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The Effect of Animations in Learning and Performance of Physics At Secondary School Level

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Abstract
This study focused on the effectiveness of the animations embedded in e-learning materials produced at the Kenya Institute of Curriculum Development. Animations embedded in Form Three Physics interactive content were studied. The first objective of this study was to find out the effect of e-learning materials with animations on the performance of learners in Physics. The second one was to find out if animations enhance conceptual understanding of text within the interactive Physics digital content. The other one was to determine the effect of animations on the concentration span of learners while learning Physics and the last one was to develop a process model for the effective utilization of animations in Physics education.The study was guided by the Piaget's theory of learning and was done in Nairobi City County. Four public secondary schools were purposively sampled out of sixty public secondary schools in the City County. One hundred and four students from the sampled schools were involved in the study. Quasi – experimental research design was used. The instruments used in collecting data were piloted in two schools. After piloting, the instruments were validated and made more reliable. During the study, a pre-test was administered to the learners selected to participate in the control and experimental groups and their performance was determined. Their scores were recorded and stored for use during data analysis. Treatment was given to the experimental group which consisted of two schools and in this case, each of these schools was given interactive digital content with animations embedded in it. They were given academic learning time of fourteen weeks to learn and interact with Physics content developed on two topics namely Refraction and Newton's laws of motion. The control group consisting of another set of two schools was given same content as experimental group but without animations. Both groups were given a post – test to determine their performance on the topics tested during pre- test. Data was analysed using descriptive statistics and inferential statistics including T–test. The scores were recorded and for both groups, the collected data was analysed to determine whether there was a significant difference in the performance of the learners who learn using content with animations and the ones who use content without animations. The findings from the study showed that learning outcomes for learners who used the interactive digital content with animations improved significantly. After comparing the means of the learners in the two study groups, during pre-test, the mean posted by learners in the control group was 11.35 while learners in the experimental group posted a mean of 15.40. The difference between the means of the two groups in pre - test was calculated using T-test which gave t (90.48) = -1.60, p = 0.64. During post - test, learners in the control group posted a mean of 12.88 while their counterparts in the experimental group had a mean of 25.27. The significance of the difference between the two means was calculated using T-test which gave t (102) = -3.45, p = 0.066. This shows that there was a significant difference between the means posted by the subjects in the two study groups during the post-test.

The results from the data collected from the teachers' questionnaire, learners' questionnaire and the observation schedule show that learner's conceptual understanding of Physics content was enhanced when they used animations and similarly, use of interactive digital content provided stimulus variation more hence extending their concentration span. It is therefore recommended that content developers should design, develop, produce and disseminate interactive digital content with quality animations embedded in it to help learners conceptualize abstract concepts, laws, theories and principles found in the subject matter.

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I. Introduction

The overarching goal of this study was to determine the effect of animations in e-learning materials on physics performance among secondary school learners. The tools for collecting data were piloted in two schools within Nairobi City County. The two schools used for piloting were not sampled for the main study. Later, the data gathering tools were reviewed to make them valid and more reliable. Physics teachers and learners in the sampled schools were oriented on how to use the interactive digital content at the beginning of the study. Learners were given enough time to interact with the digital content before data gathering began.The researcher later administered pre - tests and post-tests to all control and experimental schools in order to determine the effectiveness of the animations embedded in the Physics interactive content. The schools in the control group were given content without animations while the ones in the experimental group were given content with animations. The assessment items were administered to all learners, marked and the scores recorded in an excel worksheet. The researcher visited the schools and observed how the learners were interacting with the interactive digital content and an observation sheet was filled. Questionnaires were also filled by the learners and Physics teachers and the responses were keyed into the SPSS software in readiness for analysis. Means, percentages and T-test have been used in this chapter in the analysis of data. Data was collected from both teachers and learners from the four (***4***) secondary schools in Nairobi City County. The number of Physics teachers and learners who participated in this study was four (*4*) and one hundred and four (*104*) respectively.

Problem statement

Materials developed for instructional purposes must serve the purpose of enhancing the teaching and learning process through transmission of knowledge, skills and the desired attitudes to the learners. The content contained in them therefore has to be designed in such a way that it aims at attaining this overall objective. E-learning materials are supposed to assist in improving the quality of education. Multimedia elements are embedded in the content to increase its interactivity, make learning interesting and at the same time assist in helping the learners to understand difficult concepts. Dickerson (2001) argues that multimedia presentation, development, internet-based learning and access to distant resources can spark student's learning.

As earlier stated, Kenya Institute of Curriculum Development has already developed digital content in twelve subjects at secondary school level. In all the subjects developed, the effectiveness of the multimedia elements has never been ascertained by other educational stakeholders. A related study which has been carried out so far by KICD was done to monitor the use of digital content in ESP schools. The objectives of this KICD study were to assess the availability of digital content, establish utilization levels of KICD digital content, establish extent to which training received from the ICT champions enabled teachers to use digital content, find out extent to which ESP schools are using available infrastructure to access other educational learning resources, establish challenges being experienced by ESP schools in utilizing KICD digital content and find out teachers' and learners' opinions on the quality of KICD digital content (Wambua, Tumbo, Muchiri, Njue, Mucheru & Nyanjui, 2013). Among the objectives of this study, there was nothing to do with the effectiveness of the animations embedded on the content learners were using. This has been identified as an existing gap which needs attention to facilitate continuous improvement of the developed content. This study sought to inform on the effectiveness of animations in the teaching and learning process in Physics in order to develop a process model for effective development of animations in Physics Education.

Research model

Four schools were sampled for the study from Nairobi City County, Kenya. Two of the sampled schools were experimental while the other two were control. A quasi - experimental research design was used during the study. It involved a pre –test / post – test experimental-control groups. In this design, Form Three classes from four (4) secondary schools were either in the experimental group which received the treatment, or control group which did not receive treatment.

Study group

Experimental and control groups were used where sets constituting both groups were picked from different secondary schools which are geographically far from each other such that the set making the experimental group was on the Western side of Nairobi City County and the set constituting the control group was drawn from the Eastern side of the County. Two (*2*) schools coded school C and D were used to provide learners for the control group while a set of the other two (*2*) schools coded school A and B provided learners who constituted the experimental group. According to Suleiman (2011) selecting the experimental and the control groups from different schools in different locations helps in controlling experimental treatment diffusion. The researcher to some degree, controlled extraneous variables by failing to reveal the main areas of interest in the study to both groups.

A sample is a finite part of a statistical population whose properties are studied to gain information about the whole (Webster, 1985). According to Kothari (2007) sample size refers to the number of items to be selected from the universe to constitute a sample. He further argues that the size of the sample should neither be exclusively large nor too small, it should be optimum.

Two secondary schools which benefited from the Economic Stimulus Project (ESP) were selected from two randomly selected constituencies in Nairobi City County. This gave a total of four (*4*) secondary schools from the county and *104* Form Three Physics learners. The experimental schools had a total of fifty eight (58) students while the control group had forty six (46) learners. The experimental group comprised of thirty eight (38) girls and twenty (20) boys. The control group comprised of nineteen (19) girls and twenty seven (27) boys.

The total number of students in the four schools was one hundred and four (104) and this constituted sample size for the study.

Table 1: Sampling grid for the study

No. of bigger Constituencies in Nairobi City County	Population of Secondary schools in Nairobi County	No. of constituencies in the Sample for this study	No. of Physics students involved in the Sample for the study	No. of Physics teachers involved in the Sample for the study
8	60	2	104	4

II. Data collection tools

Physics teachers and learners from both control and experimental schools were oriented on how to utilise the interactive physics digital content at the beginning of the study. To determine the instructional role played by the animations in enhancing conceptual understanding of the content and the effect on student performance, the researcher gave tests (pre – test and a post – test) to the learners in the course of the study. These tests were administered to one hundred and four (*104)* Form Three learners from the sampled schools. The experimental group had fifty eight (*58*) subjects out of which, thirty eight (*38*) were girls and twenty (*20*) were boys. On the other hand, the control group had forty six (*46*) subjects among which nineteen (*19*) were girls and twenty seven (*27*) were boys. Before administering the treatment, a pre - test was given to both the control and experimental group. The role of this pre-test was to determine content mastery of the subjects within the experimental and control groups on the topical areas under study. The experimental group was given the treatment which in this case was interactive digital content with animations. The control group was given digital content without animations for learning purposes. After a period of four months of interacting with these materials, a post - test was administered to the two groups. The tests were marked to determine the performance of the learners in the topics of interest to the researcher. Learners' scores were recorded for use during data analysis.

Physics teachers in the experimental schools were given a questionnaire to fill in order to determine how relevant each animation was to the text it was attached to among other attributes such as the level of interactivity of the animations and the ability of the animations to simplify abstract concepts. All animations in the content were serialized for ease of identification. Ratings on the relevance of animations was done by use of a five – pointer Likert scale and the data collected was analysed to determine whether the animations were relevant or not. The researcher also designed an observation schedule which assisted him in gauging the learners' concentration span while using interactive digital content.

Experimental process

Physics teachers and learners in the sampled schools were oriented on how to use the interactive digital content at the beginning of the study. Learners were given enough time to interact with the digital content before data gathering began.The researcher later administered pre - tests and post-tests to all control and experimental schools in order to determine the effectiveness of the animations embedded in the Physics interactive content. The schools in the control group were given content without animations while the ones in the experimental group were given content with animations. The assessment items were administered to all learners, marked and the scores recorded in an excel worksheet. The researcher visited the schools and observed how the learners were interacting with the interactive digital content and an observation sheet was filled. Questionnaires were also filled by the learners and Physics teachers and the responses were keyed into the SPSS software in readiness for analysis. Means, percentages and T-test have been used in this chapter in the analysis of data. Data was collected from both teachers and learners from the four (***4***) secondary schools in Nairobi City County. The number of Physics teachers and learners who participated in this study was four (*4*) and one hundred and four (*104*) respectively.

Data analysis

During this study, both quantitative and qualitative data was collected. Quantitative data has been analysed under several headings as seen in the paragraphs which follow. Qualitative data was cleaned up and organised in terms of themes. Key excerpts from the respondents' responses have been used to compliment the quantitative data. Analysis of data was done following the objectives of the study. The results from the analysed data were used to test whether the null hypotheses made are valid or not and retention or rejection of the null hypothesis was be based on the findings made.

Findings

The subjects in this study were given a pre and post test in order to establish the effect of animations embedded in the Physics interactive content. The findings are presented in the following paragraphs.

Analysis of the pre and post tests for control and experimental groups

The data collected from the pre and post-tests was analysed and presented as in the tables which follow. The analysis makes a comparison between the control and the experimental groups. Table 2 shows the performance of learners in the pre - test.

Table 2: Showing performance of learners in the pre - test

	Study group	N	Mean	Std. Deviation (σ)	Std. Error Mean
Pre – test scores	Control	46	11.35	13.52	1.99
	Experimental	58	15.40	11.93	1.56

The pre - test was conducted to determine whether the control and experimental groups considered for the study were of similar ability. The total number of subjects considered in this study for the control and experimental groups were 46 and 58 subjects respectively. The mean and standard deviation of the control schools in the pre - test was 11.35 and 13.52 respectively. On the other hand, from table 2, the mean and the standard deviation of the experimental group in the pre -test was 15.40 and 11.93 respectively.

Comparison of the means posted by the control and the experimental groups in the pretest was done using T - test. The T - test was conducted to give extra assurance that the difference between the two means was significant. Table 3 gives the results obtained after conducting the T - test.

Table 3: Comparison of means of control and experimental groups in pre - tests

	Levene's Test for Equality of Variances		T-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Pre - test scores	0.23	0.64	-1.60	90.48	0.11	-4.05	2.53	-9.09	0.98

From table 3, for the pre - test, the T-statistics gave t (90.48) = -1.60, p = 0.64. The calculated value T is simply the calculated difference represented in units of standard error. The greater the magnitude of T, the greater the evidence against the null hypothesis. This means there is greater evidence that there is a significant difference. The closer T is to zero, the more likely there is no significant difference. In our case, the value of T is very close to zero. This implies that the means of the two groups are not significantly different. In other words, the performance of learners from experimental and control groups in the pre - test was similar. This means the two groups were almost of similar ability. Their entry behaviour was almost the same and this further implies that quasi-experimental design can be used to conduct the study.

The level of learner's knowledge in the Physics concepts drawn form the topics of Newton's Laws of motion and Refraction of Light was almost the same for learners belonging to the two groups. By extension, their knowledge of the laws, theories and principles related to these two topics is also the same. The effect of administration of the treatment to the experimental group can be clearly seen when the two groups start while having almost similar entry behaviour.

The findings from the pre - test show that the control and the experimental groups were of similar ability. Learners from the two groups had almost the same entry behaviour and this means the effect of introducing the treatment was to be clearly noticed from the results posted by experimental group after administering the post-test.

During the study, a post-test was administered after the pre - test. Learners were given fourteen (14) weeks to interact with the learning resources before the post - test was administered. Table 4 shows the results posted by the control and experimental groups after a post-test was administered.

Table 4: Showing performance of learners in the post - test

	Study group	N	Mean	Std. Deviation (σ)	Std. Error Mean
Post – test scores	Control	46	12.88	15.26	2.25
	Experimental	58	25.27	20.19	2.65

In the post-test, the control group posted a mean of 12.88 with a standard deviation of 15.26. After treatment was administered, the experimental group posted a mean of 25.27 with a standard deviation of 20.19.
To check whether the difference in the means posted was significant, a T-test was conducted to for the means posted by the control and experimental groups for the post-test. Table 5 gives the results obtained after conducting the T-test.

Table 5: Comparison of means of control and experimental groups in post - test

	Levene's Test for Equality of Variances		T-test for Equality of Means						
								95% Confidence Interval of the Difference	
	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Post - test scores	3.456	.066	-3.45	102	.001	-12.38	3.59	-19.50	-5.27

The post-test results show that t (102) = -3.45, p = 0.066. The difference between the means of the control and experimental groups is larger for the case of pretest. It is also worth noting that the difference between the means posted by the control and experimental groups is significant. This means that after administering the treatment to the experimental group, which in this case is content with animations, the learners' outcomes improved to a certain extent. Content with animations had some effect on the learners' performance. Learners in the control schools were given content without animations and this might have caused the significant difference in the means of the two groups.

This study aimed at establishing whether animations embedded in the Physics interactive content are effective in terms of improving the learning outcomes. The pre - test and post-test results were given to assist in establishing this. The findings displayed from the experimental group can be used to make several inferences. The number of subjects involved in the experimental group was 58 (N=58). As mentioned earlier, learners in the experimental group posted a mean of 15.40 in the pre - test and the standard deviation was 11.93. After the treatment was administered, the learners in the experimental group posted a mean of 25.27 and with a standard deviation of 20.19. This indicates that the learners improved to a great extent. This improvement can be attributed to the treatment which was given to the subjects which in this case is interactive content with animations.

According to Mayer & Moreno (2002) animation is a technology product that enables teaching subjects with visual and audio elements . It enables learners to see pictures and other graphics with motion. They further assert that using animations in education activities enables explaining abstract subjects in a more concrete way, developing representational process of individuals hence making learning fun, a more permanent activity, and offering a rich teaching resource for educators. Appropriate, suitable and on-time use of animation supports the learning process.

Dikmenli *et al.,* (2018) asserts that there is a significant difference between learners who are taught using animated films and those taught without animated films. They conducted a study whose main objective was to establish the effect of animation film use on earthquake knowledge level of 4^{th} grade learners. It was found out that the experimental group was more successful than control group in terms of academic success and animation film use in earthquake knowledge level of 4^{th} grade learners led to improved learning outcomes.

Jesse (2011) indicates that learners taught while using Computer Assisted Instructions (CIA) perform significantly better than learners taught through Conventional Instructional Techniques (CIT) in Science. This conclusion was made out of a study conducted among secondary school learners in the Science subjects. The study was quasi-experimental in nature and a control group and an experimental group were used. Learners in the experimental group were taught using technology while learners from the control group were taught without using technology.

From these two studies, use of technology in teaching and learning can lead to improved learning outcomes. From the study done by Dikmenli and his associates, use of animation film to teach learners about earthquake led to improved learning outcomes. The study done by Jesse shows that use of technology in teaching and learning leads to better academic performance. From this study, it has been seen that the means of the control and experimental groups differ. The experimental group posted a higher mean in their post-test after learning using content with animations. This therefore leads to rejection of the null hypothesis which states that there is no significant difference in performance between learners who are taught using e-learning materials with animations and those who use e-learning materials without animations. Teachers in the experimental schools supported the fact that the content was useful. This is an excerpt from one of the teachers teaching in School A:

> *"The digital content is very resourceful in demystifying and enhancing the learning of Physics as a subject. However, the content requires learners to have computer or smart phone with some basics on the use of a computer. Some good videos and animations should be repackaged for consumption using other platforms like WhatsApp. I highly recommend it." (EXP- ND-PT001).*

Another teacher from an experimental school indicated that using the Physics interactive digital content as a complementary learning material, learners are able to capture abstract concepts within the content.

Further, Dale (1969) indicates that learners retain more information by what they "do" as opposed to what is "heard", "read" or "observed". Experiential learning or action learning is what educators should be using to ensure that students learn effectively. He further argued that learners generally remember ninety percent (*90%*) of what they do as they perform a task. The interactivities in animations engage learners to the extent of doing where Dale indicated that optimum learning takes place.The aspect of interacting with the animations made learners very interested in the content. Learners from the experimental group made positive comments about the interactive Physics content. This is an excerpt from the comments made by one of the learners from the experimental group:

> *"The Physics interactive digital content has been a great stuff especially to some of us (students) who were serious with the content. It has brought a positive change and to add a suggestion if concerned staff could add even form four content it would be a good act." (EXP-ND-L-N005)*

This learner attests to the fact that content with animations was helpful in terms of demystifying abstract content within the Physics content.

According to Dikmenli (2018), use of animations increases learners knowledge on a subject where the animation is used. It also increases the permanency of the knowledge acquired. Animations help learners in creating concept maps which are very useful when storing knowledge in the sub-conscious mind.

Other educational technologists though argue that not all digital content is useful to learners during the learning process. Mohammed (2018) asserts that increase of digital information calls for availability of tools which help learners and teaching staff members organize and integrate e-resources effectively and search within them to achieve learning and education objectives. He further notes that learners who have self-organization of their studies in an E-learning environment often suffer from over-cognitive load. He further insists that there is dire need for instruments that can manage digital information in the educational contexts without tiring the learners with unnecessary and low quality content. This applies to animations by extension; they should be relevant for students to learn effectively and improve on their learning outcomes.

In regard to the quality of interactive content, learners using content designed for the control schools indicated that their content needs more interactivities. For example, one learner indicated that animations should be increased to make learning more understandable (*CTR-JEH-L-J018).* Another learner pointed out that the content makes one develop positive attitude towards physics as a subject. More illustrations should be made on refraction of light (*CTR-JEH-L-J013).* Another learner praised the content and stated that:

> *"The programme has actually helped a lot because one can read whenever he/she is interested like I. I think if the system is introduced, learning will be much easier through continuous reading will help us remember through the information being stored in a long-term mind. Practicals should be done practically and steps followed so through this during exams we will remember so easily. Otherwise I support your programme keep it up!"* (*CTR-JEH-L-J018).*

A teacher from one of the control schools also made his comment on the field of additional comments. This is an excerpt from the Physics teachers teaching in one of the control schools.

> *"More illustrations based on the day to day life situation will enhance concentration. All content (audio) to have a video / visual support. At break point, more time (commercial breaks) this will ensure learners get to track. Theory questions were many as opposed to numerical questions. We should add more numerical questions. Practical questions need to be added. The content was easy to navigate through. The learners used the content very few times. Some learners sat for the pre - test and failed to sit for post-test because of absenteeism". (CTR-JEH-PT004)*

These comments from Physics teachers and learners indicate that interactive digital content needs to be of high quality. They agree with Mohammed that interactive content should engage learners fully without tiring them with unnecessary and low quality content. Animations make interactive digital content more interactive and increase its quality.

III. Conclusion & Discussion

The following conclusions can be made from this study:

a) Quality animations have an effect in the teaching and learning process. The study used several tools to establish this and their effect in this study was seen through the improved learning outcomes. A comparison of the mean scores posted by learners from the control and experimental groups was able to bring the difference out. The significance of the difference in the two means was tested using t-test and the results showed that the difference between the two means was significant.

b) Physics interactive content with animations helps learners to understand abstract concepts better. Physics teachers and learners were able to reveal this through different items in their respective questionnaires. Their responses pertaining to the extent to which the interactive content assisted them to understand the topic on Refraction of Light and Newton's Laws of Motion were able to able to establish whether the content helped them to understand the abstract concepts or not. Further more, their performance in the tests give was a good demonstration that the content was able to help them understand abstract concepts.

c) Interactive content with quality animations is interesting to the learner and it engages them fully hence extending their concentration span. This was observed during the study. Learners from the experimental schools spent more academic learning time interacting and learning with the content. Learners from the experimental schools indicated that the interactive digital content was more interesting than Physics textbooks produced in print format and hence they preferred using this kind of content to using the textbooks.

d) Interactive digital content with animations improved verbal interactions to a great extent in the experimental schools' classrooms. There are several interactions which take place in the classroom one of it being the teacher to learner interactions. There is also the learner to learner interaction and learner to teacher interaction. These interactions were observed taking place in the experimental schools. The level of verbal interactions in the control schools was not as high as in the experimental schools.

Recommendations

The observations made during this study have led to the following recommendations:

a) KICD should ensure that the parties developing interactive digital content are properly guided to design, develop, produce and disseminate the content with quality animations embedded in it to help learners understand Physics concepts, laws, theories and principles.

b) Ministry of Education through KICD should ensure that digital content developers consider factors like correctness of content, friendliness of the user interface, adequacy of navigation aids, interoperability and portability of the platform hosting the content while designing, developing, producing and disseminating interactive digital content.

c) KICD should guide digital content developers to produce content that can be utilized by use of a variety of technological devices. This will assist the Institute in fulfilling the global demands of ensuring that the content produced can be utilised using any platform and any computing device in the market.

d) Content developers intending to develop interactive digital content should ensure that the assessment items are varied. There should be a balanced mix between theoretical questions, numerical and practical questions.

e) Content developers should ensure that their interactive digital content is developed with a variety of multimedia elements to assist learners in understanding the abstract aspects of the content.

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