ERRORS COMMITTED BY MALE AND FEMALE STUDENTS IN PHYSICS EXAMINATION IN SECONDARY SCHOOLS OF NANDI SOUTH SUB-COUNTY, KENYA

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ABSTRACT

The study was conducted in 10 secondary schools which were categorized as; extra county, county, and sub county. The study utilized comparative and correlational research designs. The target populations for the study were 497 Form IV students taking July/August Nandi South District Joint Mock Examinations in 2014 out of which a sample of 226 students participated in the research. The instruments used were questionnaires. Results revealed significant differences between male and female students in operational errors and algorithm errors. Female students were found to commit operational error more than male students, and male students committedmore algorithm errors than female students. However, thereis no significant difference ($p>0.05$) between male and female student committing computational error ($p=0.134$) and communication errors ($p=0.183$).

Keywords: Algorithmic error, Communication error, operational error, Computational error, Error.

INTRODUCTION

The importance of Physics subject in human endeavor cannot be glossed over, for it plays a vital role and essential part of all human endeavors, especially in science and technology (Owolabi, 2013). Physics as a branch of Science has many applications for example in medicine; where throughout this century advances in Physics and medicine have gone hand in hand. The most fundamental discoveries in Physics have rapidly been exploited by medical community to devise new techniques for diagnosing and treating a variety of illness (Wambugu &Changeiywo, 2007). Knowledge of Physics and other sciences play a critical role in Science and Technology. Physics education in Kenya is a critical subject in the achievement of economic growth and development as enshrined in the Kenya Vision 2030 (RoK, 2007). The subject provides a transitional base to advancement of science and technology for industrial, economic and social development as well as empowerment of the youth who are faced with high levels of unemployment in the country which are the pillars of Kenya Vision 2030. It is for this reason that Kenya finds it important to promote science-based subjects particularly Physics.

The application of physics knowledge and other sciences increases economic productivity and improve industrial development in many nations of the world. Semela (2010) observed that productivity in the field of Science and Technology depends on the adoption of scientific knowledge, skills and attitudes as a way of life. The emerging economies for example China, Russia, South Korea, Brazil, and Singapore among others have thrived because of advancement in Science and Technology. In Kenya today, trends in economic development have seen non-traditional industries such as information, communication and technology overtaking traditional economic sectors like Agriculture in terms of contribution to national income as well creation of employment opportunities. This technological transformation and socio-economic development has been attributed to careers in Physics and other science disciplines

(Munishi *et al.*, 2006). Information, communication and technological innovations require the knowledge of principles of Physics such as energy, electricity, electronics, magnetism, and mechanics among others which are acquired in Secondary School education. Physics enable the students to apply these principles and acquired knowledge and skills to construct appropriate scientific devices while at the same time preparing students for scientific and technological vocations. Omosewo and Akanbi (2013) asserted that study of Physics subject has been recognized as a path to national development through technological development. There can however be no meaningful technological development without a very solid foundation in the sciences, especially physics. This subject is very important to prospective scientists, engineers and science educators (Amadalo, Ocholla & Memba, 2012). Due to the importance of physics, Kenya's Ministry of Education has emphasized its teaching and learning in schools (Kenya Institute of Education [KIE], 2002). Despite the importance of this subject to the development of a nation both male and female students performed poorly in physics. Studies conducted across the world shows that despite the significance position of Physics in the technology and development arena, it still remains one of the subjects that students persistently perform very poor in. For example the achievement of students in Physics in other African countries in Nigeria has remained consistently poor over the years (Omosewo & Akanbi, 2013).

The Kenya National Examination Council (KNEC) report for the last 4 years in Nandi south District shows that the average grade is C- for physics. Further analysis of the results also indicates that the performance of girls is lower than that of boys in Nandi South Sub County. This shows that gender disparity exist in the performance of the subject. This therefore, means that few girls are motivated to pursue physics course and those who pursue it achieve low grades and may not get to careers that require knowledge of physics. The reasons for this poor achievement varies; it may be due to teacher's method of teaching (Wambugu, et al., 2013); it could be due to subject area specialization or wrong subject combination (Aina, 2011). According to the Kenya National Examinations Council (KNEC), physics is clustered with biology and chemistry (Njoroge *et al.*, 2014). However, students must select and pursue at least two science subjects at Form Three and Four. Majority of the students opt for a combination of chemistry and biology due to subject clustering system which does not favour physics. Also, most of the students consider the concepts involved in the study of physics to be too abstract and difficult to understand (Amadalo et al., 2012).

To improve the performance of the subject at secondary school level, the Government of Kenya has had a number of intervention strategies that have been developed to ensure effectiveness in the teaching/learning Physics (SMASSE, 2001; SMASSE, 2004; Otiende, Barchok, & Abura, 2013). These strategies include: providing schools with qualified mathematics and science teachers and improving their remuneration and terms of service; providing schools with science equipment and facilities, and providing institutionalized In-service Education and Training (INSET) to teachers of science and mathematics under Strengthening of Mathematics and Science in Secondary Education (SMASSE) program (SMASSE, 2004). SMASSE is a Technical Cooperation initiative between the Governments of Kenya and Japan established in 1998 for purposes of strengthening quality of teaching force in mathematics and science and to up-grade teachers' skills and competence in order to improve the quality of secondary education (SMASSE, 1998). The SMASSE initiative was a response to students continued poor performance in the mathematics and sciences despite the efforts that had been made. However, low performance in physics and other science subjects still exist today in our secondary schools, even after successful implementation of SMASSE INSET program throughout the country. This implies that there are other underlying factors that need to be specifically

addressed, alongside the above initiatives. Thus, this study was undertaken to identify whether errors made by Physics students during examinations is one of the underlying factors that contribute to poor performance in the subject in Nandi South Sub-County.

LITERATURE REVIEW

The literature review is based on recent and relevant books, journals, periodicals, unpublished theses, dissertations, abstracts from ProQuest database, ERIC Document Reproduction Service, Academic Source database, and other sources from the Internet and online database information plus standard literature on the topic of the study.

Errors

An Error as defined by the chambers dictionary is a blunder or mistake. Some scholars defined error in relation to performance and knowledge (Allchin, 2001). An error is an observable event or performance which in a way judged to be significant, differs from an expected ideal, (correct) model of performance (Sanders & Crammer, 1992 in Ezenduka, Okafor, & Akusoba, 2014). The terms 'mistake' and 'error' are often used interchangeably. However, there is a clear difference between the two. According to Brown, (2004), a mistake is a failure to utilize a known system correctly and can be self-corrected, while an error refers to misrepresentation of fact in the procedure of a given problem in physics which cannot be self-corrected unless it is identified, made known to the student and the student given the opportunity to correct. The identification of error is an important and obvious stage in remediation of students' misconceptions and error. Error analysis is an invaluable source of information to teachers. It provides information on students' errors which in turn helps teachers to correct students' errors and also improves the effectiveness of their teaching.

Types of Error

Omosewo and Akanbi (2013) study revealed that the major types of errors made by senior secondary school students in physics test are wrong operation, computational errors, defective algorithms and random errors. Ekwueme and Ali (2012) analysis showed that students committed more of structural error which is the most serious error that has to do with the conceptual knowledge of the basic concepts in mathematics. Usman and Harbor-Peters (1998) also categorized the errors committed by students into conceptual, translational, logical and applied errors. Allchin (2001) classify error types broadly as material; observational; conceptual and discourse. Material errors involve physical aspects of getting the phenomenon right, where investigators have a role in creating the phenomenon. Observational errors concern methods of perception and data collection. These include the problem of framing observation on the appropriate phenomenon.

Conceptual errors involve the large body of principles and theoretical interpretations, operations, computation and manipulations, widely used in science fields. Discourse errors encompass aspects of communicating, assessing and regulating conceptual maps among a community of learners and researchers, as well as other users of scientific knowledge (Allchin, 2001). The errors identified by the various researchers can be classified into two based on the type of exam being done. Errors associated with the instruments used in exams and observation of results commonly occur in paper three and this errors to a larger extend have been addressed through SMMASE program (SMASSE, 2004) but limited research have been done on the errors commonly committed in the theory examinations. This study investigated the extent to

which the following types of errors were committed by students in Nandi South Sub County in Physics Mock examinations.

Algorithmic Error

Algorithmic approach in Physics and Mathematics is simply described as mechanized habits of response to problem (Meija & Bisenieks, 2004). Also, Suits (2001) referred to it as a problem solving process which requires substitution of numbers in a prescribed scheme (formula or equation). Since algorithmic approach demands the use of a memorize formula and manipulation of that formula based on the problem goal(s), it is susceptible to mathematical formula (algorithmic) setup errors. This error occurs when a formula or equation is used as the algorithm to solve a problem requiring the correct rearrangement for the calculation of the unknown. According to Reid and Yang (2002), these are errors made by Physics students by not following specific step by step procedure during numerical analysis. The procedure taken by the student usually does not consistently accomplish the intended purpose. This type of error may limit the accuracy of a numerical calculation and they include; approximation errors, incorrectly rounding off significant values, error in the input data, and ignoring decimals.

Research studies have found that many students perform algorithmic or mathematical manipulation by rote memorization of formulae without having a basic understanding of specific concepts (Nakhleh, 1993 in Ogunyele, 2009). The reasons why students find problem-solving difficult have been identified by many researchers as students' failure to construct meanings from the problem statement, not being able to link the meaning of the problem to their knowledge structures, or simply lacking the appropriate knowledge structure for that specific content area (Nakleh, 1993 in Ogunyele, 2009).

Communication Error

These are errors that arise due to incorrect use of language by Physics students when presenting answers to physics examination (Temitope, & Nte, 2014). They encompass aspects of communication failures, poor assessment and regulation of conceptual maps among the learners. These errors include; misinterpreting the key words in questions, providing multiple answers, irrelevant responses among other language difficulties (Ezenduka, Okafor, & Akusoba, 2014). Driver and Easely, (as cited in Okoli, 2003) opined that not until the reasons for students misconceptions are understood will progress be made in instructional terms. The findings of the study of Ezenduka et al., (2014) showed that conceptual errors exist between students and their teachers. Student's errors were caused partly by the teachers' during the course of instructions and assessment. And also by students misconception which may have arisen most probably due to lack of understanding of both the technical terms and conceptual understanding. Other factors such as use of language, poor illustration and poor diagrams in textbooks can also lead to students' error.

Computational Error

These errors manifest through falsification of facts and concept by students when answering numerical questions (Suit, 2001). They occur when the student misrepresent facts in the procedure for example insufficient working for calculations arising from incorrect formula, substitution and units of measurement. Computational error can be corrected if procedural knowledge is utilized as there are specific algorithms to solve a given task as stated by Omosewo (2009). Teachers should select corrective means and methods in order to deepen

their students' understanding of mathematical concepts that are couched in physics, improve their reasoning methods and to perfect their problem solving skills.

Operational Error

These are errors which arise when a procedure taken by a student to answer a question is different from the expected for example inappropriate procedure and materials used to achieve a desired result (Meija & Bisenieks, 2004). These errors include; incorrect mathematical operation model applied in a procedure, incorrect symbolic representations and inaccurate diagrammatic representations e.g. line of best fit. Chamundeswari (2014) research findings of the analyses revealed that there was a significant difference between the levels in committing errors in mathematical operations in Algebra among students at the secondary level in different categories of schools. These errors may be due to lack of fundamental knowledge in mathematical operations. Thus the concepts in fundamental operations should be exercised in the minds of students at an early age. It was also found that the Tamil medium students are higher in level in committing errors in mathematical operations in Algebra than English medium students and the girls are higher in level in committing errors in mathematical operations in Algebra than boys at the secondary level in different categories of schools.

Salman research in Nigeria observed that students at the two cognitive levels committed both the syntactic and semantic errors, even though the early formal operational students performed better that their concrete operational counterparts in the mathematics word problem tasks. A large number of the concrete operational students committed the syntactic error due to inability to give adequate interpretation to the construct of the word expression. The semantic error was committed due to inability to interpret the language of the problems, as well as identify the correct mathematical operations that was required for a particular transformation of a mathematical statement into its equivalent algebraic equation.

RESEARCH METHODOLOGY

The study used descriptive, comparative and correlational research designs. Descriptive research design helped in identifying common errors that Physics students commit in secondary school. Comparative research design was used to check the difference between students' gender and errors; computational, operational, algorithmic and communication errors committed by students in Physics.

Problem Statement

The performance of students in Physics in Nandi South Sub County secondary schools has been low between 2010 and 2013 despite the intervention by the Government and education development partners through SMASSE and INSET Programmes over the last ten years. This continued low performance in physics is a hindrance to the achievement of Vision 2030. Based on the persistent dismal performance and low enrolment in the subject, it is apparent that physics has been perceived as the most difficult science subject. It is also noted that studies in Kenya have focused on students' performance in physics in relation to their attitude, learning resource and facilities. Others have analyzed classroom instructional environment, interactions and teacher quality to evaluate student learning. Studies have also been conducted in Kenya to check whether teaching methods (Changeiywo, 2000; Wambugu & Changeiywo, 2007; Amadalo et al., 2012; Njoroge et al., 2014) influenced academic achievement of students in Physics subject. However, limited research has been done on the types of error made by Physics

students in KCSE examinations. For this reason, it is important to explore the underlying attitudes of students towards physics subject in the context of Kenya school environment. This is because, when teachers and learners identify attitudes toward the subject, it helps them to correct and apply best strategies and methods of teaching and learning Physics. This study sought to identify and classify the type of errors committed by male and female secondary school Physics students in Nandi South Sub-County during examinations and proposes possible intervention strategies in order to improve the performance of the subject.

Research Question

Is there a significant difference between errors committed by male and female students in Physics examinations in terms of?

a. Algorithmic Error?
b. Computational Error?
c. Communication Error?
d. Operational Error?

Findings

The research question sought to answer whether there is a significant difference between errors committed by male and female students in physics examinations in secondary schools. To arrive at the study results, independent samples t-tests were computed and the first null hypothesis was tested. The null hypothesis for the study stated that:

$H0_1$; There is no significant difference between errors committed by male and female students in Physics examinations.

Group statistics findings show that female students tended to commit operational error significantly more (M=4.63 and SD=1.34) as opposed to male (M=3.68 and SD=1.82). This is because female students have lower confidence when tackling questions on arithmetic. The calculated value for operational error and gender is (p=0.001) and the p-value is (α=0.05) shows that the calculated value is lower ($p<0.05$) than the p-value leading to conclusion that there exist significant difference between gender of students and commitance of operational error. This is in contrast to Salman et al. (2004) who found out that the students committed semantic error which was as a result of inadequate understanding of the questions asked in examinations. However, Owolabi et al. (2013) recorded that both male and female students also recorded very high percentage of errors associated with wrong operation with female students recorded higher errors in wrong operations than their male counterparts. In regard to computational error, female students also committed more (M=4.41 and SD=2.22) as in contrast to male students (M=3.85 and SD=2.66). This shows that female students face computational problems when doing physics examinations in secondary schools as opposed to boys although the difference margin between the two pairs was not significant. The calculated p-values for computational error is (p=0.13) and the critical p- value is (α=0.05) whereby the calculated p-value is higher than the critical p-value ($p>0.05$) leading to acceptance of the null hypothesis that there is no significant difference between gender and students commitance of computational error. The findings concur with Ekwueme and Ali (2012) who found out that male students are more stable in solving mathematics problems than girls since computational error had to do with carelessness, boredom and distraction. On the algorithm error, results shows that male students tended to commit significantly more errors (M=2.5 and SD=1.29) as opposed to female

students (M=2.14 and SD=1.05). This shows that females commit significantly lesser errors in physics algorithm equations than males. The computed p-values for algorithm error is (p=0.046) and critical p-value is (α=0.05) which shows that the calculated p-value is lower than the critical p-value (p<0.05) leading to the deduction that there exist significant difference between students gender and commitance of algorithm error. This agrees with Ekwueme and Ali's (2012) research results that showed that girls were committing more of the identified process errors (defective algorithm) than their male counterparts. Results for descriptive and inferential analysis are presented in Table 1.

Table 1.Gender and Committance of Errors

	Gender	N	Mean	Std. Deviation
Operational error	Male	175	3.68	1.816
	Female	51	4.63	1.341
Computational error	Male	175	3.85	2.668
	Female	51	4.41	2.220
Algorithm error	Male	175	2.50	1.299
	Female	51	2.14	1.059
Communication error	Male	175	3.09	1.882
	Female	51	2.69	1.985

Hypothesis test summary

Independent Samples Test		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff
Operational error	Equal variances not assumed	5.24	.023	-4.07	108.818	.001	-.947	.233
Computational error	Equal variances not assumed	4.16	.042	-1.51	96.056	.134	-.560	.371
Algorithm error	Equal variances not assumed	4.14	.043	2.02	98.100	.046	.360	.178
Communication error	Equal variances assumed	0.27	.603	1.34	224	.183	.405	.303

Further, it was established that male students were more likely to commit communication errors (M=3.09 and SD=1.88) in contrast to girls who committed less (M=2.69 and SD=1.98). However, the difference in the mean number of errors is not significant. Because the computed statistics for communication error is (t=1.34) and critical value is (p=0.183) which reveals that the computed p-value is higher than the critical p-value (α=0.05) which implies that there exist no significant difference between gender and students commitance of communication error in

Nandi South secondary schools. Salman et al. (2004) found out that semantic error was committed due to inability to interpret the language of the problems, as well as identify the correct mathematical operations that was required for a particular transformation of a mathematical statement into its equivalent algebraic equation. Hypothesis testing summary results on errors committed by students with regard to gender at 5% significance level is that there was significant differences ($p<0.05$) between gender of students and commitance of operational and algorithm by male and female students in Nandi South Sub County secondary schools. On the other hand, hypothesis test summary statistics reveal that there was no significant difference ($p>0.05$) between male and female students in commitance of computational and communication errors in schools. The results therefore gives a mixed reaction results whereby operational and algorithm error is gender specific but computational and communication error is not gender specific.

Owolabi (2013) found out that there was no significant interaction effect of sex and type of treatment on errors committed in physics practical. Owolabi found significant main effects for the groups was significantly different but not for the sexes which was not significantly different. There was no significant interaction effect of sex and type of treatment on errors committed in physics practical. This meant that gender of a student was not a major issue as far as commitance of errors in physics examinations was concerned. The level of errors committed by male students in physics experiment was found proportional to their female counterpart. In contrast to the study results, Ogunsola *et al.*, (1996) found out that errors were found to be gender-related with girls committing fewer errors than boys. Nevertheless, Owolabi *et al.*, (2013) found out that errors committed by male students (χ^2 male= 5.04) is significantly higher than their female counterparts (χ^2 female=4.69) in physics test. This meant that there is a significant difference in the error committed between male and female students in physics. Similarly, Ekwueme and Ali (2012) found out that students' overall performance was greatly affected since structural error which was the most frequent error committed has to do with the student' lack of understanding of the basic concepts. In summary to the hypothesis, it is clear that there exist only significant difference between gender and students commitance of operational and algorithm error as opposed to computational and communication error.

CONCLUSION

Hypothesis testing summary results on errors committed by students with regard to gender at 5% significance level is that there was significant differences ($p<0.05$) between gender of students and commitance of operational and algorithm by male and female students in Nandi South Sub County secondary schools. Female students committed more operational error (M=4.63) as compared to male students (M=3.68) while male students committed more algorithm errors (M=2.50) as opposed to female (M=2.14). In other instance, the study found out that there existed no significant difference ($p>0.05$) male and student committing computational error (0.134) and communication errors ($p=0.183$). This showed that error commitance cannot be assumed to be gender specific in all instances as there are some cases whereby boys tend to make more algorithm errors compared to their female counterparts.
The study recommends that the teachers need to adjust their teaching strategies through giving practical examples, improvising materials and introducing interactive discussions during Physics lessons to induct students on areas through which errors occurs and monitor and evaluate students regularly to identify their strength and weaknesses.

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