The Impact of Computer Simulated Direct Current Circuit Physics Lessons on Achievement, Group Interaction and Attitude of Students: The Case of 2007 First Year Physics Majoring Students at Bahir Dar University

Tsegaye Kassa[*] and Baylie Damtie[**]

Abstract: *This paper presents the effects of using computer simulations in place of laboratory equipment as teaching aids. The study was carried out at Bahir Dar University. We divided the 2007 first year Physics students at Bahir Dar University into two groups randomly named as VEG (Virtual Experimental Group) and REG (Real Experimental Group). Both groups were given lectures on basic direct current (DC) electric circuit together by one instructor. The REG carried out the traditional equipment-based DC experiment and the VEG did the same experiment via simulated equipment to enhance their conceptual understanding and practical skill. We then compared the two groups in their conceptual mastery and skills in handing real instruments. Moreover, they were compared in their attitude and group interaction. The main challenge was controlling other parameters that could have effects on the students' performance. We carefully examined the experimental setting and other parameters by applying proper analysis method. We observed that there were no significant differences between the two groups in terms of their skill, attitude and group interaction. However, they were statistically different in their mastery of concepts in Electric Circuit Concept Evaluation (ECCE) post-test. Students who used computer simulations in learning DC circuits have scored better on ECCE post-test than those who have performed traditional equipment-based experiment. Moreover, the mean time taken to complete the practical setup was different for the two groups; REG took longer mean time than VEG. Hence, the VEG may have more time for critical thinking and drawing conclusions*.

Keywords: Simulation, real object, achievement, group interaction, attitude, conceptual understanding, skill.

[*] Lecturer, Department of Physics, Bahir Dar University.
[**] Assistant Professor, Department of Physics, Bahir Dar University.

Background of the Study

Physics has played significant roles in the development of modern technologies including computer and radio communication, which have simplified human life to an astonishing scale. The industrial revolution, electronic revolution and the present day information communication and nano technology revolutions are essentially guided by research and development in Physics.

With the realization of the importance of physics for economic development, many countries in the world are doing their best to deliver state-of-the-art physics instruction to their citizens. It is known that teaching aids should support physics instructions and students are required to carry out experiments with the help of a laboratory assistant and an instructor. The experiments are traditionally done using scientific instruments which require significant investment and technical skills. To overcome the technical challenges, many institutions employ laboratory technicians to help students how to use the instruments. The costs of scientific instruments are increasing significantly.

For developing countries like Ethiopia the challenge to meet this demand is becoming harder and as a result some schools are essentially delivering physics instruction without supporting it by an experiment. The natural question that follows these arguments is that we find alternative teaching aids in lieu of real scientific instruments which allow us to train our students with the skills and concepts that we want them to acquire.

Modern computers make many things possible. They are obviously one of the resources to be exploited. In fact, many researchers have studied the use of computer simulation in real instruments in teaching physics as well as other sciences.

For example, in the studies carried out by Steinberg. et al (1996), Thornton and Sokoloff (1990) showed that using computers for data acquisitions, (to provide real-time data display and analyze the data) is as effective, and in some cases, more effective than their non-computer based counterparts.

A study conducted by Laura (2000) on effects of using computers in lieu of traditional data collection and analysis methods showed that there is no significant difference in academic achievement and attitude. The effects of substituting computer simulations and video for hands-on equipment in an elementary school have been reported in Triona and Klahr (2003). It was shown that computer simulations can be as productive a learning tool as hands-on equipment, if the same curricula are used in the same educational setting.

Moreover, the effects of completely replacing traditional equipment with computer based simulations have been published in literature (see, fore example, Triona and Klahr (2003). The results showed that the students who learned physics instruction using simulated equipment performed better in conceptual mastery and in assembling real scientific equipments than their counter part that were trained using real equipment. Of course, one must realize that these results are based on American context where computers and computer literate students are available.

The present paper examines the effects of using simulated systems as teaching aids in the context of Physics students at Bahir Dar University. It assesses students' conceptual understanding, mastery of the associated skills, group interaction and attitude toward particular laboratory tools used in teaching DC circuits.

To the authors' knowledge this research may be the first of its kind in Ethiopia. It will, therefore, have a very significant implication in science pedagogy in terms of educational expense. Moreover, the paper will also contribute significantly to the Department of Physics which is striving to become the Center of Excellence on Virtual Teaching Aids in Ethiopia (creating simulated systems and distributing them).

Statement of the Problem

Most Physics undergraduate courses in Ethiopian universities and colleges require attending regular lectures, carrying out experiments and participating in tutorial sessions. One usually considers that the effectiveness of the means of delivery of these courses is reflected in examination achievement of students. If we follow this line of thought and try to see the achievement of Bahir Dar University Physics and Mathematics majoring students in the courses Electricity and Magnetism (coded as Phys.102) and Experimental Physics II (Phys.112) for three consecutive years (from 2004 to 2006), we can obtain the results displayed in Tables 1 and 2. These tables show that 278 (72.21% students out of 385), and 178 (51.73% students out of 344) have scored C and below in Phys.102 and Phys.112 respectively.

Table 1: **Three years (2004-2006) Students' Achievement in Phys.102 at Bahir Dar University**

Grade	Number of Students	Percentage
A	26	6.76
B	81	21.03
C and below	278	72.21
Total	385	100

One may attribute different reasons to students' low score such as the instructors' use of inappropriate teaching aids in delivering the courses, problems related to teachers' pedagogical skills and teachers' knowledge of the subject matter, students' attitude towards physics as well as the environmental situations in which the students are attending the courses.

Table 2: Three Years (2004-2006) Students' Achievement in Phys.112 at Bahir Dar University

Grade	Number of Students	Percentage
A	66	19.21
B	100	29.06
C and below	178	51.73
Total	344	100

From Tables 1 and 2 we see that the distributions of students' score are very similar. The natural questions that may follow this observation are the following:

1. Can students' achievement in Phys.102 be improved by improving their achievement in Phys.112?
2. What are the possible mechanisms that can help in improving the performance of students in Phys.112?

Students' performance in Phys.112 could depend on several parameters (earlier experience in experimentation, motivation, the equipment used, the means of delivering and so on). In this study, we shall investigate the effects (in terms of improving Phys.112 and Phys.102 scores) of using simulated systems in teaching phys.112 instead of real equipment. Since it is not practical to implement the whole experiments in Phys.112 via simulated systems, we will narrow down our investigation to the case of DC circuit.

Research Questions

This study was carried out at Bahir Dar University in Physics Department using the traditional laboratory and the courses. The first year physics majoring students were chosen for the experiment. During the study, the students were divided into two groups, namely VEG and REG. To both groups lectures on DC circuit were given by the same instructor. The lectures were supported with experiment. The VEG carried out their experiment using virtual system and the REG conducted the same experiment using real equipment. Then, the following research questions were raised:

- Is there any difference between VEG and REG in terms of their achievement?
- Is there any difference between VEG and REG in group interaction?
- Do students in VEG and REG differ in their attitude towards experimentation?

Operational Definitions

This section gives definitions of terms used in the context of this study.

- **Achievement** refers to the students' score in ECCE test and skills in performing practical instrument setups.
- **Group Interaction** indicates the interaction among members of a group in terms of discussing issues related to DC and performing associated tasks together.
- **Attitude** refers to the attitude of students towards the experiments they are engaged in. It describes the like or the dislike of students in performing experiments.
- **Real-Equipment** refers to actual instruments that enabled students to perform DC experiments.
- **Computer Simulations** are computer-generated versions of real equipment-based experiments in DC.
- **Traditional Equipment**-based experiment indicates DC circuit experiment that was performed using real equipment.

Limitations and Delimitations

Due to time constraints and other practical reasons only the cases of first year Physics majoring students at Bahir Dar University was considered. Moreover, two students from each group failed to attend laboratory sessions after they had been assigned to VEG. This has reduced the sample size, and the reduction in sample might have influenced the result obtained.

This study is delimited to 2007 first year physics-majoring regular students at Bahir Dar University. It is also limited in terms of the variables considered. The variables considered include achievement, group interaction and attitude. Other variables such as gender were not considered. Moreover, the study is limited in scope; only DC is considered.

Research Methodology

Experimental Setting

This study took place on first year physics majoring students in Physics Department at Bahir Dar University. The topic DC circuit was chosen from the list of topics covered in the course Phys.102 for the study.

Conducting Theoretical Lectures

Phys.102 is a four credit hour course on electricity and magnetism. Lectures and tutorials are used to teach this course. Some topics from Phys.102 are included in Phys.112, which is an experimental physics course. DC circuit is also included in Phys.112, but the students did not carry out the DC experiment in Phys.112 before the beginning of this experiment.

The students learned DC circuit concepts in their regular lecture by one lecturer. Moreover, the investigators of this study taught students about DC circuits for about six hours. The lecture was given before dividing the students in two groups, i.e. REG and VEG. In other words, the lectures were conducted before each group got confined to its own specific experimental settings.

Experimental Setting for REG and VEG Groups

For the experiment covered topics that aim at investigating DC circuits. REG used real equipment to carry out DC experiment. The VEG, on the other hand, used computer simulation to carry out the DC circuit experiment, as shown in figures 1 and 2 respectively.

Fig 1: REG Students Working with Real Experimental Equipments

Fig 2: VEG Students Working with Simulated Experiments

The simulation used in this study was developed at Colorado University by Physics Education (PhET) groups. We obtained the simulations through mail from Colorado University. We chose these simulations since they are highly interactive, visual and frequently used by different researchers in evaluating the effectiveness of using simulation in teaching. Table 3 gives the number of sections and students assigned in VEG and REG.

Sample Organizations

Forty-eight first year students who joined the Department of Physics in the 2007 academic year were used as the subjects of this study. The students were randomly divided into two groups, i.e., REG and VEG for the purpose of this study. Each group had 24 students. Table 3 below summarizes the information related to the subjects of this study.

Table 3: Distributions of Students in Carrying out their Experiments

Group	Number of sections	Number of participants	Total
VEG	6	4	24
REG	6	4	24
Total	12	8	48

Data Gathering Instruments

Different data gathering instruments were used. The aim of the study was to measure three different variables named achievement, group interaction and attitude of students towards particular types of experimental settings.

Achievement

Students' achievement in this study has been considered in terms of mastering the concepts and skills in DC circuits.

Measuring Mastery of Concepts

To measure students' mastery of the concepts of DC circuits, a standard ECCE test with 32 items was used. The validity and reliability of these items were tested. Before administrating these items as pre and post-tests to the samples, item analysis was carried out on second year Mathematics majoring students in the year 2007. The item analysis was done in terms of item validity and reliability. Out of 32 items, 22 had discrimination indices in the interval +0.33 to +0.83.

The content validity of the items was also assessed by looking at contents of DC circuit, which usually appear on the course Phys. 102. To determine the reliability of the items, Kuder-Richardson (Cronbach's alpha) formula was applied and reliability coefficient of +0.8 was obtained.

Measuring Skills in DC Circuit

To measure students' skill in handling real equipment and taking measurements from DC circuits, we developed a one-item question that made students conduct experiment. The question was: you are given two lamps, connecting cables, DC source, voltmeter and ammeter. Connect the two lamps in parallel with the DC source and measure the current and the voltage drop across one of the two lamps. This question was marked out of 20. The 20 points were distributed in the following manner:

- successfully connecting the circuit in a parallel 5 points;
- connecting the voltmeter in appropriate place in the circuit 5 points;
- connecting the ammeter in proper place in the circuit 5 points; and
- correctly connecting the polarities of measuring devices 5 points.

In addition, the time taken to perform the experiments in both VEG and REG was recorded.

Measuring Group Interaction

To obtain data on group interaction, questionnaire that had 8 items was developed and administered to both groups of students in the study. The first two questions asked the students to show the extent to which they discussed during the experiment and the topics of their discussion. The remaining six questions asked the students to identify the activities they performed during the experiment.

Measuring Attitude

In the study, the students' attitude refers to their attitude to a particular way of experimentation. We measured this attitude using questionnaire with five items. The items required students' opinion on the extent to which they liked or disliked the type of experimentation they used to carry out DC circuits. The items were rated as agree, strongly agree, disagree, strongly disagree and neutral.

Data Analysis Techniques

In this study, t-test was employed to analyze the data obtained from achievement of students in DC circuits. Moreover, a chi-squared (χ^2) test was used to investigate data related to students' group interaction and attitude towards particular type of experimentation in DC circuits.

Investigation of Background Variables and Pre-test

All variables, except achievement, group interaction and attitude that may have effect on student's performance were referred to us 'background variables'. The focus of the study was to compare the VEG and REG in terms of achievement, group interaction and attitudes. This makes it important for us to make sure that these groups are not statistically different in terms of background variables.

An investigation of the background variable was done by administering questionnaire with fifteen items. The items were prepared in such a way that a student could respond to each question by choosing A, B, C, D or E. We made a 2x2 contingency table by combing responses of students with small frequencies and ignoring observations with zero frequency. Since our data on background variables are categorical, we have applied a χ^2 test to test the equivalence of the two groups in terms of background variables.

To check the equivalence of the two groups further on their pre-test results, an ECCE test on DC circuits was administered. The text had twenty-two items. A t-test was used to check whether or not the two groups were significantly different or whether there were differences in their pre-test results.

Investigation of Background Variables

Age

The type of equipment one wants to use can be determined by the age of the respondents. At younger age one may be interested to use modern technology, but older people may be effective in using traditional equipment. Therefore, the age distribution of VEG and REG needs to be investigated to make sure that both groups are similar in age.

Table 4: Age Distributions of Students under Study

Age	VEG (N=23)	REG (N=23)
17 or younger	0	1
18-19	7	7
20-21	13	9
22-23	3	6
24 or older	0	0

Table 4 shows the age distribution of each group. An $\chi 2$ test was employed to determine significant differences between the groups in terms of age distribution. We have combined the third and the fourth categories to be 20-23 and ignored the first and the fifth categories. The results of the $\chi2$ test indicated that the two groups are not significantly different in age ($\chi2$ (1) = 0.673, p = 0.412).

Residence

The quality and other characteristics of students' residence might affect their academic performance. If one group lives in a residence where different facilities like scientific instruments or academic environment are offered, this group could be effective in their academic performance. Therefore, we need to make sure that residence difference is insignificant in our case. The responses of students from each group to the question that asked them about their residence are shown in Table 5.

Table 5: Students Residence

Types of Residence	VEG (N=23)	REG (N=23)
Living in dormitory in Campus	21	20
Living near Campus	1	1
Living off Campus	1	2

An $\chi2$ test was used to analyze and the computed $\chi2$ test result showed that the two groups did not have a significant difference in the types of their residence ($\chi2$ =0.00, p=1.00).

Feeling of Preparation

How students feel in terms of preparation they made for the course 'electricity' and 'magnetism' (Phys.102) may affect their performance. Therefore, it is good to check VEG and REG in terms of this variable. We have presented in Table 6 the summarized data on how students feel in terms of preparation for the course.

Table 6: How Students Feel about Preparation

Items	VEG (N=23)	REG (N=23)
Somewhat prepared	5	5
Prepared	7	8
Very well prepared	11	10

We have then used χ2 test to check the difference between the two groups in terms of feelings of preparation. The χ2 test result showed that the two groups did not differ significantly on how well prepared they felt about the course Phys 102 (χ2 =0.00, p=1.00).

Prior Knowledge of Physics and Mathematics

Previous knowledge in Physics can affect students' performance. It is vital to check the previous Physics background of students in the two groups. Table 7 shows the responses of students in each group.

Table 7: Previous Experience in Physics Courses

Items	VEG (N=23)	REG (N=23)
No previous physics	0	1
Yes, in high school	11	13
Yes, in college	0	2
Yes, in both high school and college	12	7

We have then applied an χ2 test by considering responses of students with non-zero frequencies (ignored alternatives 'No physics and Yes, in college'). The result showed that the two groups were not significantly different in previous experience with physics course (χ2 =0.678, p=0.410).

Table 8: Number of Students Repeating the Course Phys. 102

Items	VEG (N=23)	REG (N=23)
No	20	19
Yes, at Bahir Dar University	0	4
Yes, at another College/University	3	4

As shown in Table 8, the number of students who repeated the course Phys.102 was small. Therefore, we could not apply an χ2 test. However, by inspection, we can conclude that there is no difference in the number of students who were repeating this course. Almost all of the students were taking the course for the first time.

Table 9: Previous Mathematics Background

Items	VEG (N=23)	REG (N=23)
No College mathematics	0	4
Algebra	0	0
Geometry	0	0
Trigonometry	0	0
Pre-Calculus	1	0
Introduction to Calculus	0	0
Applied mathematics I	22	19

Students' mathematical background may affect their performance in physics. From Table 9, we can see that there is no significant difference between the two groups in terms of previous mathematics class. All students had taken Applied Mathematical prior to the course Phys 102.

Table 10: Last high School (before Joining University) Mathematics Experiences

Items	VEG (N=23)	REG (N=23)
Algebra	1	0
Geometry	0	0
Trigonometry	0	2
Pre-Calculus	5	6
Calculus	16	12
Other, more advanced	1	3

Table 10 shows the different Mathematics class students took in high schools. We have used an χ2 test to analyze responses of students to high school Mathematics experience. We have considered only student's responses to the alternatives pre-calculus and calculus and have computed a χ2 value. This result showed that there is no significant difference between the two groups in terms of the types of Mathematics courses they had taken in their last high schools (χ2 =0.09, p=0.763).

Moreover, students have responded to the question: "Are you enrolled in mathematics course in the current semester?" The information obtained from students is shown in Table 11 below. X^2 test has been used to see whether or not there is a significant difference between the two groups. The result showed that the two groups were not significantly different in this aspect (χ2 =0.00, p=1.00).

Table 11: Mathematics Course the Students were taking during this Study

Items	VEG (N=23)	REG (N=23)
No	2	1
Yes	21	22

Computer Literacy

We can consider computer literacy as another important variable that has to be tested to see whether the two groups are significantly different. Students were asked to respond to the question asked to see how well they were computer literate.

Table 12: Computer Literacy

Items	VEG (N=23)	REG (N=23)
Uncomfortable with computer	3	6
Marginally computer literate	11	8
Fairly computer literate	8	7
Very computer literate	2	1
Extremely computer literate	0	1

Table 12 shows the distributions of students' computer literacy. $\chi 2$ test has been used after combing the first two categories to be marginally computer literate and the next two categories to be fairly computer literate. The result of $\chi 2$ test indicated that the two treatment groups are not significantly different in computer literacy ($\chi 2$ =0.004, p=0.947).

Grade Expectation

Students' grade expectation affects their academic performance. Students who expect to get a higher grade may perform better than those who expect a lower grade. Table 13 below shows the grade expectations of students. We have combined the second and third categories to be B-C. The χ^2 test result indicated that the two groups did not have a significant difference in their grade expectation in the course Phys 102 ($\chi 2$ =0.103, p=0.748).

Table 13: Students' Grade Expectation

Items	VEG (N=23)	REG (N=23)
A	8	6
B	10	11
C	5	6

Study Time

Students were also asked to respond to the question asked to know how much they expect to spend outside of class time studying the course Phys 102. A significant difference in their responses to this question could bring a significant difference in the achievements of the students in both groups. Table 14 shows the responses obtained in this regard.

Table 14: Study time by Students

Items	VEG (N=23)	REG (N=23)
Less than 2 hours per week	2	1
2-5 hours per week	6	6
6-10 hours per week	4	1
10-15 hours per week	6	7
More than 15 hours	5	8

The first two categories have been combined to be 5 and less, and the next three categories were combined to be 6 and more. The $\chi 2$ test result showed that there is no significant difference between the two treatment groups in terms of study time ($\chi 2 = 0.00$, $p=1.00$).

Number of Science Courses Students had prior to the Course Phys.102

Science courses could be related to each other. This relationship could affect the students' achievement in Physics courses. If one group has taken more science courses, the achievement of students in the group might be better than that of the other group who has taken fewer science courses.

Table 15: Number of Science Courses Students' had prior to the Course Phys.102

Items	VEG (N=23)	REG (N=23)
This is my first science course	0	5
I am taking concurrently with phys.102	0	0
1	2	5
2	4	6
3	8	7
4	4	0
5	4	0
6	1	0

Table 15 shows the distribution of number of science courses taken by each group prior to the course Phys.102. The third and fourth categories have been 1-2. The fifth, sixth, seventh and eighth categories have been disregarded. The $\chi2$ test result showed that there is no significant difference between the two groups in distribution of number of science courses taken prior to the course Phys.102 ($\chi2=0.448$, $p=0.503$).

Achievements in Pre-test Results

Students were given a pre-test on DC circuits. The questions were 32 multiple-choice items. However, after conducting item analysis in terms of both validity and reliability, ten of the items were rejected and the remaining 22 were administered to the students. A t-test was used to see whether there was a significant difference between the two groups. The results showed that the two groups did not have a statistically significant difference on their ECCE pre-test results ($t(42) = 0.223$, $p=0.824$) with a significant level of $\alpha = 0.05$.

From the analysis of background variables, we have shown that the VEG and REG did not have a significant difference in terms of all the background variables. This means that we can associate the two groups' achievement, attitude and group interaction with the methods of experimentation.

Results

The purpose of this study was to see impact of computer simulations on students' achievement, group interaction and attitude. VEG and REG were given the same to measure their achievement in DC circuits. Their achievement was investigated in terms of their mastery of DC concepts and skills. Also, an attempt was made to measure students' group interaction during experimentation. Their attitude towards experimentation was also surveyed.

Achievement

One of the research questions was designed to see if here was any difference between the VEG and REG in terms of their achievement? To answer this question, the students' achievement of concepts and skills associated to DC circuits was measured. Students' achievement in one conceptual test (i.e. ECCE) and a practical test that asked students to set up a specific DC using real equipments ware recorded. The data were analyzed using two-sample t-test. The groups' achievement difference in terms of analyzing mastery of concepts, skills and gain was measured.

Difference between REG and VEG in terms of Conceptual Understanding

Table 16 shows the difference between REG and VEG in terms of mastery of the concepts in DC circuit. The mean of the post-test scores of VEG is found to be significantly higher than the REG. This difference is significant at the 0.05 alpha level ($t(42)=3.24$, $p=0.0023$). This means that students in VEG did better on conceptual understanding than students in REG.

Table 16: Achievement of Students in terms of Mastery of Concepts on ECCE Post-test

Group	VEG	REG
Number of students participated	22	22
Maximum expected mean scores	22	22
Measured mean score	11.50	8.23
Standard deviation of the score	3.57	3.12

Difference between REG and VEG in terms of Mastering Skills

Table 17 illustrates the difference between REG and VEG students in setting up DC circuit using real instruments. We can see that there is a significant difference between REG and VEG students in terms of their achievement in practical examination. Accordingly, VEG students have scored more on practical (mastery of skills) examination. Using 0.05 alpha level, we have obtained $t(42) = 1.62$, $p = 0.111$.

Table 17: Achievement of Students in Practical Examination on DC Circuits

Group	VEG	REG
Number of students participated	22	22
Maximum expected mean scores	20	20
Measured mean score	11.36	8.41
Standard deviation of the score	5.81	6.25

In addition to the score difference in was practical achievement, we found out that the time they took to carry out the experiment was different. From Table 18 we can see that the mean of the total time required by VEG to carry out the experiment is less by about 3 minute than the time taken by REG. Using 0.05 alpha level, we have obtained $t(42) = 2.682$, $p = 0.0104$.

Table 18: The Average time (min) Required to Complete Practical Examination on DC Circuits

Group	VEG	REG
Number of students participated	22	22
Average time taken to carry out the experiment	7.68	10.27
Standard deviation for time taken	2.44	3.82

Gain

Gain is usually described as a measure of the relative score weighting function that compares the scores of students before instruction and after instruction. We denote gain by (g). Mathematically it may be given by

$$g = \frac{post\% - pre\%}{100 - pre\%},$$

where $post\%$ represents the percentage score after instruction and $pre\%$ represents the percentage score before instruction. When the gain of VEG and REG on conceptual understanding is investigated using the above equation, we can see the VEG students have better gain than the REG students.

Table19: Difference between VEG and REG in terms of Gain

Group	Percentage of pre-test score	Percentage of post-test score	Gain
VEG	36.36	52.27	0.25
REG	35.54	37.40	0.03

Group Interaction

The other research question was: Is there any difference between VEG and REG in-group interaction? To answer this question, we need to know how students interact with each other in each group during experimentation. Questionnaire, which students completed at the end of their experimentation, was used to find out the kind of students interaction. The questionnaire contains eight questions as shown in Tables 20 and 21. The questions can be grouped into two: discussion questions (questions 1 and 2) and activity questions (questions 3, 4, 5, 6, 7 and 8). Only the answers that contained 'frequently' were analyzed to investigate the students' answer to activity questions (see Table 8).

X^2 test, as shown in Table 20, was used to analyze the data. The result shows no significant difference between the VEG and REG students in terms of their group activity ($\chi^2(5)=2.187$, $p=0.8227$).

Table 20: Group interaction (activity)

Group	VEG	REG
One person in our group did most of the task	2	4
I felt I was contributing to our group's success	10	5
I felt the other members were contributing	11	9
Our group worked efficiently for its success	15	13
Our group did most task together cooperatively	15	14
Our group communicated well with each other	11	11

Table 21 shows the students' answer to the two discussion questions. These answers have been analyzed. The result obtained is χ^2 (1) =4.544, p=0.03330. This means that there is a significant difference between REG and VEG students in the types of topics they discussed during experimentation. The students in the REG discussed equipment difficulty more often than the students in the VEG.

Table 21: Group interaction (discussion)

Group	VEG	REG
Equipment difficulty	4	22
Misunderstanding concepts	3	1

Attitude

The last question asked in this study is: Do students in VEG and REG differ in their attitude towards experimentation? The students' attitude towards experimentation was investigated using the item displayed in Table 22. An χ^2 test that was used in connection with this data showed χ^2 (5) =3.400, p=0.493 at an alpha level of 0.05. This means that there is no significant difference between REG and VEG students in their attitude towards their experimentation environment.

Even though the cumulative difference in terms of students' attitude towards experimentation is not significant, there is a remarkable difference in the responses of students to the question which says: "It is my favorite to use this experimental tool in my next physics class." Students in VEG agree more than the REG students.

Table 22: Attitude of Students towards Experimentation

Group	VEG	REG
Experimentation was wasting rather than learning the physics	4	8
The tool I used helped my understanding of relations among quantities	20	17
My attitude towards physics has increased due to the tool I used	19	15
I was highly motivated to investigate principles by using the experimental tool	21	13
It is my favorite to use this experimental tool in my next physics class	20	12

Discussion

Experiments have played a vital role in studying physics. It is demonstrated by different researchers that a physics instruction assisted by experiments enhances students' conceptual understanding and associated skills. However, the experimentation used in the physics instruction has its own impact on obtaining the expected achievement of students in various aspects.

In this study, computer simulation and real-equipment based experimentations have been treated separately for two groups: VEG and REG respectively. The result shows that students in VEG achieved better in conceptual understanding in DC circuit than those in REG. This finding confirms the finding noted by earlier studies (see, for example, Finkelstein et al., 2005).

In contrast to the results of the present study in conceptual understanding in DC circuit, some researchers, such as Laura (2000) showed no significant difference between students in VEG and REG. This contradiction is due to uncontrolled variables such as background information of students in the two groups that the researcher in Laura (2000) did not consider before conducting the actual experimental research.

In the present study, we obtained a significant difference between students in VEG and REG in their achievement-in performing practical examination (assembling real equipments in DC circuit). This result agrees with a research finding by Finkelstein et al. (2005).

It is demonstrated by Berger (1984) that students in VEG required on average a shorter time (in minute) to assemble real-equipments in DC circuit experiments than those in REG. As a result students in VEG could get time for critical thinking and drawing conclusions.

Research finding by Bricken and Byrne (1992) showed that students in REG discussed equipment difficulties more often during experimentation than students in VEG. A similar result, which confirms the occurrence of equipment difficulties in REG students, is obtained by the study.

Conclusion, Implications and Recommendations

Conclusion

We can conclude that computer simulation can be used instead of real scientific instruments in an experiment designed to support theoretical lectures on DC circuits at university level. We found out that students who used virtual systems in their learning can acquired more skill in handling real equipment than those who used real scientific instruments. More importantly, the study showed that the VEG students have better conceptual understanding. They also had favorable attitude towards experimentations.

Implications of the Result

The results have very significant implications for science teaching, educational research and educational expenses in Ethiopia. First of all, if our results are confirmed in a wider scale, on different topics and educational levels and context in the country, we may be able to improve our educational system with a cheaper system. Moreover, the overwhelmingly theoretical lectures in science and engineering can be transformed into the state-of-the-art computer-assisted instructions. This will allow our country to produce competent citizens.

This research work might also open a new field of educational research in Ethiopia. Topics like why students get attracted to a particular experimentation environment and the type of relationship between experimental tool and the concepts designed to be transferred using this tool can be important research area. We can even go further and ask whether or not we can completely replace students' real experimentation environment with virtual world and still obtain the objectives we state in our curriculum.

Recommendations

The results of this paper indicate that one could use computer simulations as alternative methods of supporting theoretical lectures in physics. However, intensive investigations need to be carried out to find out the pedagogical implications. Our recommendations can be summarized as follows:

- the effects of computer simulations in teaching different topics of physics should be investigated.
- a more fundamental educational question like why some experimental tools are more effective than others should be answered.
- the economic benefit of using computer simulations instead of real instruments needs to be investigated.
- research need to be carried out to see the impacts of computer simulations on students' achievement, group interaction as well as on other variables at different educational levels and context.
- the impacts of different types of virtual systems need to be studied.

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