Effect of Teachers' Integration of Technology into Teaching on Students' Performance in Mathematics in National Tests in Makueni County, Kenya

Paper presented during the 4th Annual International Conference on Research and Innovation in Education 2022

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ABSTRACT

Teaching with technology has three elements; content, pedagogy and technology, and their interactions, which comprise the Technological, Pedagogical and Content Knowledge (TPACK) framework. This framework allows teachers to use innovative technologies and renovation to contemporary teaching practices. Past research shows that ICT integration improves student engagement and knowledge retention. This study further established how ICT integration correlates with students' performance in Mathematics in national tests in public secondary schools in Makueni County.

The study was motivated by poor performance in Mathematics in these schools, which has been agonizing for students, parents and other stakeholders in the Ministry of Education. The objectives of this study were to; determine the correlation between teachers' content knowledge, pedagogical knowledge, and technological knowledge in ICT integration and students' performance in Mathematics.

The study utilized mixed explanatory methods and sequential design. The study targeted 15,410 respondents and sampled 442 respondents, using stratified and simple random sampling techniques—the study sample comprised 25 principals, 42 Mathematics teachers and 375 forms three students. Data were collected using interviews, questionnaires, focus group discussions and documentation and were analyzed using descriptive and inferential statistics. The study's findings revealed that teachers' content and pedagogical knowledge, at $\alpha = 0.05$ significance, were not statistically significant except for technological knowledge. The study concluded that integrating ICT into the teaching of Mathematics had a direct correlation with students' performance. The study recommends that government and schools should support teachers in ICT training and use a range of technologies that enable students to become active participants in a Mathematics lesson to improve students' performance in the subject.

Keywords: Content, Integration, Pedagogy, Performance, Technology

INTRODUCTION

Integrating Information, Communication, and Technology (ICT) in education refers to computer-based communication incorporated into daily classroom instruction. In conjunction with preparing students for the current digital era, teachers are the key players in using ICT in their daily classrooms. This is due to the capability of ICT to provide a dynamic and proactive teaching-learning environment (Arnseth & Hatlevik, 2012). Adopting ICT is not a single step, but it is an ongoing and continuous step that fully supports teaching and learning and information resources (Young, 2003). Computers and technology are not replacing tools for quality teachers; they are considered add-on supplements needed for better teaching and learning.

The need for incorporating ICT in education is crucial because, with the help of technology, teaching and learning are not only happening in the school environment but also can happen even if teachers and students are physically far apart.

Effective ICT integration should focus on pedagogy design by justifying how and why the technology is used in such a way. In education, simply handing students a collection of websites or CD-ROM programs is undoubtedly not ICT integration.

In an appropriately crafted ICT-integrated lesson, ICT and other crucial educational components, such as content and pedagogy, are moulded into one entity. As a result, the quality of the lesson would be diminished if the ICT ingredient were taken away from the ICT-integrated lesson (Williams, 2003). This study was therefore premised on the fact that if ICTs were incorporated into the teaching and learning of Mathematics, performance would differ from that of arithmetic learning guided only by a teacher using blackboard and chalk or whiteboard and marker pen. As a result, the gap addressed in this study was whether or not incorporating ICT into Mathematics learning might lead to enhanced achievement in Mathematics.

Content knowledge is the teacher's knowledge about the subject matter to be learned or taught. It includes knowledge of concepts, theories, ideas, organizational frameworks, evidence and proof, and established practices and approaches toward developing such knowledge. Therefore, to teach effectively, teachers need to have developed an integrated knowledge structure that incorporates knowledge about subject matter.

Nevertheless, according to Niess (2005), for technology to become an integral tool for learning the subject, teachers must also develop an overarching conception of their subject matter concerning technology and what it means to teach with technology, that is, Technological Content Knowledge (TCK). Studies have been undertaken in different parts of the globe to determine the impact of integrating content knowledge in Mathematics teaching and learning. For example, Monica and Horacio (2017) evaluated the impact of integrating topic knowledge in teaching Mathematics with technology on mathematical abilities among learners in Santiago, Chile. According to the study, using technology in the Mathematics classroom improved performance.

Pedagogical knowledge is teachers' deep knowledge about the processes and practices of teaching and learning. This general form of knowledge applies to understanding how students learn, general classroom management skills, lesson planning and student assessment. In developed countries, ICTs feature prominently in schools, and the assumption underlying the use of ICTs in schools is that they impact positively on student outcomes, particularly in Mathematics.

However, the extent to which ICTs can achieve this depends on how a computer is used as a learning and teaching tool: that is, how the computer affects pedagogical practices (Li & Ma, 2011; Hardman, 2015). In Asian countries, Kaffash, Kargiban, and Ramezani (2010) observed that the use of ICT in learning contributed to mastery of complex cognitive skills which could not be determined through simple standard tests and therefore, ICT use in Mathematics was projected to make students acquire concrete skills and be more analytical in their responses to tests. Tamim et al. (2011) established that computer technology that supports the instruction of Mathematics is more effective than technology that offers direct instruction. This points to the importance of the pedagogical basis of ICT use. Therefore, in the context of this study, teachers' understanding of technological pedagogical knowledge can enhance students' knowledge and acquisition of content hence improving their performance.

Technological knowledge requires that teachers apply computer literacy productively at work and in their everyday lives, recognize when information technology can assist or impede the achievement of a learning goal, and continually adapt to information technology changes (Thompson & Mishra, 2009).

In Europe, research has shown that teacher incorporation of technology of ICT into a Mathematics classroom impacts student outcomes (Hegedus, Tapper & Dalton, 2016). However, the study also established that more than the availability of technology in classrooms is needed to improve student outcomes in Mathematics. The teacher's decisions on how to incorporate ICT into the Mathematics classroom will either improve or hinder students' outcomes. The research regarding the impact of ICTs on mathematical attainment points out that ICTs positively impact students' outcomes (Cheung & Slavin, 2013; Demir & Basol, 2014; Chauhan, 2017).

OBJECTIVES OF THE STUDY

The following objectives guided the study:

1. Determine the correlation between teachers' content knowledge in ICT integration and students' performance in Mathematics in public secondary schools in Makueni County.
2. Establish the correlation between teachers' pedagogical knowledge in ICT integration and students' performance in Mathematics in public secondary schools in Makueni County.
3. Assess the correlation between teachers' technological knowledge in ICT integration and students' performance in Mathematics in public secondary schools in Makueni County.

Research hypothesis: There is no statistically significant correlation between teachers' content, pedagogical and technological knowledge in ICT integration and students' performance in Mathematics.

THEORETICAL FRAMEWORK

This study was based on Technological Pedagogical Content Knowledge (TPACK) Framework by (Mishra & Koehler, 2006). Mishra and Koehler's (2006) TPACK framework, which focuses on technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), offers a productive approach to many of the dilemmas that teachers face in implementing educational technology in their classrooms. By differentiating among these three types of knowledge, the TPACK framework outlines how content (what is being taught) and pedagogy (how the teacher imparts that content) must form the foundation for any effective educational technology use.

This order is essential because the implemented technology must communicate the content and support the pedagogy to enhance students' learning experience. The theory is relevant to this study because it invites teachers to show their understanding of technological knowledge in ICT use in teaching and learning mathematics.

METHODOLOGY

This study adopted the mixed explanatory methods sequential design. Mixed methods is a procedure for collecting, analyzing and integrating quantitative and qualitative data at some stage of the research process within a single study to understand better the research problem (Creswell, 2009; Teddlie & Tashakkori, 2003). This design was appropriate for this study as the researcher wanted to follow up the quantitative results with qualitative data. Thus, the qualitative data was used in the subsequent interpretation and clarification of the results from the quantitative data analysis. This, in turn, aided in an in-depth understanding of the correlation between ICT integration and students' performance in Mathematics in public secondary schools in Makueni County. The study was carried out in two phases: in the first phase, the researcher collected quantitative data by administering questionnaires to Mathematics teachers, document analysis to get students' scores, and analyzed the results. In the second phase, qualitative data were collected through interviews with principals and focus group discussions with students. Then, the data were analyzed to help explain the quantitative results obtained in the first phase. The structure of how the design was used in data collection and data analysis is illustrated in Figure 1

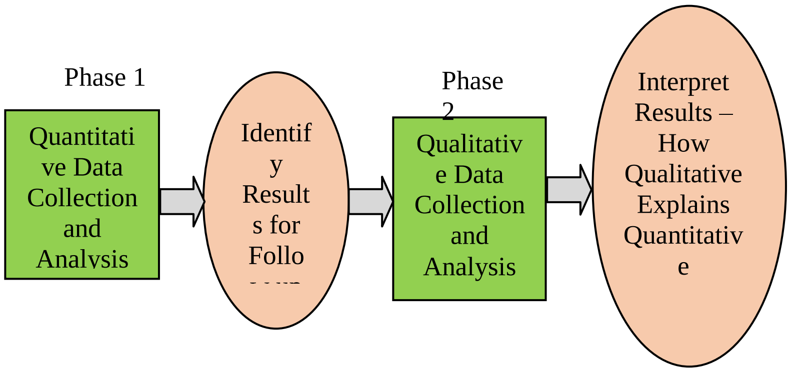

Figure 1: Model of the Research Design (Creswell, 2009)

The target population consisted of 251 principals, 14,752 from three students and 407 Mathematics teachers, comprising 15,410 respondents. The overall sample size for this study was a total of 442 respondents, that is, 25 secondary school principals, 42 Mathematics teachers, and 375 forms three students. A sample size of 10 % of the target population was considered appropriate for the principals and Mathematics teachers for the research (Gay, 1992). The researcher adopted Krejcie & Morgan's (1970) sampling table guide to sample the students.

Table 1: Target Population and Sample Sizes of Respondents

Sub-county	No. of Schools	No. of Principals		No. of Teachers		No. of Students	
		Population	Sample	Population	Sample	Population	Sample
Nzaui	45	45	4	75	8	2657	68
Makueni	46	46	5	78	8	2806	71
Kibwezi	51	51	5	86	9	2907	74
Mukaa	42	42	4	72	7	2352	60
Makindu	31	31	3	40	4	1593	40
Mbooni	36	36	4	56	6	2437	62
Total	**251**	251	**25**	407	**42**	14752	**375**

Source: Makueni Sub-county Education Office (2019)

INSTRUMENTS FOR DATA COLLECTION

The researcher used interviews with the principals, questionnaires for Mathematics teachers, focus group discussions for the students and documentation to get data on students' performance.

RESULTS

The researcher collected and analyzed quantitative and qualitative data in two consecutive phases. Quantitative data was collected using questionnaires administered to Mathematics teachers. Quantitative data were analyzed using descriptive statistics (frequencies, percentages, means and standard deviations) and inferential statistics (correlation and regression analysis).

In the second, qualitative phase, data was gathered by conducting interviews with principals and focus group discussions with form three students in the sampled schools. Such data were categorized into themes and analyzed thematically. Using the p-value approach, linear regression analysis was used to test the hypotheses at $\alpha=.05$ level of significance. In this context, linear regression analysis was suitable as it enabled the researcher to determine the correlation between the independent variables (teachers' content knowledge, pedagogical knowledge, and technological knowledge) and the study's dependent variable (students' performance).

1) *Regression Model Summary on Teachers' Content Knowledge in ICT Integration and Performance in Mathematics*

The study sought to determine how the diversity in teachers' content knowledge in ICT integration influenced secondary school Mathematics performance in Makueni County.

Table 2: Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.281[a]	.079	.049	1.210

a. Predictors: (Constant), Content Knowledge
b. Dependent Variable: Performance

Table 2 presents the model summary for regression analysis for content knowledge and performance in Mathematics. The R-value, (r=.281), indicates a weak but positive correlation between teachers' content knowledge in ICT integration and students' performance in Mathematics. The R-squared value (R^2 =.079) shows the variance in students' performance in Mathematics that could be explained by the teachers' knowledge of ICT integration. Therefore, the model summary's findings show that performance in Mathematics in public secondary schools in Makueni County was explained by 7.9% (0.079 multiplied by 100) of the variability on content knowledge in ICT integration. In comparison, the remaining 92.1% of the variability in Mathematics performance was explained by other factors not included in this model.

2) Regression Model Summary on Teachers' Pedagogical Knowledge in ICT Integration and Performance in Mathematics

This study sought to determine how much diversity in teachers' pedagogical knowledge in ICT integration influenced students' performance in Mathematics in Makueni County. Table 3 presents a model summary for regression analysis for pedagogical knowledge and performance in Mathematics.

Table 3: Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.145[a]	.021	-.011	1.274
a. Predictors: (Constant), Pedagogical Knowledge				
b. Dependent Variable: Performance				

Table 3 shows the value in R (r=.145), implying a weak positive correlation between teachers' pedagogical knowledge in ICT integration and students' performance in Mathematics. The R-square value of .021 manifests the magnitude of variability in students' performance in Mathematics that can be explained by teachers' pedagogical knowledge in ICT integration.

The model summary findings reveal that mathematics performance in public secondary schools in Makueni County was explained by 2.1% of the variability on pedagogical knowledge in ICT incorporation (R^2=.021). In comparison, the rest 97.9% of unexplored variation can be attributed to other factors that determine achievement in Mathematics but are not included in this model.

3) Regression Model Summary on Teachers' Technological Knowledge in ICT Integration and Performance in Mathematics

The study sought to establish the variability of mathematics performance based on teachers' technological knowledge in ICT integration; the findings are in Table 4.

Table 4 presents the model summary for regression analysis for teachers' technological knowledge in ICT integration and performance in Mathematics in Makueni County.

Table 4: Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.369[a]	.136	.109	1.197

a. Predictors: (Constant), Technological Knowledge

b. Dependent Variable: Performance

Table 4 shows the value in R, (r=.369), manifesting a medium positive correlation between teachers' technological knowledge in ICT integration and students' performance in Mathematics. The coefficient of determination, R^2 =.136, shows the intensity of variation in students' performance in Mathematics that can be explained by teachers' technological knowledge in ICT integration. The findings of the model summary show that performance in Mathematics in public secondary schools in Makueni County was explained by 13.6% of the variability in teachers' technological knowledge in ICT integration (R^2=.136) while the remaining 86.4% of the unexplained variation could be attributed to other factors affecting Mathematics performance not included in this model.

DISCUSSIONS

Past research by Monica and Horacio (2017), who evaluated the impact of integrating topic knowledge in teaching Mathematics with technology on mathematical abilities and teacher education programs in Santiago, Chile, revealed that content knowledge appears to be a fundamental skill linked to critical mathematical processes. Even though teachers' content knowledge in ICT integration does not significantly impact students' achievement, as per the current study, it's still crucial since it may equip teachers with the relevant knowledge required in ICT integration. Therefore, schools must ensure that teachers are equipped with content knowledge as a catalyst in incorporating ICT into teaching. Tamim et al. (2011) indicated that computer technology that supports the instruction of Mathematics is more effective than technology that offers direct instruction. This points to the importance of the pedagogical basis of ICT use.

The implication of these findings for practice was that when principals endeavour to facilitate their teachers in ICT training, this will likely assist in fostering teachers' pedagogical practices and consequently improve students' academic performance. According to Handal, Cavanagh, Wood and Petocz (2011), teachers' use of technological skills in teaching and learning needs to be appraised for two main reasons; First, upholding high-quality teaching standards in schools which ensures that students are exposed to a curriculum that takes into account instructional affordances brought about by technologies. Secondly, identifying current teachers' ICT learning and teaching skills has strategic value for planning professional development programs at both the school and systemic levels (Polly, McGee & Martin, 2010).

CONCLUSIONS AND RECOMMENDATIONS

The study's findings show a weak positive correlation between teachers' content and pedagogical knowledge in ICT integration and students' performance in Mathematics. There is, however, a relatively strong positive correlation between teachers' technological knowledge in ICT integration and students' performance in Mathematics.

Therefore, this study recommends that government and schools support teachers in ICT training and use a range of technologies that enable students to become active participants in a Mathematics lesson to improve their performance in the subject.

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