Development of Multimedia Teaching Aids for Selected Physics Sub-Topics from the Topic of Simple Machine in Tanzanian Secondary Schools

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Abstract: *Students studying science subjects in most Tanzania secondary schools experience poor understanding of scientific concepts. Despite of several efforts made by stakeholders in alleviating the problem, it still persists. This might have been caused by among others, the lack of appropriate teaching aids to aid demonstration of difficult concepts in the subject. The objective of the study was to develop educational multimedia teaching aids for Hydraulic Press System and Screw and Jack sub-topic prototypes from the topic of simple machine in physics subject book two and assess their effectiveness in complementing classroom teaching in selected secondary schools. The study was both qualitative and quantitative in nature, with semi-structured questionnaires for assessment of interactive educational multimedia courseware as quantitative part, and collected data from 134 students from three selected secondary schools from Dar es Salaam and Singida regions. Prior to development and assessment of multimedia teaching aids, requirements for system design were collected from 80 Form two students and 3 physics teachers from Jangwani girls and St. Anthony secondary schools in Ilala and Temeke municipalities in Dar es Salaam region. Requirements were also collected from interview with examination officers from NECTA as well as from documentary review. The study findings revealed that the developed multimedia teaching aid prototypes assisted 88.8 per cent of the students to understand difficult concepts in physics more clearly, and about 74 per cent of them were motivated to learn the subject; thus, improving their way of learning the subject.*

Key words: Multimedia, teaching aids, physics sub-topics, difficult concepts

INTRODUCTION

Understanding of scientific concepts is very crucial for students' learning as it helps them to get appropriate knowledge on various matters around the world. In Sub-Saharan countries including Tanzania, there is poor response in improving science education (Mabula, 2012) therefore, several efforts have been made to encourage students to gain interests in science as a means to reduce scarcity of crucial and important experts to help their

countries to solve their economic, social and technological developments (Kihwele, 2014). In most Tanzanian secondary schools, many students drop science subjects or perform poorly in their final examinations particularly physics (MoEVT, 2012). One of the causes being poor understanding of difficult concepts in physics taught in classes. It has being shown in Komba's study (Komba, Hizza & Jonathan, 2013) that student's lack of interest in science subjects like physics is associated with poor understanding of difficult concepts taught in classes, where teachers depend on class demonstration rather than practical sessions. A study by Simon(Simon, 2007) shows that, secondary school teachers lack appropriate tools and teaching aids in clarifying difficult concepts. As a result, it constrains leaners from understanding concepts presented by teachers and find the subject difficult.

To address this challenge, a number of studies have been conducted on the use of multimedia technologies to aid teaching of science concepts difficult for students to understand. For instance, a study was conducted on the use of multimedia animations to help students to learn complex computer science course concepts at the University of Dar es Salaam (Mtebe & Twaakyondo, 2012). Another study was done in two high schools in Dar es Salaam to replace practical experiments in physics subject with computer animations (Msoka *et al*., 2015). Another study was conducted by Kalinga (011) to support teaching and learning of basic mathematics by developing multimedia contents for one of the topics in basic mathematics and make them easily accessible and sharable from different secondary schools in Tanzania. From both studies, it was reported that multimedia technologies have potentials in advancing scientific knowledge to students. This recommendation is supported by Neo's study (Neo & Neo, 2009), who pointed out that using multimedia courseware for teaching helps students to solve problems by means of self-exploration, collaboration, and active participation. Despite previous studies highlighting the benefits of using multimedia technologies in teaching science subjects, there is limited knowledge on the use of multimedia tools in aiding teaching of complex concepts in physics classes without lab sessions. As per Tanzania's physics curriculum, Hydraulic Press System (HPS) and Screw and Jack (S&J) sub-topics are taught using simplified models, but in the real life or from online repository they used real objects like crane and folk, something that may confuse students when they want to refer to what is documented in their text books. The paired interview conducted with examination officers from National Examination Council of Tanzania (NECTA) revealed that

mechanics, electronics, electricity and electromagnetism were the topics whose questions are most failed or skipped by majority of students in their final examinations. Therefore, Hydraulic Press System and Screw and Jack sub-topics were selected from the topic of simple machine in form two physics book as a case study. Therefore, this study aimed at developing multimedia teaching aids and assesses their effectiveness in aiding the teaching of two sub-topics selected from the topic of simple machines in Physics in Tanzania Secondary Schools Book Two. The tools were developed and piloted in three secondary schools in Dar es Salaam and Singida regions to assess their effectiveness in helping form two students to understand the physics concepts regarded as difficulty by students.

MATERIALS AND METHODS

This was both quantitative and qualitative case study research design which applies interviews, focused group discussions, observation and semi-structured questionnaires in collecting requirements suitable for development of an educational multimedia as teaching aids for difficult concepts in physics subject. Interviews, focused group discussions and observation were used to collect qualitative data that served as requirements for design and development of the teaching aids. Semi-structured questionnaire was used to collect quantitative data during assessment of the effectiveness of the developed multimedia teaching aids. The targeted groups were Physics teachers and form two students from visited secondary schools.

The study targeted respondents chosen from form two students and teachers who were teaching or have taught physics subject from Jangwani girls in Ilala Municipality and St. Anthony secondary school in Temeke Municipality, Dar es Salaam region, and Sepuka secondary school in Ikungi district, Singida region; and officials responsible for examination matters from NECTA. The study selected the schools by considering a number of factors including private and government owned, urban and rural area locations and time and budget constraints. Prior to the development of multimedia teaching aids, focused group discussions were used to collect requirements from students in St. Anthony and Jangwani girls. A total of 80 students were randomly selected to form focused group discussions, each group having about ten (10) students. The study conducted interview with three physics teachers, one from St. Anthony, and two from Jangwani girls respectively. The study further conducted paired interview with two examination officers from NECTA. The interview with NECTA revealed poor performance of physics subject in CSEE, with fewer numbers of candidates who register for physics examination compared to other

subjects. Furthermore, the interview with NECTA revealed that physics topics whose questions are skipped or failed by most candidates are electronics, electromagnetism, mechanics, or questions associated with derivation of formulae, calculations and stating theories.

On the other hand, interview with physics teachers revealed that although teachers have sufficient teaching experience of physics (7 to 19 years) and have studied physics as one of teaching subjects in their professional education, still some of them are not comfortable with teaching the subject. The interview further noted that, there are challenges in teaching and learning physics subject due to shortage of laboratories and/or equipment for conducting practicals, as well as lack of standardized and flexible teaching aids to help demonstrating difficult concepts. On the other hand, focused group discussions with students revealed that physics is one of the difficult subjects. The reasons for its difficulty were: lack of better teaching aids, inadequate laboratory and its equipment, too many calculations and derivations, and poor teaching methodologies. After requirements were gathered from students, physics teachers and NECTA officials through focused group discussion and interview; analysis were done to come up with requirement specifications for development of Hydraulic Press and Screw and Jack multimedia teaching aids.

After the requirements being specified, Hydraulic Press and Screw and Jack prototypes were developed using multimedia technologies. The development of the HPS and S&J adhered to educational multimedia applications' characteristics such as being well understood, easy to follow, highly interactive, pedagogical considarate, and fit the curricula of intended users (Noordin *et al*., 2011). Interactivity is mulimedia feature that allows students to be assigned active roles, and jump between the selected topics (Andresen & Brink, 2013). Furthermore, it allows learning process to be modified by actions of learners and thus changing the role of both a learner and a teacher (Slawson, 1993). In the selected sub-topics, learners are demonstrated on how a small amount of force in the small piston is used to lift heavy weight at large piston and how a screw and jack is used to lift a weight through a 'pitched' jack respectively. In addition, the derivations of formulae to relate mechanical advantage (M.A) of the HPS with the ration radii of its pistons are done basing on definitions and substitutions of parameters involved in the definitions. It is crucial for students to have demonstration on how M.A is related to the associated parameters, and also to observe how a load in one piston is lifted by

applying effort in the other. Screw and jack demonstrate how velocity ratio (V.R) can be obtained from a number of experiments, by changing the radius to the effort handle in each experiment (Figure 1). Then, the demonstration on how the same velocity ratio of S&J can obtained from the definition is related to the ones obtained from a number of experiments.

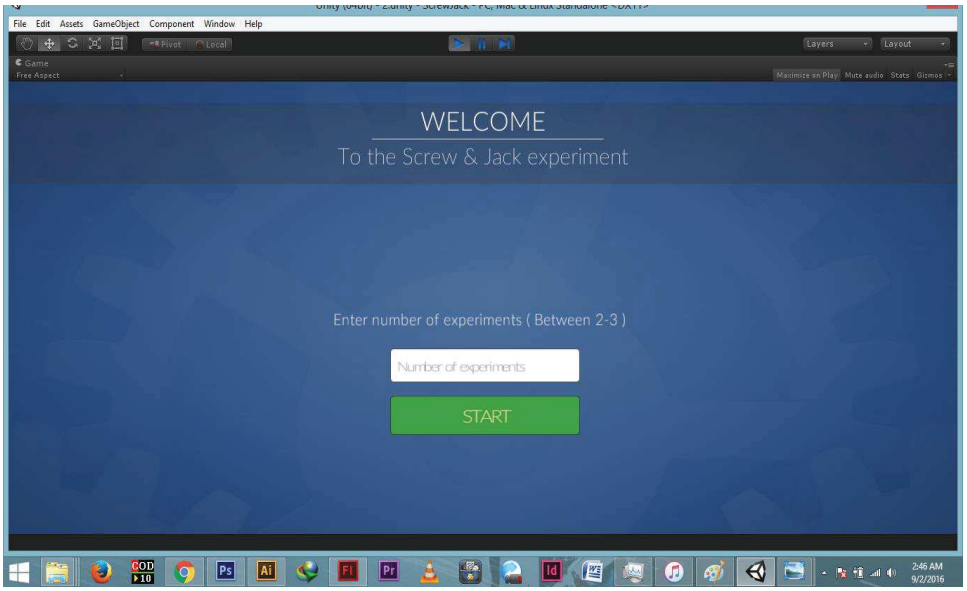

Figure 1: A Screen prompting user to enter number of experiments for S & J prototype

After the analysis of requirements collected from form two students, physics teachers and examination officers from NECTA, development of the prototypes for the selected sub-topics were guided by the algorithm presented in Figure 2.

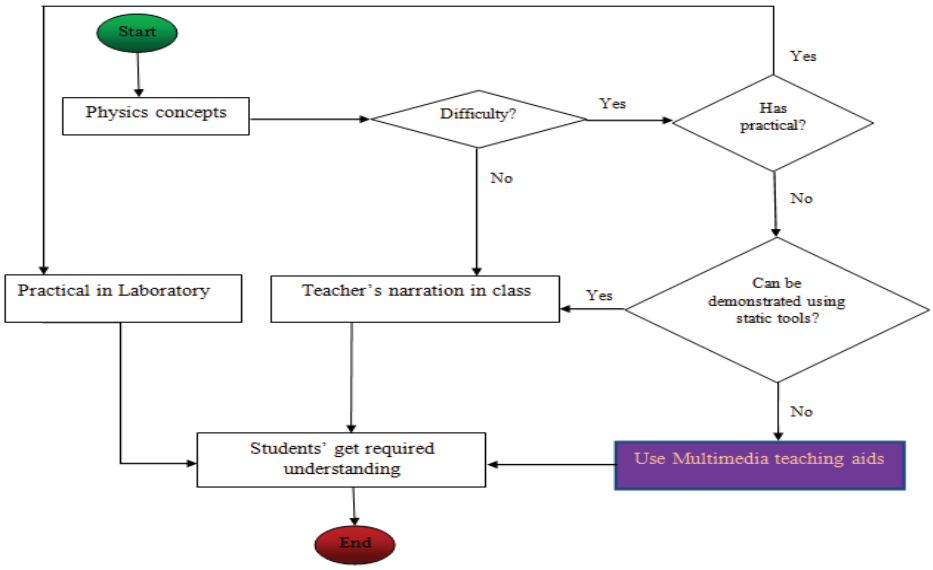

Figure 2: Algorithm for multimedia teaching aids development and inegrating in learning system

In these sub-topics, learners are demonstrated on how a small amount of force in the small piston is used to lift heavy weight at large piston and howscrew and jack is used to lift a weight through a 'pitched' jack respectively.

Finally, the study collected data through semi-structured questionnaires from 38 students of St. Anthony, 42 from Jangwani and 54 from Sepuka secondary schools for assessment of the developed multimedia teaching aids upon subjected to use in class.

RESULTS

After the teaching aids for HPS and S&J were developed and used to complement traditional classroom teaching in the selected secondary schools, form two students from those selected schools filled questionnaires distributed to them so that the researchers can get their opinion about the effectiveness of the prototypes in aiding teaching of difficult concepts. The students responded on a number of questions from the questionnaires as follows:

(i) Students' Level of Understanding After Using Multimedia Teaching Aids

The study was interested to find out whether the demonstrations from the developed multimedia teaching aids were well understood by the students. Therefore, the students were asked to rate whether they *strongly agree*, *agree*, *uncertain*, *disagree* or *strongly disagree* that the prototypes helped them understand the difficult physics concepts taught to them. As indicated in Figure 3, the majority of students (88.8 percent) agreed that the multimedia teaching aids prototypes were helpful in understanding of difficult physics concepts through demonstration. This implies that the use of multimedia teaching aids can change learning styles among students and influence understanding of taught concepts from the topics which seemed to be difficult and less interesting to them.

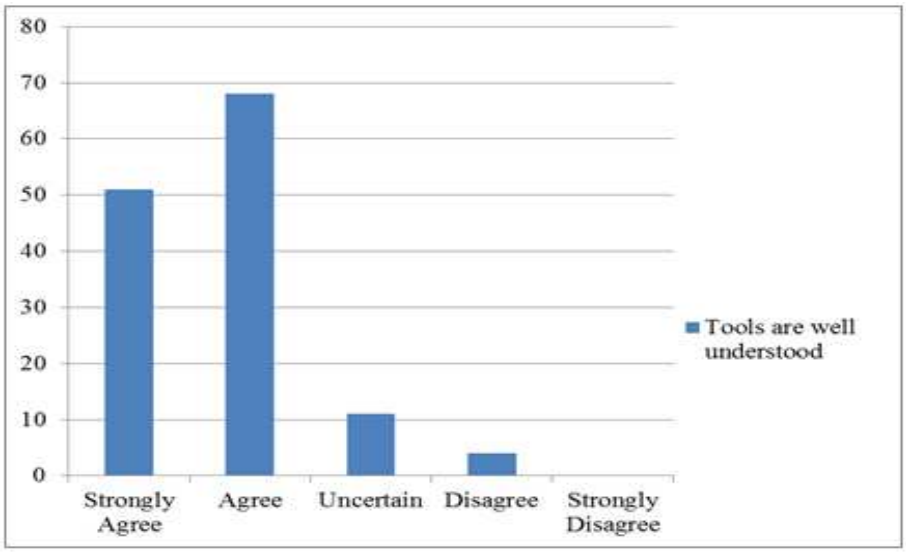

Figure 3: Students' understanding of scientific concepts

(ii) Change of Students' Motivation and Investigation Level

The study further found that about 74 percent said the demonstration of difficult concepts in physics sub-topics through multimedia teaching aids have motivated them towards loving studying the subject, whereas about 47 percent of students reported the tools to accelerate them towards exploring the subject contents, as presented in Figure 4. This means that the use of appropriate teaching aids increases students' investigations and motivations towards the subject, and hopeful acquire necessary skills for better understanding and attempt their examinations.

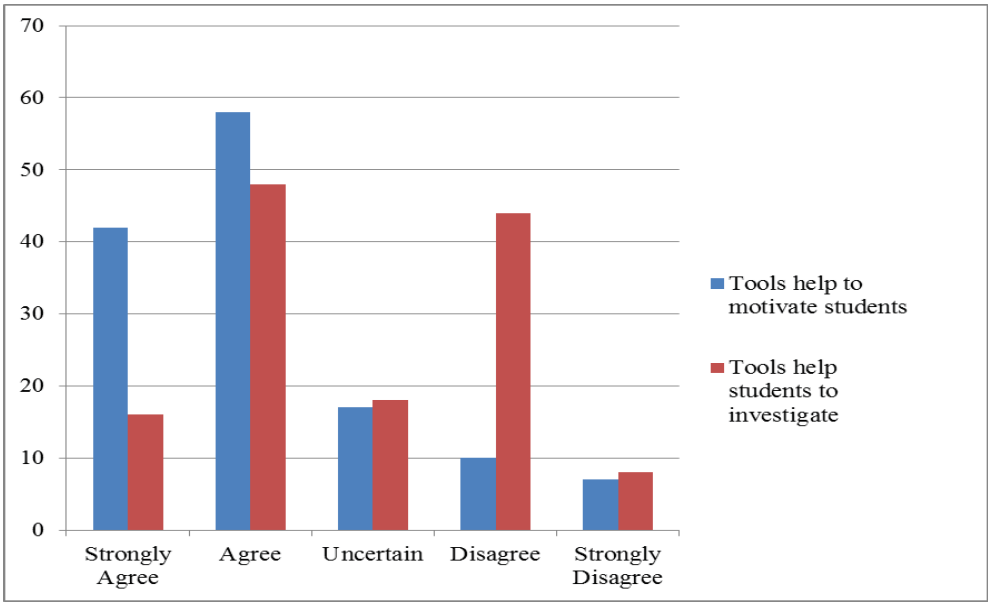

Figure 4: Students' motivations and investigations

(iii) Simplicity and Disturbance of Multimedia Demonstration in Classroom

Introducing technology in the class during teaching can simplify teaching or disturb the 'flow' of the teacher during traditional classroom teaching. Therefore, respondents were asked whether using multimedia teaching aids to complement classroom teaching made it easy to follow up or disturbed their learning.

As indicated in Figure 5, although the majority of students (75.4 percent) said bringing multimedia demonstrations in the traditional classroom teaching might disturb their learning flow, 76 percent agreed that it is easy to follow and linking up the demonstration by multimedia tools and narration from the teacher. This suggests that the use of multimedia in classroom have some overheads despites of its many advantages.

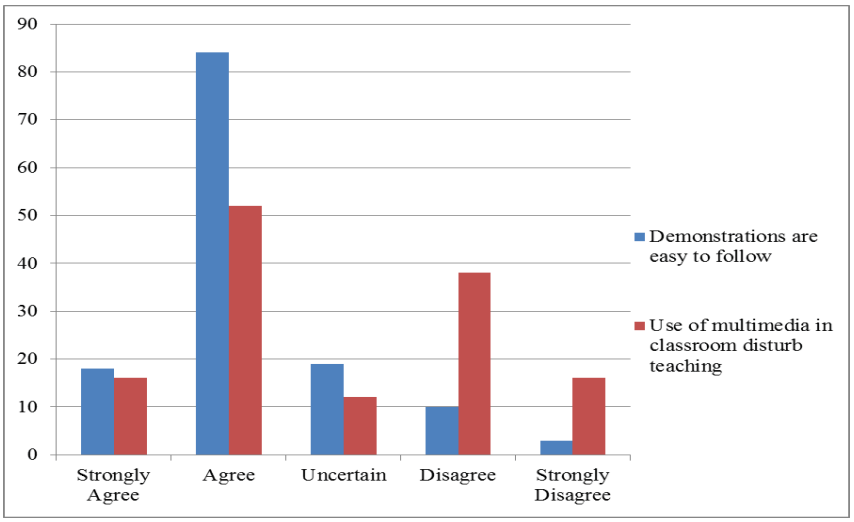

Figure 5: Disturbance and Simplicity of multimedia in classroom

(iv) Attention Towards Physics Subject

The study findings (Figure 6) further revealed that many respondents (77.3 percent) gained attention towards physics subject as a result of the use of multimedia teaching aids to complement classroom teaching. However, about 23 percent, still claimed to be uncertain or have low attention towards the subject despite the use of multimedia tools to demonstrate physics concepts.

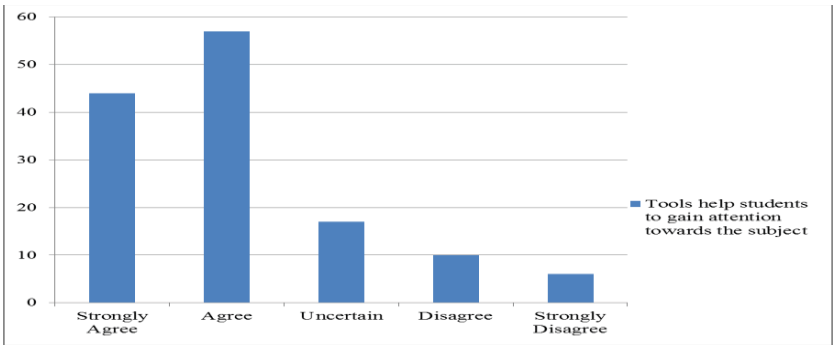

Figure 6: Students' Attention towards Physics

Furthermore, the following are some of the answers from respondents responding to some open-ended questions.

(i) Whether the use of multimedia teaching aids complements what is missing in the traditional classroom teaching:

"*Yes, they help teachers to demonstrate well to us (students) the concepts which were very difficult to explain using the "old" tools*".

(ii) Whether the teaching aids are effective to replace real practical experiments:

"*It is not good idea to replace real practical experiment with simulation because in real practical, students are the ones who control the experiment hence learning is meaningful but in simulation there are some factors being controlled by the developer*".

DISCUSSION

The study has developed an appropriate multimedia teaching aid prototypes, and has assessed their effectiveness in aiding the teaching and learning of physics subject. The requirements for development of the teaching aids incorporated pictures, audio clips and animations in teaching topics that do not have laboratory practical sessions but need to be well demonstrated. The aim was to reduce poor learning and teaching experiences of some topics in physics subject as reported in focus group discussions, interviews, observation and document review. Going through *Physics for Secondary Schools in Tanzania Book Two*, it was observed that presentation of materials for the topics such as simple mechanics (Hydraulic Press Machine and Screw and Jack sub-topics) is mostly based on definitions to derive formulae (M.A and V.R respectively), instead of giving teachers and students an alternative on how the same formulae can be obtained through conducting a number of experiments as suggested by this study. Also, interview with NECTA examination officers, students and physics teachers pointed out topics which are supposed to be taught with the aid of dynamic tools for students to realize the intended knowledge and skills.

The study findings indicated that about 88.8 percent of students agreed that the demonstrated prototypes of multimedia teaching aids helped them understand physics concepts on the selected sub-topics clearly. About 74 percent said that the prototypes have fully motivated them towards loving the subject, with about 12.5 percent being uncertain and another 12.5 percent disagreed that the use of multimedia demonstrations motivated them to love learning physics subject. Having about 74 percent who reported being motivated to love physics from demonstrations of the two selected sub-topics, suggests more students to well understand well

physics concepts which seemed difficult for them to master the subject and finally perform well in their examinations. The findings of this study show that many students have been attracted towards understanding difficult physics concepts that were taught without having appropriate multimedia teaching aids.

The study findings presented in results section are similar to what (Huk, Steinke & Floto, 2003) found in their study about the effect of signalling animations to biology students at the University of Braunschweig, Germany. Their study involved 38 students, whereby their knowledge about the topic was accessed prior to viewing projection of multimedia demonstration about the structure of enzyme ATP-Synthase. After the projection, assessment of their skills was done through post-test assessment by responding to the questionnaire distributed to them. The results showed that there was a significant performance after students had viewed the animation through projection. Although the assessment of the tools differs in these two studies, the outcome of the use of multimedia tools in learning is similar.

The results are found to be consistent with Msoka *et al*. (2015) study about piloting interactive physics experiment for secondary schools in Tanzania; Mtebe and Twaakyondo (2012), and Kalinga (2011) study findings. For example, in Msoka *et al*. (2015)'s study that involved 157 students from Canossa and Loyola High Schools, found that interactive physics experiment was simple to use and can help students gain more skills in addition to those gained during classroom learning and during conducting real practical experiments.

Likewise, Mtebe and Twaakyondo (2012) study on using animations and simulations to help teaching difficult concepts in computer science courses at the University of Dar es Salaam showed that animations and simulations helped more students (67 percent) to grasp difficult concepts more clearly. On the other hand, Kalinga (2011)'s study showed positive impact on both students and teachers after they have interacted with contents of Relation topic of Basic Mathematics, Book Three through e-Learning management system.

The findings of this study and from others on impact of multimedia in education can be useful in preparation of educational policies and curricula that will take advantage of positive impacts of multimedia in education.

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