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Does interactive multimedia promote achievement and higher level thinking skills for today's science students?

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Abstract
This study examines the effects of Interactive Multimedia instruction upon the variables of achievement and problem solving skills on non-science majors in an Environmental Science course at a mid-western university. The findings indicate that the Interactive Multimedia had a significant effect on both of the variables. The findings are discussed in terms of the impact on self-study when students are learning outside of the classroom in a distance learning environment.

Introduction

During the 1990s critics and supporters alike have been questioning the effectiveness of science education within the American Education System. Pearlman (Gandolfo, 1993) states, "In the United States alone, education costs $450 billion a year. It is a huge burden, yet almost everybody agrees that schools are failing." Pearlman believes schools have not taken advantage of the teaching and learning enrichment that technology tools provide and it is one of the major reasons they are failing.

Perhaps schools are having some difficulty in catching onto many of the new opportunities that technology tools offer, but computers are widespread in the schools and some good things are happening. This article examines how schools are now using interactive computer-based multimedia as a tool to develop thinking skills needed to assimilate and transform massive quantities of information into solutions for today's fast paced changing society.

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Case study

One of the problem areas for schools today revolves around the lack of student interest in science. Enrollment is down and performance is low. However, today's generation shows an interest in things pertaining to the environment. In this study a package entitled *Environmental Science: Computer Lab Simulations*, Hirschbuhl, Bishop and Jackson (1996) an interactive multimedia (IMM) program based on actual geological field studies, was used by undergraduate non-science majors at a mid-western university. For this study these simulations were added to one section of an environmental studies course and compared to a section that used only the traditional method of instruction (classroom lecture).

According to Trollip and Alessi (1988) one of the purposes of adding computers to classroom instruction is to facilitate learning for students by improving the quality and quantity of what they know. Schwier and Misanchuk (1993) believe an advantage of interactive multimedia instruction is the creation of meaning developed by the learner's interaction with the new information in the program.

At the time of this investigation there was very little empirical evidence regarding the use of interactive multimedia instructional technologies in higher education (Spotts and Bowman, 1995 March/April). Most articles were anecdotal describing outstanding professors using the latest technological invention. The problem stems from the lack of research (Heller, 1990; Park, 1991; Park and Hannafin, 1993; Preece, 1993; Zachariah, 1995) regarding the effects of a self-paced interactive multimedia computer simulation on students' learning, motivation, and attitude. Reeves (1993) stated for a worthwhile study of interactive multimedia, a diverse population spending several hours in purposeful study should be examined.

Purpose of the study

This research examined the impact on students' grades and higher level thinking skills when computers were added to the classroom. Interactive multimedia simulations of "real world situations" (actual field trips of a geology professor with 22 years' experience) were incorporated into one section of an environmental geology course. The interactive multimedia modules, which promoted participation and interaction, were designed for students to gain scientific knowledge and concepts, and develop problem-solving skills without the heavy use of math.

Research design

The research design was quasi-experimental because it combined the use of "naturally assembled" intact groups (Campbell and Stanley, 1963), pre-test and post-test, and the use of a control group. The control group research design used is shown in Table 1.

Sample

One hundred and fifty-two students were involved in the study in the spring of 1996. The control group (113 students) received the traditional lecture method of instruction,

Table 1: The control group research design

O_1	X_c	O_{2-3}
O_1	X_{IMM}	O_{2-3}

Where:
X_C = Control — X_{IMM} = Interactive Multimedia
O_1 = Pre-test — O_2 = Post-test
O_3 = Course Grade

while interactive multimedia replaced part of the traditional instruction for the treatment group (39 students).

GALT instrument

The Group Assessment of Logical Thinking (GALT) (Roadrangka *et al.*, 1982, 1983) was designed to measure student cognitive development. This instrument has been used by many as a predictor of student's math and science achievement (Bitner, 1986, 1988, 1991). Roadrangka *et al.* (1983) reported a coefficient alpha of 0.85 for the total test and validity was reported with a strong correlation (0.80) between the GALT and Piagetian interview results.

The GALT consisted of 21 questions of which 18 questions not only required the student to pick the most appropriate answer, but also the reason the student chose that answer. For the question to be considered correct the student must correctly choose both the answer and the reason. Students are classified as concrete thinkers with a GALT score of 0 to 8, transitional with a GALT score of 9 to 15, and those with GALT scores of 16 to 21 are recognized as formal thinkers.

Interactive multimedia instruction

Multimedia can be loosely defined as computer-based technology integrating some, but not necessarily all, of the following: text, graphics, animation, sound, and video (Barron and Orwig, 1995). There are several definitions of IMI (interactive multimedia instruction (Galbreath, 1992)) and, as the multimedia environment changes rapidly, so may the meaning of interactive multimedia instruction. According to Schwier and Misanchuk (1993) IMI is "instructional, multiple-sourced (ie, multiple media sources are involved) intentionally designed, and coherent" (p. 4).

Interactive multimedia modules for environmental geology

The topics of the eight units of interactive multimedia are: 1) Introduction to Environmental Science, 2) Energy from Coal, 3) Geology of Homesite Selection, 4) Minerals for Society, 5) Legal Control of the Environment, 6) Stream Pollution, 7) Streams and Floods, and 8) Radiation in the Environment. All of the modules are based on actual field studies, and the student assumes the role of investigator, with each module presenting a different environmental problem.

All modules have a consistent screen format and each consists of an introduction to the problem to be addressed, the role that the student must play in the investigation, a means for the student to collect data relevant to the problem, a modeling book where the student enters, reviews and draws conclusions based on the collected data, a multiple choice test and an essay test. The essay test puts the responsibility of solving the problem on the shoulders of the student, who takes on the identity of an official in charge, who must make critical decisions based on the problem and data collected. The student is always in control and may access additional data, recheck data collected, access a glossary of appropriate terms, listen to audio associated with the problem, and may elect to take or repeat the multiple choice test. From the menu page a student can access any one of the eight modules, the progress report, or send the instructor email. Students must make some data collections before they are allowed to take the test or write their essays; thus forcing active participation and preventing students from rapidly paging through the modules and declaring themselves finished.

Procedure

For the treatment group five weeks of classroom instruction were replaced with eight units of environmental science computer lab simulations (interactive multimedia). The GALT was used as a pre-test prior to use of the interactive multimedia and after use as a post-test (Figure 1). The GALT was computerized and available at the university-testing center. The treatment group was told it was a required part of the class while students from the control group were given extra credit for participation. Forty-eight students in the control group and 26 from the treatment group completed a pre- and post-test GALT.

The mean of the pre-test GALT scores was 9.08 for the treatment group and 8.92 for the control group giving a difference of only 0.16 between groups which suggests both groups' cognitive level of knowledge were similar. The GALT was used as a pre- and a post-test to determine if there had been a change in the students' formal operational cognitive level of knowledge.

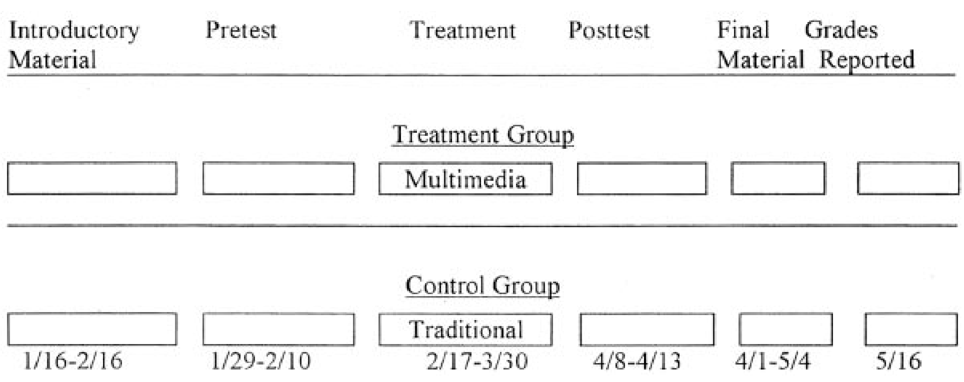

Figure 1: Timeline of the experiment

Results

First validation of the GALT as a predictor of student success was examined. Students in all groups who attained a GALT score indicating a cognitive level of development equal to transitional level or higher (score of 11 or above) performed significantly better than those who did not when grades of B or better were compared to those below B (see Table 2). The continuity adj. chi-square value = 10.808, and p = 0.001.

Next the GALT scores were found to be significantly higher for the post-test over the pre-test for those students using the treatment (IMM). When the difference in the treatment group GALT score was compared to the difference in the control group score no significant difference was found, F = 2.58, p = 19.

Finally the proportion of students with a passing grade (B or better) was significantly higher for those students in the treatment group when compared with those in the control group. The continuity adj. chi-square value was 30.922 with a p = 0.001.

Seventy-four percent of the experimental group received a passing grade (B or better), while only 27% of the control group received a passing grade. This result is comparable with the findings of Massaro (1995) where he found 74% of students who chose to use four modules of interactive multimedia as an independent study attained grades of B or better compared to 55% of the students who chose to attend regular lectures and scheduled tests.

Conclusions

The following conclusions were drawn from this study:

1. Those students in all groups having attained a GALT score indicating a cognitive level of development equal to transitional level or higher (score of 11 or above) performed significantly better in a course for non-science majors than those with a GALT score less than 11 when grades of B or better were compared to those below B.
2. There was a significant difference in pre- and post-test GALT scores for the treatment group.

Table 2: GALT vs grade

GALT vs Grade	*B or Better*	*Less than B*
⩾11	29	4
<11	20	21

Table 3: Treatment vs grade

Treatment vs Grade	*B or Better*	*Less than B*
Treatment	29 = 74%	10 = 26%
Control	26 = 23%	87 = 77%

3. The proportion of students with a passing grade (B or better) was significantly higher for those in the treatment group when compared with those students in the control group).

Discussion

Overall, this study validates the effectiveness of the IMM treatment in significantly increasing student achievement and problem solving skills in environmental science. The following statements support this claim:

First, this study appears to validate the use of the GALT as a predictor of student performance because the probability of those students with a GALT score of 11 or above receiving a passing grade (B or better) was significantly greater than those with GALT scores less than 11.

Next, both groups had post-test GALT score gains over the pretest. The treatment group showed a significant reasoning gain while the gain for the control group did not. When the gains of the GALT scores between groups were compared the difference was not significant. Part of the increase in the GALT scores might be attributed to students taking the same GALT test for both the pre- and the post-test.

Finally, the proportion of students with a passing grade (B or better) was significantly higher for students in the treatment group when compared with those in the control group. This increase was so significant it is hard to suggest uncontrollable variables normally attributed to the difference, such as; classes meeting at different times of the day, different days of the week, being taught by different instructors, grading standards or student attendance could account for all of the variance. This result is supported by the findings of Massaro's (1995) study.

According to Wills and McNaughton (1996) educational software using interactive multimedia must actively engage the student, which is exactly what we witnessed one morning when not a sound could be heard as students were intensely engrossed interacting with the computer program in the Multimedia Lab.

This study validates the effectiveness of the use of interactive multimedia as field trip simulations for an environmental geology course. However future studies should be conducted using different research design, methodologies, disciplines and quality software to determine the long-term consequences of the use of interactive multimedia.

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