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ABSTRACT

Designed to investigate whether or not science teachers can positively influence student achievement in, and attitude toward, science, this study focused on a specific teaching strategy and utilization of a computer-based simulation. The software package used in the study was the simulation, Volcanoes, by Earthware Computer Services. The sample population consisted of 20 average and below average eighth grade earth science students who were randomly assigned to one of two computer simulation laboratories. Teacher behavior varied between the two laboratories. In one laboratory, the teacher was a content and simulation expert, employed a discovery and questioning approach to instruction, and moved about among the students. In the other laboratory, the teacher played the role of one unfamiliar with the content of the simulation, offered only minimal assistance, and remained at the teacher's desk. Student attitudes and achievement were measured. Positive attitudes toward science, scientists, and microcomputers were evidenced. Based on the posttest measure, neither laboratory group learned significantly more than the other about the content of the volcanoes simulation. Results are discussed and the attributes of good simulation courseware are specified. (ML)

The Effect of Teacher Involvement on Student Performance in a Computer-Based Science Simulation

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THE EFFECT OF TEACHER INVOLVEMENT ON STUDENT PERFORMANCE IN A COMPUTER-BASED SCIENCE SIMULATION

ABSTRACT

The purpose of this study was to establish the influence of the teacher in facilitating student use of a computer-based science simulation. The simulation selected for study, Volcanoes by Earthware Computer Services, possesses three important characteristics: (1) it fits well within the eighth grade science curriculum; (2) it is supported by a relatively large quantity of ancillary instructional support materials; and, (3) it is highly rated as a vehicle for teaching several science process skills.

The study population consisted of 20 average and below average eighth grade students from a rural, south Georgia public school system. These students were randomly assigned to one of two computer simulation laboratories where teams of two students each worked for a total of three hours over a period of four days to become proficient in predicting volcanic eruptions.

Teacher behavior was systematically varied between the two laboratory groups. In one laboratory, the teacher was a content "expert" and employed a Socratic questioning strategy to assist the students in "discovering" facets of the simulation. In the remaining laboratory, the teacher played the role of one unfamiliar with the content of the simulation and therefore was able to offer only minimal, technical assistance.

Student attitudes and achievement were measured using locally developed test instruments. Student attitudes toward science, scientists and microcomputers were generally positive. Based on the posttest measure, neither laboratory group learned significantly more than the other about the content of the volcanoes simulation. However, the total population mean on the posttest was only 55% indicating that these students learned little from the simulation experience despite the differences in teacher involvement.

THE EFFECT OF TEACHER INVOLVEMENT ON STUDENT PERFORMANCE IN A COMPUTER-BASED SCIENCE SIMULATION

Purpose

The purpose of this study was an attempt to establish the influence of the teacher in facilitating student use of a computer-based science simulation. Although teachers may potentially play many roles in integrating computer-based instructional materials with traditional curricula, and there are many instructional applications for microcomputers, this study focused on the influence of a specific teaching strategy on student's performance on a single instructional simulation.

Theoretical Basis

The rationale for this study is relatively simple. Can science teachers effectively utilize commarically available software to positively influence student achievement in and attitudes toward science (Lunetta & Hofstein, 1981)? While a thorough answer to this question will not be possible until a wide variety of commercially produced computer assisted instruction (CAI) packages have been researched, this study examined one specific instructional application--the simulation--as exemplified by the commercial software package Volcanoes by Earthware Computer Services. While the subject of the study may seem narrow by focusing on a single simulation, this particular simulation was selected based on it fulfilling three important criteria not often addressed by other CAI materials. First, the simulation fits a curricular niche in eighth grade earth science. Second, the simulation is supported by a relatively large quantity of ancillary instructional support materials. And third, the simulation is highly recommended as a vehicle for teaching the science process skills of observation, inference, data collection/analysis, and hypothesis generation. These three factors should make the simulation attractive to teachers. However, the question of how effectively the materials can be utilized in the classroom will depend on many other factors such as the teacher's physical science content background, level of computer experience and repertoire of teaching strategies. These additional factors combine to form the independent variable in this study--teacher involvement.

Procedure

The sample population chosen for this study was composed of 20 eighth grade earth science students attending public school in a south Georgia rural community. These students were described as average and below average in ability and were selected to examine how this population might respond to using a computer-based science simulation (Jamison, Suppes, & Wells, 1974). The group mean for these students on the Otis-Lennon School Ability Index (SAI) was 91 with a standard deviation of 14. These students were randomly chosen from within a single intact class, and were then randomly assigned to one of two treatment groups. Within treatment groups the ten students were randomly assigned to one of five teams. One treatment group was designated as the "Red" laboratory group and met for a total of four 45-minute periods on Mondays and Wednesdays of two consecutive weeks. The remaining treatment, the "Blue" laboratory group, met for an identical time period on Tuesdays and Thursdays of the same two consecutive weeks. During the computer simulation laboratories, the students worked with the Volcanoes simulation and attempted to determine how to investigate volcanoes and predict future volcanic eruptions, and when to warn the threatened populations.

The research design employed for the study is a variation of the Campbell and Stanley (1963) Posttest-Only Control Group design.

R	O_1	X_I	X_{BR}	X_1	X_3	X_5	X_7	O_2	O_3
R	O_1	X_I	X_{BR}	X_2	X_4	X_6	X_8	O_2	O_3

O_1 = Computer experience questionnaire

O_2 = Attitude questionnaire

O_3 = Volcano posttest

X_I = Common introduction to simulation

X_{BR} = Assigned background reading

$X_{1,3,5,7}$ = Red laboratory group

$X_{2,4,6,8}$ = Blue laboratory group

Three instruments were developed for use in this study. The first instrument was used to collect data on the level of computer experience each student possessed.

The second instrument was used to collect data on student attitudes towards science, scientists and microcomputers. This instrument is based on a Likert-type scale with five response categories which ranged from strongly disagree (1) through undecided (3) to strongly agree (5). The third instrument was used as a simulation posttest. It is composed of 32 multiple choice items and possesses a Kuder-Richardson reliability (KR-20) of .64.

The independent variable in this study is the role of the teacher in interacting with the students in the two Volcanoes simulation laboratories. The same teacher taught both laboratories, however, a different teaching strategy was consistently employed in each laboratory. In both laboratories, the teacher's role was that of a "computer competent". This means that the teacher was sufficiently knowledgeable about the hard/software used in the simulation to minimize hard/software failures and keep the student teams on task. Thus, any selective influence of this variable was not measured. The purpose for controlling this variable was to ensure that each laboratory had equivalent time periods with which to explore the simulation.

In the Red laboratory, the role of the teacher was that of content and simulation expert. That is, the teacher was prepared at all times to interact with student pairs concerning the content of the Volcanoes simulation, as well as the nature of the simulation itself. However, the nature of this student/teacher interaction was not of the typical student question/teacher answer variety. The method used was more Socratic in nature where the teacher, by asking a series of related questions, would help the student to answer his/her own original question. This strategy was also characterized by an active (i.e., mobile, walking) teacher and a relatively high degree of teacher/student interactions.

In the Blue laboratory, the role of the teacher was that of a teacher with a very poor background in the content of the simulation. In response to student questions concerning both subject content and specific simulation content, the teacher feighned ignorance. In other words, the teacher did not volunteer information about the content or the simulation and, when asked, would respond in a manner similar to the following, "I don't know.", "I'm not sure.", "I think maybe . . .", or "That's what you're supposed to figure out from the simulation!". On occasion minor content questions were directly answered, but only in an effort to keep the students moving through the simulation. This strategy was characterized by the teacher being relatively less mobile (i.e., remaining at the teacher's desk) during the laboratory, and the students appeared to engage in more intra-team discussion.

Results

This study resulted in three major findings. First, based on the Volcanoes posttest, neither treatment group learned significantly more than the other about the simulation (see Table 1). However, the mean posttest score for the combined treatments was only 55%. Second, the attitude measures from both treatments indicated that both groups of students reacted positively to their experiences using the Volcanoes simulation (see Table 2). Third, the Volcanoes simulation suffers from a number of significant pedagogic flaws which may have adversely affected student achievement.

The affective data indicate that the students reacted favorably to the simulation experience. All students felt that they got enough help from the teacher ($\bar{X}_R = 4.2$; $\bar{X}_B = 4.1$), and that the simulation helped them learn about how scientists do their jobs ($\bar{X}_R = 4.2$; $\bar{X}_B = 4.2$). However, all students also felt that they would not like to become scientists ($\bar{X}_R = 2.2$; $\bar{X}_B = 2.0$). Only three of the Likert statements resulted in significantly different responses ($p < .05$) from the two treatments. The Blue group agreed more strongly that science involves collecting and using information ($\bar{X}_B = 4.6$; $\bar{X}_R = 4.0$) and that microcomputers would be useful in helping them learn science ($\bar{X}_B = 4.4$; $\bar{X}_R = 3.9$), while the Red group felt more strongly that they enjoyed learning science ($\bar{X}_R = 3.7$; $\bar{X}_B = 2.9$) even though the mean score didn't quite reach the "agree" criterion of 4.0.

Several pedagogic flaws were identified in the Volcanoes courseware. The student manual for Volcanoes contained too much historical background material which bears no discernable relationship to "successful" completion of the simulation. This extra material could be distracting, confusing and/or frustrating for some students. In addition, although the simulation is rated as appropriate for grades 7-12, readability analyses performed on the text material indicate that the reading level of the manual is approximately grade 12 (see Table 3). Neither the student nor teacher manuals adequately describe the basis for scoring used within the simulation and neither strongly stresses the need for cooperation among players. The scoring system utilized in the simulation penalizes all players for a poor prediction by any player, and contains inconsistencies which result in rewards being given to players who "cry wolf" by claiming that all of his/her volcanoes are highly likely to erupt all the time! Feedback comments concerning student progress are not specific enough to assist the student in developing a successful strategy, and no performance "norms" are stated such that students or teachers can evaluate how well students might be progressing in learning the principals embodied in the simulation.

Conclusions

The posttest performances by both treatments would seemingly indicate that neither teaching strategy is superior to the other in influencing student achievement. An alternative explanation, however, is that the simulation did a poor job in teaching content and providing instructional problem solving experiences for this population of students. While the former interpretation cannot be ruled out, the latter interpretation is supported to some extent by the extremely low mean score ($\bar{X}$ = 55%) on the posttest. Thus, this may indicate that low ability students will have difficulty utilizing simulations like Volcanoes regardless of the nature of teacher involvement. However, more work must be done in utilizing simulations with lower ability students to ascertain whether the nature of simulation might be too complex or abstract for this group, or whether the design characteristics of specific simulations can positively or negatively influence student achievement. Additionally, more work must be done to clarify the relationship between teacher involvement and student achievement using simulations. Is there an ideal level of teacher involvement for all students using simulations, or are different levels of teacher involvement desirable for students of varying abilities? That is, how much and what kinds of help do different "types" of students need to "successfully" complete an instructional simulation?

The affective data are difficult to interpret. Although the students did not seem to learn a great deal from the simulation, they enjoyed working with the simulation. This may have been due to the nature of the simulation itself, or it may simply have been due to the novelty of working with microcomputers and conducting a special laboratory. In either event, during the simulation these low ability students appeared highly motivated, well behaved and task oriented, despite what they were actually learning as reflected by their poor posttest performances.

As mentioned earlier in this paper, Volcanoes was originally selected for this study because it appeared to possess characteristics which would make it attractive to teachers. Analysis of the Volcanoes materials has lead to the development of the following list of highly desirable characteristics for instructional simulations. Good simulation courseware should possess the following attributes:

1. a curricular niche,
2. a list of specific objectives the simulation will "teach",
3. ancillary materials which are heavily content oriented to provide adequate background material for teachers who may be weak in or uncomfortable with this particular area of science,
4. information about suggested possible teaching strategies for use with the simulation,
5. information and rationale for the teacher about suggested problem solving strategies for "success" in the simulation,
6. information about how the scoring is accomplished in the simulation,
7. specific feedback within the simulation itself to help guide the student to an optimal solution pathway,
8. on-line help screens or tutorial sessions for student assistance,
9. information about additional instructional resources and learning activities which might precede, enhance or extend the simulation experience, and
10. sample test questions related to the knowledge and skills necessary to complete the simulation.

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TABLE 1

VOLCANOES POSTTEST RESULTS

I. Descriptive Data

Treatment	N	$\bar{X}$ *	sd
Red Group	10	18.00	4.24
Blue Group	10	17.50	4.20

* Raw scores based on 32 item multiple choice examination.

II. Analysis of variance summary

Source	df	MS	F	p
Treatments	1	1.25	.07	.79
Error	18	17.81		

TABLE 2

COMPARISON OF MEANS ACROSS TREATMENTS ON LIKERT SCALE
AFFECTIVE DATA (SA(5), A(4), U(3), D(2), SD(1))

Item	Treatment					
	Red (N=10)		Blue (N=10)		t	p
	X̄	SD	X̄	SD		
1. I would like to become a scientist. . .	2.22	.67	2.00	.82	.65	.27
2. Scientists are involved in the world around them	4.22	.67	4.40	.52	.66	.26
3. Scientists depend on other people for information	3.00	1.25	3.10	.99	.20	.42
4. Scientists work together on ideas . . .	4.20	.42	3.90	1.20	.75	.24
5. Scientists spend most of their time in laboratories	3.30	.95	3.10	1.10	.44	.34
6. Scientists are sure of their predictions	2.70	.95	2.20	.92	1.20	.12
7. Scientists get all the information they want	2.10	.88	1.90	.74	.55	.30
8. Science is interesting to me.	3.60	.97	2.80	1.40	1.49	.08*
9. Science is mostly a collection of facts to be learned.	3.50	.97	3.80	1.32	.58	.29
10. Science involves collecting and using information	4.0	.80	4.60	.52	2.57	.008**
11. Science is useful to people in their daily lives	4.30	.48	4.00	1.00	.85	.21
12. Science always provides answers to questions or solutions to problems. . .	2.90	1.29	2.80	.92	.20	.42
13. Science is something people do alone. .	1.80	.63	1.70	.67	.34	.37
14. Science is a way of thinking about things.	3.60	.70	3.70	.82	.29	.38
15. I enjoy learning about science.	3.70	.95	2.90	.99	1.84	.04**
16. I get enough help from the teacher. . .	4.20	1.03	4.10	.99	.22	.41
17. The volcanoes simulation helped me learn about how scientists do their jobs.	4.20	.79	4.20	.79	.00	.50
18. Using the volcanoes simulation has made me want to learn more about science	3.50	.85	3.10	.88	1.04	.16
19. My science teacher helps me think more carefully.	3.70	.67	3.10	1.20	1.39	.09*
20. Using the volcanoes simulation has made me want to learn more about computers	4.20	1.03	4.40	.70	.51	.31
21. I like to use microcomputers in school	4.40	.52	4.70	.48	1.34	.097*
22. Microcomputers would be useful in helping me learn science.	3.90	.74	4.40	.52	1.76	.047**
23. I would like my teacher to use microcomputers in class	4.40	.52	4.40	.70	[illegible]	.50
24. Using a microcomputer makes me feel uncomfortable.	1.70	.95	1.80	1.03	.23	.41
25. I did more thinking when we used the Volcanoes simulation	3.90	1.10	4.00	.82	.23	.4[illegible]
26. I do not need to learn more about microcomputers.	2.00	.94	2.00	1.15	.00	.50
27. A person needs to go to college to be able to use a microcomputer . . .	1.90	.88	1.90	1.37	.00	.50
28. I learn more from a microcomputer program when my teacher helps me. . . .	3.60	.97	3.80	1.14	.42	.34
29. I would prefer to use the microcomputer by myself instead of having a partner.	3.30	1.34	3.10	1.52	.31	.38
30. I am interested in computers and would like to learn to program them . .	4.10	.99	4.40	.52	.85	.21

Note: * = $p < .10$ and ** = $p < .05$.

TABLE 3

SELECTED READABILITY CALCULATIONS ON THE *VOLCANOES* SIMULATION

Readability Measure	Grade Level
Fry	12
Raygor	11
Flesch	13 - 14 (Freshman/Sophomore in College)
Gunning-Fog	17.2 (Graduate School)