2006-1738: EFFECT OF SUPPORTING COMPUTER-BASED INSTRUCTION WITH A PAPER-BASED WORKSHEET ON THE PERFORMANCE OF 5TH GRADERS

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Effect of Supporting Computer-based Instruction with a Paper-based Worksheet on the Performance of 5th Graders

Abstract

The use of computer-based instructional technologies in educational settings has created a debate on the possibility of computer technology completely replacing traditional methods of teaching and learning. While supporters of this notion have based their arguments on the effectiveness of computer-based instruction, others have argued that the effectiveness can be better harnessed if used in conjunction with traditional methods of instruction.

This study explores the effect of providing a supplemental paper-based worksheet to a self-instructional interactive CD ROM on the performance of students in an elementary science class. Data were collected by means of a pre- and post-test experiment on a 5th grade science class (N=91). The school's administration had previously divided the class into four periods on the basis of the students' academic abilities. Period 1 is the group of least achieving students and Period 4 the most achieving students.

The specific objectives of the study were to determine if a supplemental paper-based worksheet when coupled with an interactive CDROM improved the performance of 5th graders, and, if the impact of the supplemental worksheet differed across periods. For the purpose of this study each period was randomly divided into control and experimental groups. While the experimental groups worked with both the self-instructional interactive CD ROM and paper-based worksheet, the control groups worked only with the interactive CD ROM. Performance was measured by calculating the difference between the scores of the students in the pre- and post-tests.

The results revealed that there was a significant difference between the control and experimental groups (P=0.0132) A two way Analysis of Variance (ANOVA) showed that class period had no significant effect on the performance of the students (P=0.0674). Likewise, the result showed that there was no interaction between the use of the worksheet and class periods (P=0.1772)

The study concludes that supplementing a CD ROM with a paper-based worksheet may improve the performance of students. The result of this study fills an existing research gap. Most of the experimental research on computer-aided learning involved the comparison of learners using computer-based instruction with learners using traditional methods. There have been very few experimental studies comparing groups of learners using computer-based instruction with learners using both computer-based and traditional paper-based instruction.

Introduction

The rapid development of information and communication technologies continues to have a major influence on the education of all students. Computer-based educational technologies have been tested and proven to enhance teaching and learning in American classrooms. In particular, Computer Based Instruction (CBI) has been used to enhance self directed learning in educational settings. The advantages of this form of instruction can not be overemphasized. For example,

CBI has been argued to "facilitate understanding, retention, retrieval, and transfer of knowledge and information in ways that non-technological or traditional methods of instructions cannot"[1].

However, the integration and use of instructional technology in educational settings has created a debate on the possibility of computer technology completely replacing the traditional methods of teaching and learning. Traditional methods include the use of paper and pencil by students. It is also defined as being teacher-directed with preponderance of written seatwork [2].Given the rate of incorporation and use of computer technology in American classrooms, it is sensible to ask if computers would ever replace the use of paper and pencils and face to face teaching in the 21st century classrooms.

While the supporters of the notion of replacement have based their arguments on the effectiveness of CBI, others have cautioned that computer technology may not work for everybody[3]. For example, research has shown that "learning technologies are less effective or ineffective when the learning objectives are unclear and the focus of the technology use is diffuse"[4]. It has also been argued that the effectiveness of CBI can be better harnessed if used in conjunction with traditional methods of instruction. Those in this school of thought reason that the goal of educators and researchers should not be to replace traditional methods of instruction with CBI but to find a way of combining the two methods for optimum output [5].

Apparently, the introduction of technology into classrooms might result in some changes in the existing educational methods and the use of CBI might reduce the rate at which traditional methods of learning are employed in the classrooms. Notwithstanding, paper and pencils can not be replaced by computer mice and teachers can never be displaced by technology[5].

This study proposes that supplementing the traditional methods of instruction with CBI can improve students' performance. Based on the notion that the provision of instructional materials in both computer and paper formats can improve students' performance, this study argues that supplementing an interactive CD ROM with a paper-based worksheet can increase students' performance in the domain of elementary science.

Research Objectives and Rationale for Study

The purpose of this study was to explore the effect of combining a traditional instructional method of learning (paper-based instruction) with a self instructional interactive CD ROM on the performance of students in an elementary science class. The aim was to examine the effectiveness of providing instructional materials in both paper and computer formats. The specific objectives of the study were to determine if:

(i) the addition of a paper-based worksheet to a self-instructional CDROM increased the knowledge gain of 5th graders, and

(ii) the impact of the supplemental worksheet differed across the class periods.

The research questions that guided the study are; what impact does the introduction of a supplemental paper-based worksheet when coupled with a computer-based interactive CD have on the performance of the students and, does the impact of the supplemental worksheet differ across the class periods?

It is expected that the results from this study would help fill an existing research gap on the use of CBI in classrooms. Most of the available research on the use and effectiveness of CBI in classrooms have been based on the comparison of CBI to traditional methods of instruction in quasi-experimental studies. There are two main faults associated with the previous research. First, many of these comparisons lacked objective evidence of the effectiveness of CBI and are based on questionnaire and student opinion and perception [6]. Second, most of the experimental research on CBI involved the comparison of learners using CBI with learners using traditional methods of instructions [3]. There have been few experimental studies comparing groups of learners using CBI with learners using both CBI and paper based instruction. However, some studies have compared the effect of learning styles on the performance of students utilizing multimedia instruction versus students receiving lectures supplemented with multimedia instruction [7], but these studies were based on questionnaires on the students' perceptions of the two methods.

Method

Subjects and Setting

This quasi-experimental study used a pretest-posttest design to determine the effects of combining a paper-based worksheet with a self instructional interactive CD ROM on the knowledge gain of elementary students. The study was conducted with a 5th grade science class. The school is public and located in Indiana State. The organization of the school is such that each grade (class) is divided into periods on the basis of the academic abilities of the students. The grouping of students into periods was done by the school administration prior to this study. The school administration explained that the grouping was done based on the scores of the students on a standardized test. Although the school is multi-racial and some students are bi-lingual, all classes are taught in English Language.

The 5th grade is divided into four periods. Students in each period have similar academic abilities. Each of the four periods differs in prior knowledge levels of the subject (Elementary Science). Period 1 is the group of least achieving students and period 4 is the most achieving group of students. A total of 91 students participated in the study.

Table 1: Distribution of students into experimental and control groups

Periods	N	Control Group (CD)	Experimental Group (CD&WK)
Period 1	20	11	9
Period 2	23	11	12
Period 3	24	10	14
Period 4	24	11	13
Total	91	43	48

NOTE: The inequality between the control and experimental groups in periods 1 to 4 is due to the fact that a few students did not complete the exercise; hence such data were not included in the study.

Experimental Procedure

For the purpose of this study students in each period were randomly assigned into experimental and control groups. The control groups (CD) received the instruction via the CD ROM only while the experimental groups (CD & WK) had both the CD ROM and a paper-based worksheet. The distribution of students into experimental and control groups in each of the periods was as shown in Table 1. The activities involved in the study were conducted in English Language. While the researchers provided the CD ROMs and paper-based worksheets, the school administration provided the personal computers.

Participation in the study was voluntary. The University researcher and class teacher introduced the students to the activities. The same researcher and teacher supervised the four periods in the pre- and post-test. There was no additional instruction given by the researcher or the teacher. Their role was to introduce the activity to the students. To ensure that the students used the worksheet and CD ROM as intended, the instructions were carefully explained to the students. Students were encouraged to ask questions if the instructions were not clear to them. Students were also assured that their scores would be treated as confidential.

Students were pre-tested prior to accessing the instructional materials. The aim of the pre-test was to assess the students' prior knowledge of the subject. The pre-test also served as a baseline in calculating the knowledge gain of the students. During the experiment, the students learned the instructional materials independently. Group work was not allowed. Students in the experimental group (those working with both CD and WK) worked on the worksheet while

interacting with the CD. Each student spent an average of forty minutes to complete the lesson, but had up to fifty minutes if needed.

After the lesson, a post test was conducted to assess the students' learning performance. Both the pre and post tests were created for the purpose of this study based on the content provided in the CD ROM. The tests contained fifteen multiple choice items.

Instructional Materials

The instructional materials employed in this study were an interactive CD ROM and a paper-based worksheet developed for the purpose of the study. The materials were developed and designed by a faculty of the School of Education in a mid- western University. The CDROM and paper-based worksheet were both designed in English language. The CD ROM was self-instructional and highly interactive. Students could easily navigate the CD. The same course content was presented in both the worksheet and the CD ROM. The content covered some elementary topics (electrical paths, basic electron flow theory, closed/open circuits, series/parallel circuits, and insulators/conductors) in the domain of electricity. The purpose of the worksheet was to serve as a reinforcement of information on the CD ROM. The CD ROM was animated and colorful. A CD ROM was chosen as an appropriate CBI for this age group because it allows for extensive user interaction [5].

Following is a screen shot from one screen of the program. (see Figure 1). In this activity the students were asked to drag the item to the circuit tester to see if it is a conductor or an insulator. Figure 2 shows the same question asked verbally in the paper-based worksheet.

Figure 1: A screen shot from the CD ROM

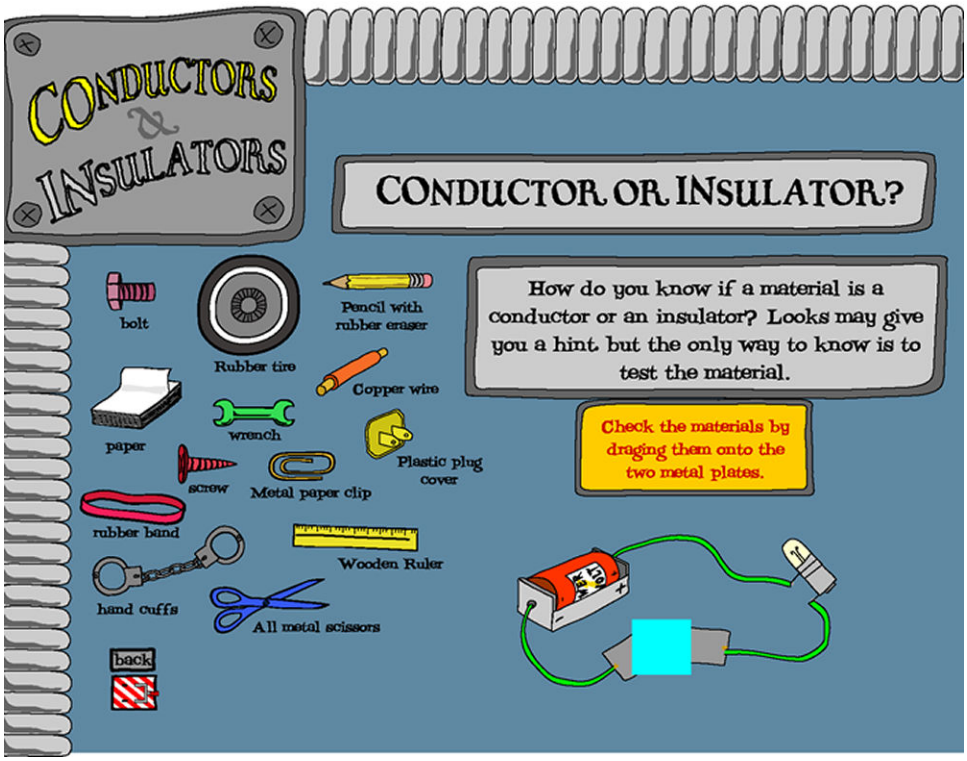

Figure 2: Question on conductors and insulators as asked in the paper-based worksheet

CONDUCTORS AND INSULATORS

Which of the following would be a good conductor and which would be a good insulator? (Circle all that are conductors and draw a line under those that are an insulator

Copper	Rubber
Plastic	Metal

Figure 3: A student answers questions on the worksheet while interacting with the interactive electric CD program.

Results and Discussion

Following the conduction of the post test the performance of the students was measured by assessing the level of knowledge gain. (i.e., Performance = Knowledge gain)
Knowledge gain was calculated as the difference between the scores on the pre and post tests. For each student, the percentage knowledge gain was calculated as:

Percent knowledge gain = ((Post test score – Pre test score)/Pre test score) x 100

The scores of the students are presented in Appendix 1. In the worksheet column of Appendix 1, the students who worked with only the CD ROM are coded as 0 and the students who worked with both the worksheet and CD ROM are coded as 1.

Data were analyzed using the General Linear Model of SAS[8]. The results of the analyses are discussed below.
In order to determine if the addition of the paper-based worksheet increased the knowledge gain of the students in the 5th grade science class, a one way ANOVA was carried out to compare the performance of the control (CD) groups with the experimental (CD &WK) groups. The result is

presented in Table 2. Table 3 compares the percentage knowledge gain of the control and experimental groups.

Table 2: ANOVA table for the effect of the worksheet on students' performance

Source	DF	TSS	MSS	F-value	Pr > F
Worksheet	1	17045.62	17045.62	6.39	0.0132

Note:
DF= Degrees of Freedom
TSS = Type III Sum of Squares
MSS= Mean Sum of Squares

Table 3: Mean percentage knowledge gain of control and experimental groups

Groups	N	% Knowledge gain
Control (CD) group	43	48.25[a]
Experimental (CD&WK) group	48	75.66[b]
Standard Deviation		51.65
P value		0.0132

Means with different superscript letter are significantly different (P<0.05)

The results revealed that supplementing the CD ROM with a paper-based worksheet had a positive impact on the performance of the students. At a 95% confidence interval, there was a significant difference in percentage knowledge gain between the CD and CD&WK groups (P = 0.0132). As shown in table 3, the CD & WK group performed better than the CD group. (Mean % Knowledge gain for the CD&WK group = 75.66 and mean % knowledge gain for the CD group = 48.25)

The above finding is in line with the argument that the effectiveness of CBI can be better enhanced if used in conjunction with traditional methods of instruction. The result shows that supplementing the information in the CD ROM with a paper-based worksheet improved the performance of the students. The provision of the learning material in both paper and computer formats had a positive influence on the students' learning and improved their knowledge in the subject.

Another objective of the study was to examine if the effect of the paper-based worksheet differed from one period to another. Since the class was divided into four periods based on the academic abilities of the students, it was hypothesized that the effect of the worksheet on students' performance may vary from one period to another. It is also possible that there is an interaction between the effects of the worksheet and class periods. For this reason, a two way ANOVA was carried out to examine the effect of class periods on students' performance, and to determine if there is an interaction between the effects of the worksheet and class periods. The result of the analysis is as shown in Table 4

Table 4: ANOVA table for interaction between worksheet and periods

Source	DF	TSS	MSS	F-value	Pr >F
Period	3	18310.38	6103.46	2.47	0.0674
Worksheet (WK)	1	15322.82	15322.82	6.21	0.0147
Period *WK (Interaction)	3	12456.27	4152.09	1.68	0.1772

Note:
DF= Degrees of Freedom
TSS = Type III Sum of Squares
MSS= Mean Sum of Squares

The two way ANOVA revealed that at a 95% confidence interval the effect of class period on the performance of the students is not statistically significant (P= 0.0674). Likewise, there was no interaction between the effects of class periods and the use (or no use) of the paper-based worksheet (P =0.1772). However, the effect of the worksheet on the performance of the students was found to be significant (P = 0.0147). The results show that the class periods have no significant effect on the performance of the students, i.e., the effect of the worksheet does not vary across the periods. It does not appear that students' academic performance, reflected in the class period to which they were assigned, is significant. Hence, the supplemental worksheet can produce positive results in both lower and higher achieving students. Weak students do not benefit more or less than good students.

Conclusions

Based on the results of this study, it is concluded that supplementing CBI with a paper-based worksheet will result in increased learning compared to using CBI alone. It is also concluded that the increased learning occurs for students that are low achievers as well as students that are high achievers, and also for average students.

In order to confirm the conclusions of this study, there is the need for replication across larger number of classes and levels of education.

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Appendix 1: Scores of students in the pre and post tests

period	worksheet	pre test	post test	gain	%gain
1	0	8	9	1	12.500
1	1	6	7	1	16.667
1	0	10	11	1	10.000
1	1	6	9	3	50.000
1	0	10	14	4	40.000
1	1	8	11	3	37.500
1	1	9	9	0	0.000
1	1	9	12	3	33.333
1	1	10	12	2	20.000
1	0	5	8	3	60.000
1	0	8	9	1	12.500
1	1	7	11	4	57.143
1	0	8	13	5	62.500
1	1	5	14	9	180.000
1	0	7	15	8	114.286
1	0	6	12	6	100.000
1	1	11	15	4	36.364
1	0	8	9	1	12.500
1	0	6	12	6	100.000
1	0	8	13	5	62.500
2	1	5	12	7	140.000
2	1	5	5	0	0.000
2	1	10	12	2	20.000
2	0	9	11	2	22.222
2	1	7	14	7	100.000
2	1	7	12	5	71.429
2	1	7	12	5	71.429
2	1	4	10	6	150.000
2	1	7	12	5	71.429
2	1	7	15	8	114.286
2	0	11	15	4	36.364
2	1	8	14	6	75.000
2	1	6	14	8	133.333
2	1	4	8	4	100.000
2	0	8	9	1	12.500
2	0	8	15	7	87.500
2	0	8	13	5	62.500
2	0	8	13	5	62.500
2	0	10	13	3	30.000
2	0	5	10	5	100.000
2	0	9	13	4	44.444
2	0	11	14	3	27.273
2	0	9	13	4	44.444
3	0	9	12	3	33.333
3	1	3	8	5	166.667

3	1	6	7	1	16.667
3	1	11	15	4	36.364
3	1	4	8	4	100.000
3	0	10	15	5	50.000
3	0	7	11	4	57.143
3	1	13	15	2	15.385
3	0	8	14	6	75.000
3	1	9	11	2	22.222
3	1	4	9	5	125.000
3	1	7	8	1	14.286
3	0	7	7	0	0.000
3	0	9	13	4	44.444
3	0	13	14	1	7.692
3	0	7	12	5	71.429
3	1	10	14	4	40.000
3	1	12	15	3	25.000
3	1	6	14	8	133.333
3	1	12	14	2	16.667
3	1	8	9	1	12.500
3	0	12	14	2	16.667
3	0	11	14	3	27.273
3	1	14	15	1	7.143
4	1	5	9	4	80.000
4	1	9	15	6	66.667
4	1	9	14	5	55.556
4	1	4	15	11	275.000
4	1	5	9	4	80.000
4	1	10	15	5	50.000
4	1	3	11	8	266.667
4	1	5	10	5	100.00
4	1	3	8	5	166.667
4	1	13	15	2	15.385
4	1	7	14	7	100.000
4	1	6	12	6	100.000
4	0	11	15	4	36.364
4	0	9	13	4	44.444
4	0	10	15	5	50.000
4	0	10	13	3	30.000
4	0	12	15	3	25.000
4	0	4	10	6	150.000
4	0	5	7	2	40.000
4	0	12	15	3	25.000
4	0	13	14	1	7.692
4	0	9	15	6	66.667
4	0	5	10	5	100.00
4	1	9	15	6	66.667