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Effects of Teachers' Knowledge in Instructional Technology on Students' Performance in Mathematics in Secondary Schools in Kakamega County, Kenya

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Abstract: ***Instructional technology well employed in mathematics classroom improves learners' performance in mathematics. This study examined the effects of teachers' level of knowledge in instructional technology in Mathematics on students' performance in the subject. The study employed mixed methods approach as guided by the TPACK theory. Eight hundred and one (801) teachers of Mathematics in public secondary schools formed the target population. After multistage sampling procedures, 80 teachers were sampled to participate in the study. The teacher technology knowledge questionnaire and learners' achievement document analysis guide were the research instruments. Data collected were analyzed using frequency counts, means, percentages, standard deviations and Pearson's correlation. A strong positive relationship between teachers' level of knowledge in instructional technology and student performance in Mathematics was revealed i. e. teachers' instructional technology knowledge affects students' performance. These findings will provide useful information that may be used to improve policies on Mathematics education.***

Keywords: Knowledge, Technology, Mathematics, Students' Performance

1. Introduction

Instructional Technology Knowledge (TK) is the knowledge that is oriented to various technologies and their use (Harris et al., 2009). For the teacher to teach the content, technology is appropriately employed in order for the teacher to support the conversation between him and the student (Hammond & Manfra, 2009). Research studies provide evidence that integration of technology in mathematics saves time during learning and improves depth of understanding. Hurk et al., (2019) conducted a study to investigate the effectiveness of using multimedia on student learning outcome and results indicated that students under multimedia aided instructions had better outcomes than those in traditional teaching methods.

Mathematics is a core subject which forms an essential prerequisite for joining colleges, for communicating research findings, for industrialization, as well as for self-employment (Ishenyi, 2015). In Kenya, the concern of making students better problem solvers by the Ministry of Education (MOE) through Strengthening Mathematics and Science Education (SMASE) workshops as well as competency based curriculum workshops are on high gear. The teachers in these workshops are encouraged to embrace 'hands on' approach to teaching Mathematics. This approach encourages classroom discourse whereby learners actively get involved in the learning process through technology enhanced learning among other techniques. However, the Kenyan national examinations help teachers to define the important content and therefore have a role to play to influence teacher's classroom teaching (Wanjala et al., 2016). The Kenya National Examinations Council (KNEC) examines secondary school learners' content recall, comprehension, application as well as general reasoning. Some students perform well while majority fail. According to 2021 Kenya Certificate of Secondary Education **(**KCSE) KNEC report, performance in Mathematics for the last 5 years were as summarized in Table 1.

Table 1: Candidates National Performance in KCSE Mathematics Alternative A from 2016 to 2020

Year	Candidature	Mean Scores (%)	Std Deviation
2016	570, 398	20.79	21.165
2017	609, 525	25.48	22.215
2018	658, 904	26.445	21.005
2019	694, 445	27.54	22.47
2020	742, 796	18.36	17.19

Source: KNEC, 2021

Table 1 shows percentage mean scores ranging between 18% and 26% depicting poor performance in mathematics with the worst performance being the most recent in the year 2020. Kakamega County, where the study was carried out is one of the most affected in this regard, with KCSE county 5 year mean score of 3.18 (D). This poses a very worrying scenario. If this poor performance in Mathematics persists, Kakamega County and the Country at large may face a shortage of professionals such as engineers, doctors, accountants, architects, scientists and better teachers of Mathematics among many others. This threatens the realization of Kenya's vision 2030 whose main aims are to transform Kenya into an industrializing and middle-income country by providing high quality of life to all its citizens by 2030.

Lyublinskaya and Tournaki (2012) assert that insufficient teachers' instructional Technology Knowledge, pedagogical knowledge and content knowledge (TPACK) in mathematics is the cause of students' poor performance in

Mathematics. To reverse the current poor performance trend in mathematics in Kenya, teachers' knowledge in instructional technology needs to be assessed with a view of improving performance in Mathematics. The current research on effects of teachers' level of knowledge in instructional technology on students' achievement in mathematics in secondary schools in Kakamega County have not been documented, which makes policy action a tall order. It is on these premises that the present study was carried out.

1.1 Objective of the Study

The specific objective of the study was to examine the effect of teachers' knowledge in technology use in Mathematics instruction on students' performance in mathematics.

1.2 Research Hypothesis

The following null research hypothesis was formulated from the specific objective above and tested at 0.05% significance level.

H_{01}: There is no statistically significant relationship between teachers' knowledge in technology use in Mathematics instruction and student performance.

2. Literature Survey

The literature reviewed comprises: theoretical framework, Instructional Technology and achievement in Mathematics as well as the gap in the Literature

2.1 Theoretical Framework

Mishra and Koehler (2006) developed a theory namely Technological Pedagogical and Content Knowledge (TPACK) theory on which this study was based. They explained that they established the model after their 5 year experimental studies on the way teachers of varied cadres operated in their classrooms. Their studies were based on Shulman's (1986) work. Shulman asserted that every teacher had a set of knowledge regarding the way teaching is done thus pedagogy. He further said that a teacher needs to blend two sets of knowledge namely pedagogy and content, to come up with an amalgamated knowledge that effectively serves to teach. He referred this to as Pedagogical Content Knowledge (PCK). Twenty (20) years later on since 1986, Mishra & Koehler (2006) realized a big revolution with regards to the emergency of technology use in the teaching process. Instructional Technology Knowledge was then taken as a third set of knowledge in addition to pedagogy and content sets of knowledge. Within their 5 year experimental study, Mishra & Koehler (2006) came up with a new model known as TPACK representing combined Technology knowledge, Pedagogy knowledge and Content Knowledge which brought on board technology knowledge on top of the first PCK model. The fresh outfit stressed on the blend of Technology, Pedagogy and Content domains of Knowledge showing their interactions and connections as the knowledge regions which the teachers works with while teaching as shown in figure 1.

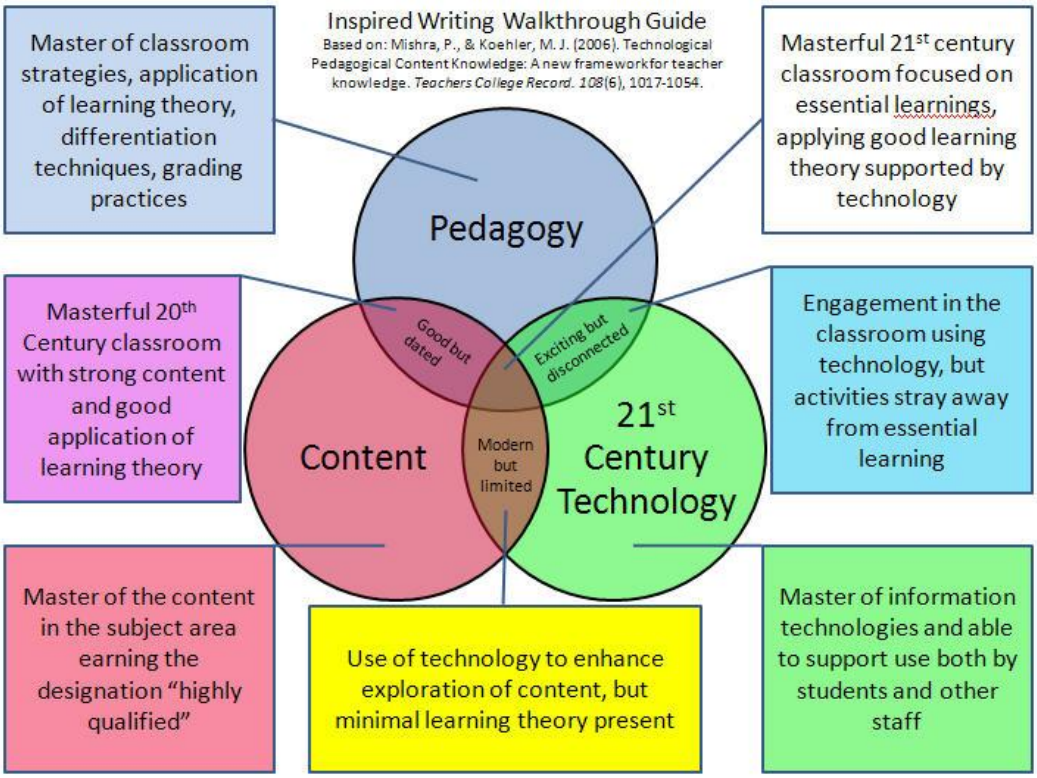

Figure 1: TPACK Model of Mathematics Instruction

From Figure 1 above, it's clear that Mathematics instruction requires a blend of the three domains of knowledge to create the most desirable atmosphere for learners as demonstrated in the TPACK model. Therefore the model in figure 1 illustrates teachers' Knowledge in technology, Pedagogy and content required for teaching learners a subject and teaching it effectively. Harris, Hofer, et al, (2010) asserts that the TPACK model simply explains why a much known teacher in the world may not be the best teacher if he does not make the subject easily learnt with the aid of Technology. This study therefore assessed the teachers' instructional technology Knowledge and its effects on the learners' achievement in Mathematics at secondary schools in Kakamega County, Kenya. The study was conducted with a view of encouraging effective teaching that would improve student performance in Mathematics.

2.2. Instructional Technology and achievement in Mathematics

A correlation study on Characteristics of Teachers Equipped with Technological Pedagogical Content Knowledge, carried out by Jessa and Marvin, (2018), showed that secondary school mathematics teachers who were highly equipped with instructional technology knowledge were young, single, and usually female. According to Baek, Jong & Kim (2008), experienced teachers are less ready to integrate Information Communication Technology into their classroom teaching. This finding agreed with the United States National Centre for Education Statistics report, (2000). The report revealed that teachers who were less experienced in the teaching of mathematics were more likely to integrate computers in their teaching as compared to more experienced teachers. According to the report, teachers with more than 20 years teaching experience utilize computers 33% of their time utilizing computers, teachers with experience between 10 and 19 years spend 47% of the time utilizing computers, teachers with teaching experience between 4 and 9 years, spend 45% of their time utilizing computers, and finally teachers with up to three years teaching experience reported spending 48% of their time utilizing computers. These disparity supports the facts that may be fresh teachers are more experienced in using the technology.

In a structured curriculum, systematic use of software promotes mathematical education and teaching (Dick & Hollebrands, 2011). According to Suh (2011), a teacher performs a critical role in using technological devices including development of mathematics lessons. Technology enriches student interactions as mathematics learners and maximizes incentives for the learning about and familiarity of interaction and information technology-driven approaches (Project Tomorrow, 2011). Technology use in the classroom supports both the learning of mathematical procedures, skills and proficiencies (Gadanidis & Geiger, 2010).

A section of teachers seem to have positive attitude towards the use of technology in the classroom. Bingimlas (2009) conducted a study that exhibited teachers' strong desire to integrate Information Communication Technology into classroom discussion. Even though, to a certain extent, a number of teachers of mathematics are still reluctant in the integration of technology in mathematics classroom due to some personal and technical barriers such as inadequate instructional Technology Knowledge (Bingimlas, 2009). Research shows that the use of computational resources can promote mathematical skills training as well as advanced math abilities, such as problem solving, reasoning, and explaining (Pierce & Stacey, 2010). In Asia, these technological barriers hinder the appropriate use of technology in the mathematics discourse among mathematics teachers (Hudson, et al., 2008). In America too, same technological barriers hinder the appropriate integration of technology in the mathematics discussion among mathematics teachers (Palmer, 2002). This intercontinental problem urges the researcher to probe into the local situation and investigate mathematics teachers' knowledge in technology use, the technology integration among mathematics teachers in the classroom and how this affects learners' performance in Mathematics.

2.3 Gap in the Literature

Lyublinskaya & Tournaki, (2012) among other researchers aver that poor performance in Mathematics subject is a problem resulting from insufficient mathematics teachers' instructional technology knowledge among other domains of knowledge. To address this problem, policy on teachers' use of instructional technology in Mathematics instruction needs to be revised. There is scanty information from research addressing this problem in Kakamega County. This necessitated the current research on assessment of effects of teachers' level of knowledge in instructional technology on students' achievement in mathematics in secondary schools in Kakamega County, Kenya.

3. Approach

A descriptive survey research design was adopted in this study. According to Kothari (2010), descriptive research design is good for it is concerned with describing, recording, analyzing and interpreting conditions that exists without the researcher having any control of the variables studied. This study appropriately used the design to: describe, record, analyze, and interpret information about Mathematics teachers' instructional Technology Knowledge and learners' performance in Mathematics without the researcher having any control of the two variables stated above. The study was conducted in Kakamega County, Kenya. Kakamega County is located in western part of Kenya with its headquarters in Kakamega town. Kakamega County has a large population of over 1, 660, 651 persons and is the Kenya's second most populous County. The County occupies a geographical area of 3, 050.3 km^2. The county has 429 secondary schools, over 3, 620 teachers and with an enrolment of 154960 students. The study targeted a population of 801 form one teachers of Mathematics with their 32012 Form One students in public secondary schools within Kakamega County. Eighty (80) teachers together with their 3320 students were sampled to participate in this study. The sample size formed 10% of the targeted respondents, which was deemed sufficient to represent the entire population for educational researches

(Mugenda & Mugenda, 2003). Table 2 gives a summary of the specific procedures involved at each stage of multistage sampling.

Table 2: Sampling Frame

Sampling Procedure	Population	Sample
Purposive sampling of Sub County schools from all public schools	429	276
Simple random sampling of schools to participate from the sub county schools.	276	80
Purposive sampling of Form One teachers from sampled schools	801	174
Simple random sampling of teachers to participate	174	**80**
Purposive sampling of students to participate	32012	**3320**

First, purposive sampling was used to select 276 Sub County schools from a total of 429 schools in Kakamega County as indicated in Table 2. The Sub County schools selected had similar characteristics such as students' entry behavior which was an important aspect in this research. It is also important to note that Sub County schools generally perform poorer than county, extra county and National schools. Simple random sampling was used to select 80 schools from the sampled 276 Sub County schools in the county whose teachers were studied. There were 174 teachers teaching Mathematics in Form One in the 80 Sub County schools selected. Purposive sampling was used to select teachers of Form One (174) from a population of all teachers of mathematics (801) in the county because the study was carried out in Form One classes only. Simple random sampling was further used to select 80 teachers of Form One (one teacher per school) from those 174. The 80 teachers plus their students (3320) formed a total sample size of 4000 respondents who participated in this study. Two research instruments were used. Information on Students' performance in Mathematics was collected by use of the document analyses. Questionnaire was used to collect background information of the respondents as well as the teacher's instructional Technology Knowledge used in Mathematics instruction. A pilot study was carried out prior to the actual study in two Sub County secondary schools in ten sub counties within Kakamega County. The teachers and students who participated in the pilot study did not participate in the actual study, so as to avoid redundancy and *halo* effect in the actual study (Long-Crowell, 2015). Data collected from the pilot study was used to reliability of the research instruments. The research instruments were administered in person and assisted by research assistants in some cases. Research assistants were trained before commencement of the study. Questionnaires were administered and collected the same day. Data analysis involved the use of descriptive and inferential statistics computed by aid of SPSS version 23. Descriptive statistics involved computation of frequencies, means, percentages and standard deviations to analyze data of the demographic information of respondents and respondents' instructional Technology Knowledge. Pearson's correlation was used to test the null hypothesis H_{01}. The correlation was brought on board to establish the strength and direction of association between the independent and dependent variables in the objective.

4. Results

The demographic data was collected on school type, age of participants and gender distributions. Of the 276 sampled schools, 216 were co-educational, 24 boys' schools, and 36 girls' schools. Of the 80 teachers sampled in the study, 49 were male while 31 were female. Of the sampled 3320 students, 1552 were male while 1768 were female. Several descriptive measures were computed on data that were collected by the research instruments, with the intention of establishing trends and patterns that would give explanations to some of the observations made in the analysis of quantitative data. Teachers' instructional technology and students' performance as measured by the instruments were analyzed descriptively to generate Means and Standard Deviations (S. D) and the outcome was as presented in Table 3 thus:

Table 3: Statistics of instructional Technology Knowledge and Achievement

Variable	Mean (%)	Std. Deviation
Teachers' instructional Technology Knowledge Scores	78.73	12.64
Students' Mathematics performance Scores	56.85	5.75

It can be observed from Table 3 that with respect to instructional Technology Knowledge, the sampled teachers had a mean score of 78.73% and standard deviation of 12.64 units. Additionally, it can be observed from the Table that the selected Students' Mathematics performance mean Score was 56.85% and a standard deviation of 5.75 units. These descriptive statistics imply that instructional Technology Knowledge. The results also imply that teachers' instructional Technology Knowledge had a higher score with more scattered data as compared to Students' Mathematics Performance Scores.

The specific objective of the study was to examine the effect of teachers' knowledge in technology use in Mathematics instruction on students' performance in mathematics. Data concerning teachers' level of knowledge in instructional technology and their students' performance in Mathematics were collected using the instruments administered to the participants in line with the research design. The study tested one null hypothesis;

H_{01}: There is no statistically significant relationship between teachers' knowledge in technology use in Mathematics instruction and student performance.

The null hypothesis was tested at 0.05% significance level using Pearson's correlation. This test was done in a bid to determine the direction and strength of association between the two variables in question. Results were as presented in Table 4.

Table 4: Correlation between Teachers' Instructional Technology Knowledge and Students' Mathematics performance

Variable	Students' Mathematics Performance score	Teachers' Technology Knowledge score	Descriptives	
			Mean	S. D
Teachers' Instructional Technology Knowledge score	0.796*	-	78.73	12.64
Students' Mathematics Performance score	-	0.796*	56.85	5.75

* p = 0.000, α = 0.05

As shown in Table 4, the results of a correlation analysis revealed a statistically significant association between teachers' instructional Technology Knowledge scores and students' Mathematics performance scores. The association was positive and strong [r=.796, p<.001 at α=.05]. The third null hypothesis was therefore rejected in favor of the alternative hypothesis *'there is a statistically significant association between Mathematics teachers' knowledge in technology use in Mathematics and students' performance in Mathematics'*. These finding implies that teachers' knowledge in technology use in Mathematics positively affects students' performance in Mathematics. This implies that Teachers with high instructional Technology Knowledge scores are likely to produce higher Mathematics performance mean scores from their students as compared to teachers with lower instructional Technology Knowledge scores. On the other hand, students taught mathematics by a teacher with relatively lower knowledge in technology use in Mathematics may score lower than the students taught mathematics by a teacher with higher knowledge in technology use in Mathematics. Therefore teachers' knowledge in technology use in Mathematics needs to be improved so as to improve the students' performance in mathematics.

5. Discussion of Findings

It was established that there is a statistically significant strong positive association between Mathematics teachers' instructional Technology Knowledge and students' performance in Mathematics. These finding is similar to that of Kimberly, (2017) whose survey revealed a statistically significant relationship between teachers' instructional Technology Knowledge and student's performance in Mathematics and reading. Results of this study are also in tandem with those of Erdogan and Sahin, (2010), whose study investigated the relationship between mathematics teacher candidates' instructional Technology Knowledge and students' performance levels. These findings are also in tandem with those of Slavisa, Miroslav and Passey (2019), who conducted a study to investigate how an information and communications technology (ICT) systems could support greater connection across and outcomes from home and school mathematics learning practices for 11-to-14-year-old students. The study, which explained the design approach, including features, accessibility and implementation of a web platform (eZbirka) created as a tool for solving teacher-reported problems in learning practices and the effects and contributions of web-based home-and-school-linked practice on students and teachers. Interviews with and surveys from students and teachers were used to gather data. Findings highlighted the efficacy of the system, indicating benefits arising when students and teachers used the entire range of features. This communication and collaboration tool enabled teachers to assist students in developing knowledge and abilities only a short time after its inception. Research revealed specific features of the software that support ICT integration into mathematics teaching and learning practices; specifically, it shifted an ineffective learning process and offers new ways of thinking about mathematical learning.

6. Conclusion

Teacher's level of knowledge in technology use in a mathematics classroom affects students' performance in the subject. Thus students who are taught Mathematics by a teacher with a high level of instructional Technology Knowledge in Mathematics instruction are more likely to obtain higher performance scores in the subject than those who are taught by a teacher with a relatively lower level of instructional Technology Knowledge in Mathematics instruction. This calls for a look out on the latest advances in technology that could be applied in the classroom to teach mathematics more effectively.

7. Recommendations

It is on the basis of such an effect size, that several recommendations are hereby made to key stakeholders in the education sector, for purposes of policy action.

Recommendations to Ministry of Education

Findings from this study have implications for the Ministry of Education (MoE), specifically the Kenya Institute of Curriculum Development (KICD). Curriculum planners need to develop a greater awareness and understanding of instructional technology knowledge that significantly determines performance among secondary school students and thus integrate it into the existing curriculum.

Recommendations for Teachers of mathematics

Teachers of Mathematics should do self evaluation of their instructional technology knowledge for the sake of using the feedback to improve their instructional technology knowledge as well as their students' performance in the subject.

Recommendations for Secondary School Principals

Limitations aside, results of this study emphasize the importance of teachers' instructional Technology knowledge. Persistent monitoring and evaluation of the same is therefore very important measure, because teachers' technology knowledge positively affects students' performance in mathematics. Principals of all secondary schools in the country need to send all their teachers of Mathematics for any in-service training opportunity that arises, in order to boost their teachers' instructional technology knowledge. This should guarantee high performance in Mathematics, which is a compulsory subject in all secondary schools in Kenya.

8. Future Scope

It was not possible to investigate all issues surrounding students' performance in Mathematics, due to a number of limitations such as limited time, insufficient funds and unique programs of various potential participant schools in the study. However, with regard to research on the influence of Mathematics teachers' instructional technology knowledge on students' performance in Mathematics, many gaps will still exist, even after adoption of all recommendations of the present study. For this reason, further research is recommended with the hope of bridging some, if not all the gaps that this study leaves behind. For technical reasons, this study was done in secondary schools within Kakamega County only. Generalizing the findings of this study to the whole country may therefore be a farfetched idea. It is therefore suggested that a similar study be replicated in other counties within the republic of Kenya apart from Kakamega County, so as to ascertain if findings of this study are universal.

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