IMPACT OF INTERACTIVE MULTIMEDIA SIMULATIONS ADVANCE ORGANIZERS TEACHING APPROACH ON STUDENTS' ACHIEVEMENT IN SECONDARY SCHOOL PHYSICS

David G. Ngatia[1]*, Assistant Lecturer, University of Kabianga, Kenya,
dgachiu@yahoo.com, +254725620042 (*corresponding author)

Prof J. Changeiywo[2], Professor, Egerton University, Kenya,
jchangeiywo@yahoo.com +254722858563

Dr. Patricia W. Wambugu[3] Senior Lecturer, Egerton University, Kenya,
patriwa2010@gmail.com, +254722433741

Abstract

This study investigated the effect of Interactive Multimedia Simulations Advance Organizers (IMSAO) teaching approach on physics achievement in the topic Measurement in Kenyan secondary school Physics. IMSAO approach integrates interactive multimedia simulations and advance organizers in the teaching learning process. Solomon-four, quasi-experimental research design was used. Four schools were purposefully sampled from the 24-mixed day public secondary schools in Nyahururu Sub-County of Laikipia County, Kenya. The sampled schools were randomly assigned to experimental and control groups.168 students from the sampled schools were involved in the study. A Physics Achievement Test (PAT) was developed, validated and pilot tested for use in data collection. The reliability coefficient of PAT was 0.83. A training manual on IMSAO was developed. Thereafter, the teachers in the experimental schools were trained on how to use IMSAO. A pretest was administered to students in one control and one experimental group and after the treatment a posttest PAT was administered to students in all the four groups. Data was then scored and analyzed using Analysis of Variance (ANOVA), Analysis of Covariance (ANCOVA) and t-tests at α level of 0.05. The findings indicated that students taught using IMSAO approach demonstrated significant improvement in PAT when compared to those taught through Conventional Teaching Methods (CTM). On the basis of the findings, the study advocates for the use of IMSAO on effectiveness and improved academic achievement in secondary school physics.

Key Words: Advance Organizers, Conventional Teaching Methods, Interactive Multimedia Simulation, Students Physics Achievement

1. Introduction

The knowledge of physics is essential for scientific and technological development of any society. Physics is the science that attempts to describe how nature works using the language of mathematics. It is often considered the most fundamental of all the natural sciences and its theories attempt to describe the behavior of the smallest building blocks of matter. Physics plays a constructive role in the socio-economic development and also provides basic hands-on experience in equipment handling useful for minor repairs even without specific technical training. In addition, Physics helps people to develop the scientific approach in their daily lives making them more practical minded persons (Edmund, 2005).

Technologies that are continually transforming the world can be directly traced back to researches in physics. For example, research on semiconductors enabled the first transistor to be developed in 1947. This seemingly simple device is the key component in most electronic systems, including computers, and it is now considered one of the most important inventions in human history (Khalija, 2004). The laws of optics describing the way light behaves have led to the development of the optical fiber networks that are beginning to crawl over the entire globe, easing communication and drawing the world close together. The ongoing research on nanostructures and photonics, which are branches of physics, may lead to the next generation of technologies including faster and more robust computers and communication systems (Stephen, 2002). Further the theories of physics have provided some of the deepest notions of space, time, matter and energy (Modini, 2011).

In spite of its great importance, majority of physics students, both past and present, believe that physics is one of the most difficult subjects studied in school (Semela, 2010). The physics achievement by students has generally been a poor and a major concern to science educators globally (Sakiyo & Sofeme, 2008; UNESCO-UNICEF, 2003). The physics achievement in Kenya has been poor and has remained a matter of concern to the Ministry of Education and other stakeholders (KNEC 2012, 2013, 2014). In Nyahururu Sub-County of Laikipia, the performance of physics in KCSE has also been poor with a mean grade of C- in the period 2010-2014 despite the fact that only few and apparently bright students take physics at KCSE (Nyahururu Sub-County Education Report, 2015).The poor performance in physics nationally is worrying considering that physics is among the key subjects expected to turn Kenya into an industrialized country by the year 2030 providing high quality life for all its citizens (Republic of Kenya, 2007). This can only be achieved by exploiting knowledge in science, technology and innovation (STI) in all sectors. Physics knowledge is therefore fundamental in the realization of vision 2030 (NESC, 2007).

According to Ango (1990), students' poor performance in physics is basically due to lack of teaching approaches that involve the students in the teaching-learning activities. The general lack of understanding of the value of physics, combined with poor teaching approaches, may be some of the factors that make them perform poorly in the subject. If a student doesn't understand what physics is, they are unlikely to grasp the relevance of physics to society, and more importantly the relevance of physics to themselves (Neuschatz & Farling, 2002). There is therefore need for teaching approaches which would improve the achievement in physics.

One such approach is Interactive Multimedia Simulation Advance Organizers (IMSAO). This is a teaching approach which combines the use of interactive multimedia simulations and advance organizers in the teaching process. The IMSAO teaching approach use simulation program that mimics the real laboratory equipment. The program is interactive and enables the learner to manipulate the apparatus and get immediate feedback on the success or failure in performance of his/her tasks. Interactive Multimedia Simulation Advance Organizers prepared for use in teaching activities are able to create a teaching atmosphere like laboratories where students are active (Perkins *et. al*., 2006).

A variety of visual representations of physics concepts in the Interactive Multimedia Simulation Advance Organizers make concepts visible that are otherwise invisible to students (Finkelstein *et. al*., 2005). Jones (1988) contends that proper integration and use of interactive multimedia simulations advance organizers in education can smoothen the path to instructional enlightenment because it can, among other things, provide effective communication, clarify concepts and enhance teaching and learning via the natural multisensory and intuitive approach. Steinberg (2000) argued that one major way to promote learning is through the use of computer simulations of physical phenomena. The simulations, if designed appropriately, can serve several purposes: to help students extend their experience with hands-on experiments and collect additional phenomenological data; to make models explicit and help students collect model-based evidence; and to provide multiple representations of the same or related concepts.

An advance organizer on the other hand could help the learner anticipate and organize new information (Ausubel, 1978). Advance organizers therefore foster meaningful learning. While physics teaching may benefit from use of IMSAO teaching approach, no study has been carried out to investigate the effects of IMSAO on the achievement in physics topic "measurement". This study aimed to investigate the effects of using IMSAO teaching approach on students' physics achievement on topic Measurement in Kenyan secondary schools. According to KNEC (2010), this has been one of the poorly done areas in KCSE. The students are unable to take measurements using vernier calipers and micro-meter screw gauge and to comprehend other related concepts in the topic such as zero errors and the least count.

1.1 Purpose of the Study

The purpose of this study was to investigate the impact of Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach on students' achievement in the topic measurement in form two physics syllabus.

1.2 Objective of the Study

The objective of the study was to compare students' achievement in Physics between those taught using IMSAO approach and those taught using Conventional Teaching Methods (CTM).

1.3 Hypothesis of the Study

To achieve the objective of the study, the following null hypothesis was tested:

Ho: There is no statistically significant difference in achievement in Physics between students exposed to IMSAO teaching approach and those exposed to CTM.

2. Research Methodology

The study was a quasi-experimental research where the researchers used the Solomon-Four Non-Equivalent Control Group Research Design. The reason for this is that secondary school classes once constituted exist as intact groups and school administrations do not allow such classes to be broken up and reconstituted for research purposes. The Solomon four-group nonequivalent control design is considered rigorous for quasi-experimental studies (Gall, Gall and Borg, 2007; Cook & Campbell 1979). This design makes it possible to evaluate the main effects as well as the reactive effects of testing, history and maturation (Fraenkel, Wallen and Hyun, 2011). Four schools were purposefully sampled from the 24-mixed day public secondary schools in Nyahururu Sub-County of Laikipia County, Kenya. Two of the sampled schools were randomly assigned to experimental groups while the other two were assigned to control groups.168 students from the sampled schools took part in the study. A Physics Achievement Test (PAT) was developed, validated and pilot tested for use in data collection. The reliability coefficient of PAT was 0.83.A training manual on IMSAO was developed. Thereafter, the teachers in the experimental schools were trained on how to use IMSAO. A pretest was administered to students in one control and one experimental school. IMSAO teaching approach was then applied on the experimental groups as treatment for three weeks. Thereafter, a posttest PAT was administered to students in all the four groups. PAT results were then scored and analyzed using ANOVA, ANCOVA and t-tests at α level of 0.05. Figure 1 shows the representation of the Solomon Four Non-Equivalent Control group design.

Group E1	O_1	X	O_2
Group C1	O_3	-	O_4
Group E2	-	X	O_5
Group C2	-	-	O_6

Figure 1. Solomon Four Non-equivalent Control Group Design

Where O_1, O_3, represent the pre-test observations while O_2, O_4, O_5 and O_6 represent the post-test observations

X - the treatment where students were taught using Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach.

Group E1 – the experimental group that received the pre-test, treatment X and the post-test.

Group C1– the true control group, which received a pre-test, followed by a control condition and finally a post-test.

Group E2 –the experimental group that receive treatment X and a post-test. These groups was not be pre-tested.

Group C2 –the control groups that received the post-test only.

Group C1 and C2 formed the control groups that were taught using Conventional Teaching Methods (CTM) while Group E1 and E2, are the experimental groups which were taught using IMSAO teaching approach.

3. Results and Discussion

The PAT scores were recorded and constituted data used in the study. Data was analyzed using ANOVA, ANCOVA and t-tests at α level of 0.05. A statistical package for social sciences (SPSS version 20) was used in data analysis

3.1 Results of the Pre-tests

Pretesting was done to establish the homogeneity of the experimental and the control groups before the administration of the treatment. This also helped to identify the entry behavior of the subjects under study. Groups E1 and C1 were pretested on the physics achievement using pretest PAT. The pretest analysis involved comparing the students' pretest mean scores of the groups on Physics Achievement based on the teaching approach. The results of the comparison by teaching approach are in Table 1.

Table 1.
Comparison of the Students' Pre-test Mean Scores in Physics Achievement between E1 and C1 using a t-test

Scale	Group	N	Mean	SD	df	t-value	ρ-value
Physics achievement	E1	37	17.89	3.60	71	0.167	0.868
	C1	36	17.69	6.18			

The results in Table 1 show that the physics achievement pretest mean score (M = 17.69, SD = 6.18) of C1 was not significantly different from that of E1 (M = 17.89, SD = 3.60) at the 0.05 level, t (71) = 0.167, ρ = .868 which is greater than .05. This means that the two groups were similar before the administration of the treatment as measured by physics achievement pretest mean scores. Given the similarity in characteristics between the two groups E1 and C1 in the Physics achievement, the four groups were considered suitable for the study as they were drawn from same population and sampled randomly.

3.2 Difference in Students Physics Achievement by Teaching Approach

In order to test whether there was a statistical difference in achievement in Physics between students exposed to IMSAO teaching approach and those taught using conventional teaching methods, the Physics Achievement Test posttest means of the experimental and the control groups (E1, E2 C1and C2) were used. Table 2 gives the descriptive statistics of the posttest PAT scores for the four groups.

Table 2.
Students' Physics Achievement Post-test Mean Scores and their Standard Deviations

Group	N	Mean	Std. Deviation
E1	37	53.70	5.79
E2	45	52.49	5.58
C1	36	31.11	8.17
C2	50	28.96	7.80

Table 2 shows that the posttest PAT scores for the experimental groups E1 (M = 53.70, SD = 5.79) and E2 (M = 52.49) were higher than those of the control groups C1 (M = 31.11, SD = 8.17) and C2 (M = 28.96, SD = 7.80). Analysis of variance (ANOVA) was used to test for statistical differences in the means. The results are as shown in Table 3.

Table 3.
Comparison of Students' Physics Achievement Posttest mean scores by Teaching Approach using ANOVA

Scale	Sum of Squares	df	Mean Square	F-ratio	ρ-value
Between Groups	22673.544	3	7557.848	157.007	.000*
Within Groups	7894.450	164	48.137		
Total	30567.994	167			

*Significant at 0.05 level

The results of the ANOVA test in Table 3 indicated that the difference among the Physics Achievement Test mean scores of E1, C1, E2 and C2 were significant at the 0.05 level in favour of the experimental groups, $F(3,164) = 157.0$, $\rho < 0.05$. The large F ratio indicated that there was more variability between the groups caused by the independent variable than there was within each group. The results from table 3 did not however indicate which group were different from which another group. The statistical significance of the differences between each pair of groups was further carried out using Least Significant Difference (LSD) Post Hoc. The test was selected because it is suitable for cases where the sample sizes of the groups being compared are small.

Table 4.
LSD post hoc Comparisons *of Physics Achievement Posttest Mean cores*

Paired Group	Mean Difference	ρ-value
E1 versus E2	1.21	.432
E1 versus C1	22.59	.000*
E1 versus C2	24.74	.000*
E2 versus C1	21.38	.000*
E2 versus C2	23.53	.000*
C1 versus C2	2.15	.158

*Significant at 0.05 level

The Least significant Differences (LSD) test in Table 4 further indicated significant differences between the physics achievement post-test mean scores of the experimental groups (E1 & E2) and control groups (C1 & C2). Since the ANOVA test do not have features to level out initial differences in the groups, Analysis of Covariance (ANCOVA) test was further used with the Kenya Certificate of Primary Education (KCPE) scores as the covariate. The adjusted physics achievement post-test mean scores with KCPE marks as the covariate are summarized in Table 5.

Table 5.
Adjusted Physics Achievement Posttest Mean Scores with KCPE as the Covariate

Teaching approach	Mean	Std. Error
E1	53.64	1.14
E2	52.48	1.03
C1	32.24	1.16
C2	28.93	0.98

The results in Table 5 show that the adjusted post-test mean scores of the experimental groups E1 (M = 53.64) and E2 (M= 52.48) were higher than those of the control groups C1 (M = 32.24) and C2 (M = 28.93). Preliminary checks were conducted to ensure that there was no violation of the assumptions of homogeneity of variances using the Levene's test as indicated in in Table 6.

Table 6.
Levene's Test of Homogeneity of Variances for adjusted Physics Achievement Post-test mean scores

F	df1	df2	Sig.
2.172	3	164	.093*

*Significant at 0.05 level

The results in Table 6 confirmed that the adjusted Physics achievement post-test mean scores variances for the groups were significant at α=.05 level of significance (ρ > .05). The assumption of the equality of variances was therefore not violated and ANCOVA test on the variances could be done. The ANCOVA analysis was conducted in order to find out whether the difference among the mean scores were significant. The results of the ANCOVA test are contained in Table 7.

Table 7.
ANCOVA Test on Students' Physics Achievement Posttest Mean

Scale	Sum of squares	Df	Mean Square	F-ratio	ρ-value	Partial Eta Squared
KCPE	61.95	1	61.95	1.29	.258	.008
GROUP	22504.88	3	7501.63	156.11	.000*	.742
Error	7832.50	163	48.05			

*Significant at 0.05 level

The ANCOVA test from Table 7 showed that the differences among the groups were significant in favor of the experimental groups [F (3,163) =156.11, p=.000, partial eta squared=.742]. The effect size, as indicated by the corresponding partial eta squared value showed that much of the variance in the Physics Achievement Post–test mean scores could be explained by the teaching approach. The value in this case was 0.742 which translates to 74.2 % contribution to the differences in variances in the groups. The influence of the covariate, in this case the KCPE marks, was found not to be significant in influencing the PAT post-test mean scores [F (1,163) =1.29, p=.258, partial eta squared=.008].The covariate only influenced only 0.8% of the variances in the groups.

3.3 Comparison of Students Physics Achievement test Mean Gain by Teaching Approach

The gain made by learners in the physics achievement test was obtained by getting the differences between the pre-test and post-test mean scores of the groups E1 and C1. This gave an indication of the relative impact of treatment on the Physics Achievement on the study groups. The results are summarized in table 8.

Table 8.
Students' Physics Achievement Pretest and Posttest Mean Scores, Standard Deviations and Mean Gains by Teaching Approach

Stage	Scale	Group	
		E1 N = 37	C1 N = 36
Pre-test	Mean	17.89	17.69
	Standard Deviation	3.60	6.18
Post –test	Mean	53.70	31.11
	Standard Deviation	5.79	8.17
	Mean Gain	35.81	13.42

The results in Table 8 showed homogeneity of the both the experimental and control groups at the stage of the pretest in terms of the mean scores in the Physics Achievement Test. The means scores of groups E1 and C1 were 17.89 (SD = 3.60) and 17.69 (SD = 6.18) respectively. The two groups were therefore considered similar before the treatment was administered. After the treatment, the mean scores of E1 and C1 were 53.70 (SD = 5.79) and 31.11 (SD = 8.17) respectively. The increase in the physics achievement mean scores as measured by the mean gain was 35.81 for E1 and 13.42 for C1. This indicated that the experimental group PAT mean score improved with a higher margin than that of the control group. A t-test was further carried out to determine whether the difference between the mean gains of the two groups were significant. The results of the t-test are given in Table 9.

Table 9.
Comparison of Students' Physics Achievement Mean Gain of E1 and C1 using a t-test

	N	Mean Gain	SD	Df	t-value	ρ-value
E1	37	35.81	6.69	71	11.79	0.000*
C1	36	13.42	9.36			

* Significant at 0.05

The results of the t-test indicate a significant difference between the mean gain (M = 35.81) of E1 and that of C1 (M =13.42), t (71) = 11.79, $\rho < 0.05$ in favour of E1. Since both groups were similar before the commencement of the treatment, the major improvement in the PAT mean scores of E1 was attributed to the treatment.

4. Discussion of the Results.

The hypothesis of the study sought to find out whether there was statistically significant differences in physics achievement between students taught through Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach and those taught through Conventional Teaching Methods (CTM).

The study established that students who were taught through IMSAO teaching approach achieved significantly higher scores in the PAT than those who were taught through the CTM. The results of ANOVA, ANCOVA and gain analysis showed a significant difference in PAT mean scores between the experimental groups and control groups, in favor of the experimental groups. The null hypothesis which stated that there is no statistically significant differences in achievement in Physics between students exposed to IMSAO teaching approach and those that are not exposed to it was consequently rejected at .05 level. This is a pointer that IMSAO teaching approach was more effective in improving students' Physics achievement as compared to CTM. Since IMSAO teaching approach appears to improve achievement in physics when compared to the conventional methods used by teachers, it should therefore be integrated in the teaching of physics in secondary schools to improve the dismal performance in the subject.

The findings of the study are in tandem with researches carried out By Holec, Spodniaková and Raganová (2004). Their study used interactive computer simulations to teach the physics topics mechanics in secondary schools in Slovak Republic. A test was given and the effect of interactive computer simulations on student performance was compared with performance of students not exposed to the treatment. The results indicated that integration of computer simulations into school physics influenced students' level of physics knowledge positively.

The results agrees with the findings of a research conducted in Kenya by Jesse, Twoli and Maundu (2014). In their study, they found out that physics performance is enhanced when the subject is taught using interactive computer assisted instruction. Another study carried out by Sarabando, Cravino and Soares (2014) showed that the use of the interactive computer simulations helped students learn the physics concepts of weight and mass better than the conventional teaching methods. Further, a study by Shah and Khan (2015) revealed that multimedia-aided teaching is more effective in improving students' academic achievement and development positive attitude towards science.

5. Conclusion and Recommendations

From the findings, it is evident that the Interactive Multimedia Simulation Advance Organizers (IMSAO) teaching approach has a positive effect on the physics achievement. The approach should therefore be incorporated in the teaching of physics in the secondary schools to improve the performance of physics. The physics curriculum developers should also design the teaching-learning materials in line with the IMSAO teaching approach to help the learner easily grasp the physics concepts which would otherwise appear difficult to them.

REFERENCES

Altun, T., Yiğit, N. & Alev, N. (2007). *The Effects of Computer Supported Materials on Student Achievements and Perceptions in Science Education*, Conference IMCL2007, April 18 -20, Amman, Jordan.

Ango, M. (1990). *Basic science laboratory with practical suggestions and procedures*. Lagos: Hinders

Ausubel, D. P, Novak J. D and. Hanesian H, (1978); *Educational psychology: A cognitive view*. 2nd edition. New York: Holt, Rinehart and Winston, Inc.

Cook, T.D. & Campbel, D. (1979). *Quasi Experimentation* Boston, Houghton Mifflin.

Edmund Z. (2005).Physics for Development: Catching up is hard to do. *IAEA bulletin 47/1*. http://www.iaea.org/sites/default/files/publications/magazines/...1/47105694649.pdf retrieved on 9/11/2018.

Finkelstein, N.D., Adams, W.K., Keller, C.J., Kohl, P.B., Perkins, K.K., Podolefsky, N.S., Reid, S. &LeMaster, R. (2005). When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment**.** *Physical Review Special Topics - Physics Education Research*, 1(1), 1-8.

Fraenkel JR, Wallen NE, Hyun H (2011). How to design and evaluate research in education (8thed.). Boston, MA: McGraw-Hill Education.

Fraser, B. J., & Walberg, H. J. (1995). *Improving Science Education.* Chicago, Illinois: National Societal for the Study of Education.

Gall MD, Gall JP, Borg WR (2007). Educational research: An introduction (8thed.). Cranberry, NJ: Merrill.

Githua, B.N. (2002). *Factors Related to Motivation to Learn Mathematics among Secondary School Students in Kenya's Nairobi Province and Three District of Rift Valley*. Unpublished Doctoral thesis, Egerton University.

Holec S, Spodniaková M. & Raganová J. (2004). Computer Simulations in Mechanics at the Secondary School, *Informatics in Education*, Vol. 3, No. 2, 229–238 229

Jesse S., Twoli, N. and Maundu, J. (2014) "Enhancement of Science Performance through Computer -Assisted Instruction among Selected Secondary School Learners in Kenya," *Kentucky Journal of Excellence in College Teaching and Learning*: Vol. 12, Article 4. pp 40-51

Jones, K. (1988). *Interactive learning events: A guide for facilitators.* Kogan Page Ltd

Kara, İ. (2008). The Effect on Retention of Computer Assisted Instruction in Science Education, *Journal of Instructional Psychology,* 35(4), 357-364.

Kenya Institute of Education (KIE) (2002). *Secondary Education Syllabus. Volume seven*. Self.

Kenya Institute of Education (KIE) (2008). *Ministry of Education. Secondary Education Curriculum. General Science Syllabus*. Self.

Kenya National Examination Council (KNEC) (2009). *2008 K.C.S.E Examination Report,* Nairobi: KNEC.

Kenya National Examination Council (KNEC). (2010), *2009 K.C.S.E Examination Report,* Nairobi: KNEC.

Kenya National Examination Council (KNEC) (2013). *2012 K.C.S.E Examination Report,* Nairobi: KNEC.

Khalijah M. Salleh (2004). *Role of Physics Community for the Development and Advancement of Physics Education in the Globalization Era*; Indonesian Journal of Physics Vol. 15 No.1

Modini R. (2011).*Why Study Physics and is Physics Relevant? An* article in ITS Tutorial School website *http://www.tuition.com.hk/physics.htm on (*11/6/2011)

National Economic and Social Council of Kenya (NESC) (2007*). Kenya Vision 2030*; Government Printers, Nairobi

Neuschatz M. & Mc Farling M. (2002). Background and Professional Qualifications of High-School Physics Teachers. *The Physics Teacher. Vol 38. . pp 98-104.*

Nyahururu Sub-County Education Report (2015). *KCSE Examination Report*

Perkins, K., Adams, M., Dubson, M., Finkelstein, N., Reid, S., Wieman, C. &LeMaster, R. (2006). PhET: Interactive simulations for teaching and learning. *The Physics Teacher*, 44(1), 18-23.

Republic of Kenya (2007). Kenya Vision 2030: A globally competitive and prosperous Kenya. Nairobi: Government printers.

Rupe, V. S. (1986). *A Study of Computer-Assisted Instruction: Its Uses, Effects, Advantages, and Limitations*. South Bend, IN: Indiana University

Sakiyo, J., & Sofeme, R. J. (2008). Effectiveness of science technology society and traditional science teaching methods on students' performance in Yola metropolis, Adamawa state. *Research in Curriculum, 5*(1), 11-17.

Sarabando C., Cravino J. and Soares A. (2014). Contribution of a computer simulation to students' learning of the physics concepts of weight and mass. *Procedia Technology 13 (2014) 112 – 121*

Semela, T. (2010) Who Is Joining Physics and Why? Factors Influencing the Choice of Physics Students among Ethiopian University. *International Journal of Environmental and Science*, **5**, 319-340

Shah I. & Khan M. (2015); Impact of Multimedia-aided Teaching on Students' Academic; *US-China Education Review* Vol. 5, No. 5, 349-360

Steinberg R. (2000). Computers in teaching science: To simulate or not to simulate? *American Journal of Physics. 68, 37-41.*

Stephen W. (2002). *Theories of Human Communication;* Wadsworth Group. Belmont, USA.

UNESCO/UNICEF (2003) *Monitoring Learning Achievement (MLA II) Project*, Database 2003, UNESCO Paris.