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Influence of the Interaction between Teachers' Content Knowledge and Classroom Discourse on Students' Performance in Mathematics among Students in Kakamega County, Kenya

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Abstract: ***The use of appropriate classroom discourse is vital to realize good performance in mathematics in secondary schools in Kakamega County, Kenya. The objective of this study was to determine the influence of the interaction between Mathematics teachers' classroom discourse and content knowledge on students' performance in Mathematics. TPACK theory guided the study using the descriptive survey research design. The target population was the 801 Mathematics teachers in public secondary schools in Kakamega County. A sample of 80 Mathematics teachers was selected by a combination of purposive and simple random sampling procedures. Questionnaire, interview schedule, an Observation Schedule, and document analysis guide were used. Data collected were analyzed using descriptive and inferential statistics. ANCOVA was used to test the null hypothesis. Results revealed that teachers' classroom discourse and their Mathematics content knowledge levels do not significantly interact to influence students' academic achievement. These findings have important implications in Mathematics education and are of practical value to teachers, the Teachers Service Commission, the Ministry of Education, as they provide useful information that may be used to formulate policy on how Mathematics classroom discourse should be implemented in order to improve the current students' low performance in mathematics.***

Keywords: Interaction, Teachers, Content Knowledge, Classroom Discourse, Students Performance, Mathematics

1. Introduction

Mathematics is a very important subject and plays several roles in the society. Abba Gumel (2019) asserts that mathematics is a catalyst for industrialization**.** Even though, many countries in all continents have complained about the shortcomings of the modes of teaching mathematics and how the subject is learned (European Mathematical Society, 2012). There exists numerous research evidences in this study with regard to the teachers' way of teaching mathematics and how it affects learning. There is therefore need for teachers to check the manner in which they carry out meaningful classroom discourse.
The teacher needs to choose appropriate technology to be used in class as well as determine the teaching approach suitable for the lesson (Kereluik, *et al*., 2010).

Performance of mathematics among secondary schools in Kenya is poor as can be seen in table 1. The Ministry of Education (MOE) has put up efforts to eradicate the poor performance such as in-service courses but the measures have not yielded significant positive change. The MOE through 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' in Mathematics. According to KNEC report (2021), Kenya Certificate of Secondary Education **(**KCSE) performance in Mathematics for the last 5 years (2016 to 2020) was as shown 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

From Table 1, the mean scores range from 18.36% to 26.445% confirming undesirable performance in mathematics nationally. Kakamega County, the location of this study equally registers an average mean score of 3.1(D). With persistence of such poor performance in mathematics, the country faces a risk of having acute shortage of professionals like accountants whose profession relies on Mathematics. This threatens therealization of Kenya's vision 2030 that aims at Kenya becoming an industrializing and middle-income country by providing high quality of life to all its citizens by 2030.. Poor classroom discourse causes students' poor academic achievement (Bishop, 2012; Bostic & Jacobbe, 2010). This study was therefore conducted to determine the influence of the interaction of teachers' classroom discourse and content knowledge on performance in Mathematics among secondary school students in Kakamega County, Kenya. This was done with a view of improving performance in Mathematics at secondary schools in the County. No Similar study in Kakamega County has 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 objective of this study was to determine the influence of the interaction between Mathematics teachers' classroom discourse and content knowledge on students' academic achievement in Mathematics.

1.2 Research Hypotheses

A null research hypothesis formulated from the objective of this study was stated as below and tested at 0.05% significance level.
***$H0_1$*:** *Interaction between Mathematics teachers' classroom discourse and content knowledge does not influence students' performance in Mathematics.*

1.3 Significance of the Study

1) The findings may assist the teachers to improve their classroom discourse and hence improve students' performance.
2) The findings may inform the school principals as well as the board of management about the possible cause of poor performance in mathematics. This may make them employ necessary measures to improve performance in mathematics.
3) The findings may also step up awareness to colleges and universities about the quality of the teachers they produce with regards to their classroom discourse and hence improve on their pre-service training. This could lead to production of teachers with desirable competencies to work with learners to produce good results.
4) It is hoped that the findings will enable the ministry of education at large to adjust the school mathematics curriculum to the better which in turn could bring about bright future to the learners after doing well in their examinations
5) The findings are hoped to be a source of new knowledge which could improve Mathematics education.

2. Literature Survey

The literature reviewed comprises: theoretical framework, content knowledge, mathematics classroom discourse and learners' performance in mathematics; and finally the gap in the literature

2.1 Theoretical Framework

This study based its research on the TPACK theory which was developed by Mishra and Koehler (2006) which stated that a teacher needs to blend sets of knowledge he/she posses so as to come up with an amalgamated knowledge that effectively serves to teach. The sets of knowledge Mishra and Koehler referred to were Technological, Pedagogical, and Content Knowledge (TPACK). The blend of the knowledge domains is illustrated in a Venn diagram in figure 1.

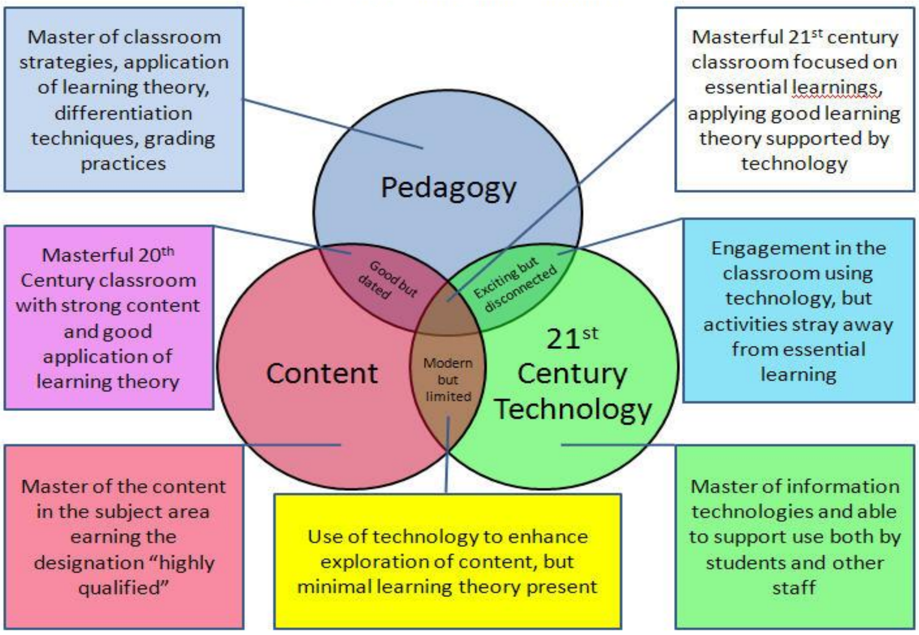

Figure1: TPACK Model of Mathematics Instruction
Source: Mishra & Koehler, (2006)

The model in Figure 1 illustrates TPACK thus an intersection or blend of teachers' knowledge in technology, pedagogy and content domains which is required for teaching learners a subject and teaching it effectively. The TPACK model explains why a much known teacher in the world may not be the best teacher in the subject for a simple justification that makes the subject easily taught (Harris, Hofer *et al*, 2010). They reiterate that to be a wonderful teacher, you should blend the three domains of knowledge to realize a masterful 21^{st} century classroom focused on essential learning, applying good learning theory supported by technology. The current study therefore assesses the influence of the interaction between the mathematics teachers' classroom discourse and their content knowledge on performance in secondary schools in Kakamega County, with a view of encouraging effective teaching that would improve student performance in Mathematics.

2.2 Teachers' Knowledge in Mathematics Content

There are a several areas of knowledge that Mathematics teachers need to have such as Content Knowledge or knowledge of subject matter (CK). Knowledge of the subject matter and Pedagogy Knowledge (PK) are taken to be a basis of sound teaching (Grossman, 1991; Shulman, 1987). There also exists 21st Century Learning Skills notion which is a model of skills, knowledge (Foundational Knowledge, Meta Knowledge and Humanistic Knowledge) and expertise. The model is considered as very important by teachers since they are equally useful to pupils in order for them to be successful in work and their general well-being, though on the other hand has drawn a lot of attention as well as disapproval with the growth of technology use in education cycles (Boling & Beatty, 2012). The definition of the Twenty-first century learning is done in varied ways and in other common ways, though Mishra and Kereluik (2011) suggested 10 basic conceptual frameworks in 3 groups as follows:

1) Foundational Knowledge that comprises of information literacy, content, and knowledge across disciplines,
2) Meta Knowledge that comprises Critical Thinking, Collaboration, and innovativeness, and
3) Humanistic Knowledge that is composed of Job Skills, Culture Competencies, and Ethical Awareness.

The Figure 2 shows the skills in the three categories of knowledge.

Figure 2: Categories of 21st Century Skills Relevant to Mathematics
Source: http://punya.educ.msu.edu/Century.pdf

Based on the 21st century learning skills shown in Figure 2, Churches (2009) considered collaboration more important skill and so listed it as the fourth element in his Bloom's Digital Taxonomy. Another argument that Information Literacy, Cultural Competence, and awareness constitute the sole skills that fit to be referred to as 21st century learning skills (Mishra and Kereluik, 2011). With regard to measuring knowledge, Hunt (2003) asserts that getting to know the level of knowledge one has is difficult because it is invisible and that tools to be used to measure TPACK must be to standard in order to manage gauging the teachers' instruction design, lesson plans, classroom activities, assessment tasks and thereafter compare them with effectiveness in the teaching of an educator. On the other hand, knowledge can be measured using a fitness assessment using observations that find required information regarding teacher's knowledge, their abilities, as well as their cognitive skills (Hill et al., 2008; Stronge, 2007). In their longitudinal survey research, Marshall and Sorto (2006) asked themselves why some teachers are more effective than others. Their enthusiasm to understand the relationship that existed between preparation of the teacher, his pedagogy and learners performance raised the morale of the researchers to move on with their research. They then focused on Mathematics teachers' knowledge. The study analyzed the effects of teacher's knowledge on student's performance. Information collected from the sampled Guatemalan schools was used. A conceptual framework was presented which linked the teacher's work to student learning. While this was done along with a general idea of the existence of varied domains of knowledge, their research focused on the Guatemalan context, whose overall results made available scientific backing for a widely held conviction in mathematics education that effective teachers have different kinds of mathematical knowledge.

An investigation of the effect of teacher's knowledge in content on mathematics performance of Fourth Grade Brazilian pupils revealed that teachers who had higher knowledge in content had a higher direct influence on the students' test scores (Guimaraes, et al. 2013). The study used test performance as a measure. Information collected yielded longitudinal data from the participating six states in Brazil that took part in the year 1999 in the FUNDESCOLA program. The analysis was done by use of value added framework which controlled for the teacher as well as the student distinctiveness, structure of the class, and the schools fixed effects. Their results showed that teachers who had higher knowledge in content had a higher direct influence on the students' test scores. These findings are also similar to those of Campbell *et al.*, (2014), who investigated whether there was a significant association between teachers' content knowledge in mathematics and performance of their students. Their study of the newly employed teachers revealed a significant association between upper elementary teachers' content knowledge in mathematics and their students' performance in the subject. The results were arrived at after all the characteristics of the teacher level and students were controlled. The fact that Campbell et al, (2014) controlled for intervening variables of their study could be the reason that explains the difference between their research findings and findings of this study.

2.3 Mathematics Teachers' Classroom Discourse and Academic achievement

Discourse refers to a negotiation of shared knowledge between teachers and students (Edwards & Mercer, 1987). A teacher is an important person in the classroom scenario since he makes instructional decisions such as their choice of materials and instruction that influence students' Mathematics learning and problem-solving performance (Good & Grouws, 2003). Discourse is the process of expressing mathematical ideas and understanding orally, visually, and in writing, using numbers, symbols, pictures, graphs, diagrams, and words" (Ontario Ministry of Education, 2005).

Also, in her research on the effects of communication on the participation of seventh graders in their Mathematics classrooms, Janneke et al. (2017) found that a classroom discourse with a focus on correct answers may be more threatening than one that emphasizes understandings. Through this research it is clear that the style of discourse is critical to the success of our students in today's classrooms. In their study on primary grade students making mathematical arguments, Whitenack, et al. (2002) discussed that all students can benefit from these discussions, including the student who is explaining and the others who are participating in the discourse. When they are asked to explain or justify their thinking, they are able to revisit their mathematical ideas. In this way rather than simply quashing their thoughts and ideas by focusing solely upon obtaining the correct answers, students will be given greater opportunities to be creative in their thoughts and focus on developing their understandings of mathematical processes and concepts.

In support of Bruce's statement, Ezrailson et al (2006) also stated that those who have not been taught, seen or experienced the discourse means of instruction may find it seemingly perplexing. Without having experienced this form of teaching in a Mathematics classroom, it is very easy for teachers to simply teach the way they were taught in the form of chalk-and-talk tasks which do not promote the use of discourse between peers and between students and teachers. Classroom discourse and its impact on teacher quality is assessed through self-evaluation measures such as questionnaires (open-ended and close-ended) and interviews; classroom observation; and the evaluation of teaching artifacts (lesson plans, student work, classroom activities and teaching materials) (Koehler, Shin, & Mishra, 2012).

2.4 Gap in the Literature

Low teacher knowledge as well as poor classroom discourse causes students' poor academic achievement (Small, 2013; Bishop, 2012; Bostic & Jacobbe, 2010). Classroom discourse that is not well orchestrated by the teacher makes the teacher unable to immediately hear and see the students' current abilities and understandings so that immediate feedback and immediate intervention can be provided to guide the students in the correct direction (Bishop, 2012). This necessitates an investigation into the teachers' content knowledge as well as the style through which teachers carry out their classroom discourse. This may reverse the current trend of students' poor performance in mathematics in Kenya, In this regard, this study endeavored to determine the influence of the interaction between Mathematics teachers' classroom discourse and content knowledge on students' performance in Mathematics in Kakamega County. This topic of research has not been done and documented in the location of this study. This justifies the mounting of the current study.

3. Approach

The study employed mixed methods under descriptive research design. Creswell (2003) avers that descriptive research design allows for use of mixed methods that combine both qualitative and quantitative methods in data analysis. The location of the study was Kakamega County, Kenya. Kakamega County is located in western Kenya and about 50 kilometers away from Uganda border. Kakamega County, with its headquarters in Kakamega town, is the second most populous County after Nairobi County. Kakamega County is among the counties performing poorly in mathematics. Kakamega County has 429 secondary schools out of which 22 are private schools while 407 are public schools. The total number of teachers in the county is 3620 with an enrolment of 154960 students. Form one students in public secondary schools within Kakamega County totaling to 32012 together with their teachers (801) formed the target population of this study. The study sample d out 3320 student and 80 teachers to participate in the study. This sample size thus 80 teachers plus 3320 students formed more than 10% of the targeted respondents. Ten (10%) of the targeted respondents is sufficient to represent the entire population for educational researches (Mugenda & Mugenda, 2003).a series of purposive and simple random sampling techniques were used under multi-stage sampling technique.

Literature review was carried out in relevant themes and thereafter four appropriate instruments of data collection namely teacher questionnaire, interview schedules, document analysis guide, and teacher observation schedule were developed as guided by the one research objective of this study. According to Kothari (2010), descriptive data are obtained by the use of questionnaires, interviews and observation methods. The interview schedules collected teachers' content knowledge information while the document analysis collected information on Students' academic achievement in Mathematics. The observation schedule collected information on classroom discourse while the questionnaire was used to collect background information of the respondents.

In this study, tests were administered after the lesson. The questions were drawn from KNEC past papers and covered current lesson topic and recently covered topics by the same teacher. The tests were marked and scores recorded in the mark books. The scores together with the recent test scores were then extracted for the purpose of gauging the students' performance in mathematics. Bryman (2004) also asserts that secondary data analysis allows for examination of existing data yet can produce new and more detailed information. Using the pilot study, reliability of instruments was assessed and the instruments confirmed as reliable to be used. The respondents who participated during piloting were barred from participating in the actual study to avoid avoiding redundancy and haloing effect in the actual study (Long-Crowell, 2015). Collection of data was commenced after all the requisite permissions were sought and granted as well as ethical considerations made. After completion of data collection, the raw data was sorted, classified and tabulated for analysis. SPSS version 23 aided the data analysis and yielded outputs in form of frequencies, means, percentages and standard deviations data of the demographic information of respondents. ANCOVA was the inferential statistics that was used to test the null hypothesis which sought to determine the influence of the interaction between mathematics teachers' classroom discourse and teacher's content knowledge on students' performance in mathematics.

4. Results

Preliminary demographic data regarding school type, age of participants and gender distributions was collected. Out of the 276 schools sampled, 36 were girls schools, 24 were boys' schools while 216 were mixed schools. On the other hand, out of the 80 teachers sampled, 31 were female while 49 were male. Lastly, out of the 3320 students sampled, 1768 were female while 1552 were male.

ANCOVA was used to test the null hypothesis of this study. All assumptions associated with ANCOVA were assessed and no violation of any one assumption was indicated. Several descriptive measures were computed on data that were collected. Teachers' content knowledge, Students' mathematics performance and classroom discourse were analyzed descriptively to generate Means, percentages and Standard Deviations (S.D). Table 2 presents the results.

Table 2: Statistics of TPACK, Classroom Discourse and Achievement

Variable	Mean (%)	Standard Deviation
Teachers' Mathematics Content Knowledge Scores	92.06	9.04
Teachers' Classroom Discourse Scores	67.75	7.38
Students' Mathematics performance Scores	56.85	5.75

Source: Researcher, (2022)

From table 2, Teachers' Mathematics Content Knowledge mean score is 92.06% with a standard deviation of 9.04 units. Also, the teachers' Classroom Discourse mean Score is 67.75% with a standard deviation of 7.38 units. Finally, students' Mathematics performances mean Score was 56.85% with a standard deviation of 5.75 units. This table reveals teachers Content Knowledge Scores as highest mean score with the highest standard deviation while students' mathematics performance mean score as the least with the least standard deviation too.

The following null hypothesis was tested at 0.05significance level.

H01: the interaction between mathematics teachers' classroom discourse and content knowledge do not significantly influence students' academic achievement in Mathematics

A continuous predictor variable (content knowledge) was used as a covariate. This hypothesis was tested using ANCOVA, whose results of the tests of between subjects' effects were as presented in Table 3 thus:

Table 3: ANCOVA Test of Between-Subjects Effects

SOURCE	DF	F	P
Teachers' Classroom Discourse (TCD) score	79	12.48	0.001
Teachers' Content Knowledge (TCK) Score	79	2.43	0.799
TCD score * TCK score	**79**	**3.247**	**0.185**

*interaction

Source: SPSS output, (2022)

As indicated in Table 3, an ANCOVA [between subjects factor: TCD; covariate: TCK] revealed no main effects of TCD or TCK, and no interaction between TCD and TCK, $F_{(1,\ 79)}=3.247$, $p=.185$, $n_p2<.001$. The p-value (0.185) at $\alpha=.05$ shows no significant interaction between the two variables under study in the null hypothesis (H_{01}). The null hypothesis was therefore not rejected but affirmed that *the interaction between mathematics teachers' classroom discourse and content knowledge do not significantly influence students' academic achievement in Mathematics.* Thus the two variables under study (TCD and TCK) may influence students' performance independently. This implies that teachers with varied classroom discourse influence their students' performance independently irrespective of their similarity in their levels of content knowledge and vice versa.

5. Discussion of Findings

Results from data collected from the objective of the study revealed that Mathematics teachers' classroom discourse and content knowledge levels do not significantly interact to influence students' academic achievement in Mathematics. This was because the p-value associated with the F-value for the interaction was greater than 0.05, the stipulated alpha level, leading to acceptance of H_{01}. These findings are in agreement with those of a study by Smart and Marshall, (2018) whose study examined the interactions between classroom discourse, specifically teacher questioning and related student cognitive engagement in middle school science. Their observations were made throughout the school year in middle school science classrooms using the electronic quality of inquiry protocol to measure observable aspects of student cognitive engagement and discourse factors during science instruction. Results of these observations indicated positive correlations between students' cognitive engagement and various aspects of classroom discourse like questioning level, complexity of questions, questioning ecology, communication patterns and classroom interactions.

6. Conclusion

On the basis of empirical evidence arising from data that were collected by the study's research instruments and the subsequent statistical data analyses, the conclusion that has been arrived at is that mathematics teacher's levels of content knowledge and classroom discourse do not interact to influence students' performance in mathematics. This means that amelioration of students' academic achievement in mathematics will depend on how well the mathematics teachers will explore the interaction of other variables, apart from the ones investigated in this study.

7. Recommendations

Teachers of Mathematics need to explore the interaction of other variables, apart from the ones investigated in this study to ameliorate students' academic achievement in mathematics. From this step, appropriate measures can therefore be put in place to ensure the highest possible mean score of the students is attained in mathematics when they sit for their KCSE examinations.

8. Suggestions for Further Research

It was not possible to investigate interaction of all domains of knowledge with classroom discourse due to a number of limitations such as limited time and insufficient funds. For this reason, the following has been suggested for future research

1) 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
2) Venture into studying other interactions apart from the one already studied in this study with a view of finding a solution to the prevailing poor performance in mathematics

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