	2.72	2.88	0.16
14	3.19	3.13	-0.07
15	3.38	3.46	0.07
16	3.04	3.00	-0.04
17	3.12	3.25	0.13
18	3.23	3.50	0.27
19	3.27	2.88	-0.39
20	3.46	3.25	-0.21
		Average change	-0.01

The drop in the score for question 8 from 3.31 to 3.00 indicates that the surveyed students changed their attitude about whether or not computers complicate simple tasks. The -.31 change in question 8 appears to indicate that the students believe computers do not complicate simple tasks as much as they thought prior to treatment.

Questions 18 states "I have a computer to use at home." The increase in score on question 18 from 3.23 to 3.50 indicates that more students had a computer at home at the end of the school year compared to November of the previous year. Christmas may have been the stimulus for the increase during the school year.

Question 19 states, “My parents use computers.” The decrease in attitude with question 19 from a pre-treatment mean of 3.27 to a post-treatment mean of 2.88 seems contradictory for two reasons. First, it would be reasonable to assume that a parent using a computer in November would also be using one in May. Second, the increase in scores showing computer availability at home should lead to a corresponding increase in parental use. However, both instances could be explained through a student attitude change both in what exactly constitutes the use of a computer, and if students feel more comfortable using a computer, they may be more likely to tell the truth about a parent who does or does not use a computer.

Question 20 presents an interesting result. The survey question asks, “If the teacher would let me, I would use computers more than I already do.” The average student response went down to 3.25 compared to their pre-treatment mean of 3.46. This drop in attitude may indicate a point of saturation of computer use by the student in education. Therefore the student who wanted a higher amount of computer use in class prior to the treatment was given such a great amount of computer use that the student now wished for less use of technology in their earth science class.

The five greatest changes in the Technology Attitude Survey, as reported by the students working in the class of teacher 2, were found in questions 2, 7, 14, 19 and 20. The changes in attitude reported on questions 2, 19 and 20 might have resulted for similar reasons as listed for the change in attitude reported by the students working in the class of teacher 1.

Table 12. Comparison of Student Pre-Treatment and Post-Treatment Technology Attitude Scores for Teacher 2

Question number	Experimental group, teacher 2, pre-treatment Technology Attitudes	Experimental group, teacher 2, post-treatment Technology Attitudes	Difference between pre and post treatment Technology Attitudes
1	3.00	3.22	0.22
2	2.62	2.89	0.27
3	3.43	3.33	-0.10
4	2.81	2.94	0.13
5	3.29	3.06	-0.23
6	3.24	3.33	0.10
7	2.38	2.89	0.51
8	3.10	3.17	0.07
9	3.00	3.17	0.17
10	3.00	3.11	0.11
11	2.95	2.88	-0.07
12	2.57	3.00	0.43
13	2.43	2.71	0.28
14	2.90	3.29	0.39
15	3.24	3.59	0.35
16	2.71	3.06	0.34
17	3.33	3.41	0.08
18	3.19	2.94	-0.25
19	2.71	3.12	0.40
20	2.67	3.24	0.57
		Average change	0.19

Question 7 asked if the student's attitude about school improved when they get to use computers at school. The positive change of 0.51 in the students' response to this question was the second highest change reported by the students in the class of teacher 2 moving from 2.38 to 2.89 following the treatment.

Question 14 addressed whether or not the student agreed with the statement that computer skills should be taught at all grade levels. The students working for teacher 2 reported a higher level of agreement with this statement following the treatment changing from a pre-treatment mean of 2.90 to a post-treatment mean of 3.29.

Summary, Conclusions and Recommendations

Statistical analysis of the data collected in this project unearthed a significant difference between the pre-treatment and post-treatment geology test scores as reported on the geology test instruments. Essentially this means that an influx of technology and training into a science content course will increase science content knowledge compared to an equivalent group.

The statistical analysis of the reported difference in Technology Attitude scores of the students did not indicate a significant change took place. No results were found that withstood statistical analysis to the point of being considered significant.

While further research is recommended to put a finer point on the findings of this study, the significant improvement in student scores on the subject matter posttest should be viewed as demonstrating the ability of additional technologies to directly improve educational performance.

This investigation suggests that the addition of certain technologies to an existing earth science curriculum will increase the performance on a subject-matter assessment. A large portion of current literature in educational computing is limited to the speculation of an improvement due to certain technologies rather than a scientific inspection leading to research-based findings. The most likely reason for the small body of statistical research in the area of technology integration efforts is due to the inability of school districts to allow unequal distribution of technology resources within the same curriculum, grade, and teacher. This unique opportunity to investigate student performance and attitude change independent of the teacher's influence on the class was a rare treat in educational research.

Based upon the results of this study, it is clear that, in certain applications of technology, student performance will be higher than if the technology was absent. As was detailed in Chapter 2, most of the literature regarding technology integration does not address the effects of the technology, but rather the application or types of technology used.

The research base addressing technology in the classroom needs to encompass both the commonly found technologies and the more advanced classroom and field-based technologies. It is imperative that more research be done to explore the impact of educational technology. Without data collection during technology integration efforts, each effort becomes an isolated experiment with no contribution to the body of educational research. It is hoped that this study will be joined by others to continue building the body of research necessary to successfully and effectively integrate the powerful tools of technology into the classroom.

Directions for Further Research

Many factors could have caused the significant findings of this study, all of which may be housed within the combined set of additional technologies integrated into the earth science classroom. Obvious candidates for further study include gender issues with technology, the specific grade level where the introduction of the technologies takes place, the effect of a student’s prior experience with technology, parental use of technology, and the effect of the student's spatial abilities on the success of the technology use.

While this study did provide answers to the two research questions, it also opened up many other questions worthy of further investigation. One area in need of more investigation is with a possible point of saturation of technology integration. Several questions on the post-treatment attitude survey taken by the students offered insight into what may be a maximum amount of classroom technology where any additional technology hits a point of diminishing returns, or worse, a decrease in performance. The saturation level, if it exists, is where the student who earlier expressed interest in more technology no longer desires additional technologies. Several possible causes for this come to mind, but without further study, one can do little more than speculate.

Another area where more research appears necessary is with the effects of the individual technologies applied to the specific classrooms in this study. At least four distinct technologies were combined to form the complement of additional technologies discussed in this research. The additional technologies are portable computers with probeware, digital cameras, Internet, and multimedia. Without further study, it is unknown whether any individual technology is responsible for the changes found in this study, or if there is a combination of effects totaling the results found here.

There is the potential for a synergistic effect with the combination of technologies explored in this study. The synergy would be expressed with the case where the total significant change found in this study cannot be recreated by adding the performance changes caused by each individual additional technology when used in isolation of the others. Instead, the effects found in this study may only be replicable by using the particular combination of specific technologies all applied at the same time.

Most of the additional technologies applied during the implementation of the Goals 2000 grant involved technology that can be used in a field-based environment. While the students began their use of the technologies in the classroom, outside use of the technology was a large part of the integration effort. Further study is needed to separate the effects of the technology from the environment in which it is used.

Another area in need of experimental exploration is the effect of technology upon the specific skills students' use during science class. Additional research should address how the specific skills of science are impacted by the technology. The specific skills include graph reading, data analysis, reporting the results of an experiment, and communicating with others about science. Since science is a process combining many skills and techniques, the performance of the students on the science knowledge test only tells part of the picture.

One last area for study is whether the effects of the additional technologies on student performance are robust enough to last in the absence of the use of the additional technologies as the student moves into another grade. If the effects of the additional technologies do not remain with the student upon leaving the classroom with the technologies, it could be used as evidence for either side of a technology integration argument. It could provide support for an across-the-board technology integration effort in order to keep the performance levels higher. However, the results could also be used to show the multiplied costs of outfitting all classrooms with additional technologies in order to preserve the positive effects.

While attitudinal data were collected as a part of the Goals 2000 grant, the statistically significant findings of this study centered on the improvement in student performance as a result of the use of technology. While further research is recommended to put a finer point on the findings and observations of this study, the significant improvement in student scores on the subject matter posttest found with this study should be viewed clearly as demonstrating the ability of the additional technologies to improve educational performance.

As technology integration continues to be a major issue in education, research needs to be done in order to look into the direct effects of the technology on student performance in order to most appropriately target the specific technologies to the best-suited applications. Grounding technology integration efforts upon the findings of those who are using technology is of paramount importance. Blindly choosing and implementing technology will likely diminish the capacity of educational technology to make continued improvements. Without research, one of the most powerful communication tools in the world will become little more than just another popular trend in public education.

Contributors

Martin Horejsi is Assistant Professor of Science Education and Instructional Technology at Idaho State University. Dr. Horejsi teaches undergraduate and graduate courses in science methods, research and writing, statistics, instructional design, multimedia development, and technology integration. His research interests and special projects include probeware and real-time data collection in science education with special focus in the space sciences.

Albert Strickland is a professor in the Science, Math and Technology Education of the College of Education.

References

Ausubel, D. P. (1968). *Educational psychology: A cognitive view.* New York: Holt, Reinhart and Winston.

Bruner, J. S. (1966). *Toward a theory of instruction* (4th ed.). Cambridge: Harvard University Press.

Bybee, R. W. (1993). *Reforming science education: Social perspectives and personal reflections*. New York: Teachers College Press.

Gagne, R. M. & Briggs, L. J. (1979). *Principles of instructional design* (2nd ed.). New York: Holt, Reinhart and Winston.

Gall, J. P., Gall, J. P. & Borg, W. R. (2005). *Applying educational research: A practical guide* (5th ed). New York: Pearson.

Kovacs, D. K., (1995). *The Internet trainers guide*. New York: Van Nostrand Reinhold.

Lowery, L. F. (Ed.). (1996). *NSTA Pathways to the science standards: Guidelines for moving the vision into practice*. Arlington, Virginia: National Science Teachers Association.

Zakon, R. (1995). *Internet Timeline: 1960-1994* [Internet], Internet Valley, Inc. [Online] Retrieved December 10, 2004, from http://www.zakon.org/robert/internet/timeline/