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Mathematics Teachers' Level of Knowledge in Pedagogy and Student Achievement in Secondary Schools in Kakamega County, Kenya

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Abstract **Original Research Article**

The purpose of this study was to assess the effects of Mathematics Teachers' Pedagogical knowledge on achievement in Mathematics among secondary school pupils in Kakamega County, Kenya. Specific objective of the study was to assess the association between Mathematics teachers' level of knowledge in pedagogy of Mathematics instruction and students' achievement in Mathematics. The study was guided by the Technological Pedagogical and Content Knowledge (TPACK) theory, and was implemented using descriptive survey research design, via mixed methods approach. Target population was 801 Mathematics teachers in public secondary schools in Kakamega County. A sample of 80 Mathematics teachers was selected by multistage sampling; a combination of purposive and simple random sampling procedures. Research instruments included; a questionnaire, an observation checklist, and document analysis guide. Data collected were analyzed using descriptive and inferential statistics. Descriptive statistics involved frequency counts, means, standard deviations and percentages while inferential statistics involved Pearson's correlation. Qualitative data were however analyzed thematically. Results revealed that there was a strong positive association between Mathematics teachers' level of knowledge in pedagogy of Mathematics instruction and student achievement in Mathematics. The findings have important implications in Mathematics education and are of practical value to the Teachers Service Commission, the Ministry of Education and Principals of secondary schools, as they provide useful facts and figures that may be used to formulate policy on how Mathematics instruction should be implemented in the current curriculum, in order to improve the current students' low achievement in the subject.

Keywords: Mathematics Teachers, pedagogical Knowledge, Achievement.

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INTRODUCTION

Mathematics is a very important subject and plays several roles in the society. Mathematics forms an essential prerequisite for joining tertiary colleges, universities and for employment [1]. Many professionals such as engineers and accountants use mathematics [2]. It therefore plays a very important utilitarian role in the society. Other than utilitarian role of Mathematics, it has communication role. Communication of messages, ideas and research findings are done by use of Mathematics. Besides, research findings are presented both in numerical and graphical forms then analyzed and decisions made based on the findings [3]. Mathematics has aesthetic role in the society. Beauties generated from architectural and engineering designs, for instance the beautiful houses, cars and other models are as a result of Mathematics [4]. Mathematics has a social role too. Thus, it teaches intervals, sequences and series which are applied in social life, for instance, rhythms in the music world and in a variety of entertainments. Concepts such as diagonals, course and tracks are well applied in games such as soccer, basketball, hockey and swimming among many other games [4].

Besides the roles of Mathematics, many countries of the world have lamented on weaknesses in ways Mathematics is taught and learned in schools [5]. A lot of research evidence is accumulating regarding teachers' impact on children's Mathematics learning experiences. Several of such research evidences are highlighted in this study. The knowledge the teachers receive from colleges and higher institutions of learning range from general to content specific knowledge as well as pedagogical knowledge. Knowledge in pedagogy and content is an examinable subject [6]. Pedagogical content knowledge is knowledge about teachers' content knowledge, their knowledge in pedagogy and the process of teaching which dictates the level which the teacher has mastered what they teach [6]. Content together with pedagogy cannot be

separated and so they form an understanding that is solid [6]. The postulation of [7] is that the teachers' knowledge in content and the skills in pedagogy cannot be assumed in educational arena because they must be integrated in education.

Pedagogical Knowledge (PK) is the knowledge of the process of teaching and learning. This is knowledge which comprises classroom strategies of management and educational organization [7]. PK is the knowledge that is oriented to lesson planning, the practice of teaching accordingly, student assessment, management skills in general management skills, knowing the learning styles of students and student assessment [8]. Technology involvement in the classroom depends on the objective of the teacher for the lesson that he wants to achieve. Teachers embrace a variety of methods in the classroom to bring out what is aimed for student behaviors as well as giving required support to the students [9]. They further aver that technology should be led by Pedagogy. It is not right to front technology for pedagogy to follow.

Pedagogical Content Knowledge (PCK) is the knowledge of different teaching methods for different subjects [10]. The teachers' knowledge in Pedagogy and Content enables the teacher to understand how to approach the teaching of a challenging or easy topic [6]. PCK means the blend of content and pedagogy that guides the teacher to deliver a particular subject and solve educational problems that involve the way of organization, representation and adaptation of varied interests of pupils and their skills [7]. The teacher has a central role in orchestrating the oral and written discourse in ways that contribute to students' understanding of Mathematics [11]. The benefit of effective teaching techniques in supporting teachers to assist students become good problem solvers cannot be overemphasized [12]. A teacher with Technology Pedagogy Knowledge understands the give and take coexistence between pedagogy and technology thus teaching and learning [8].

The teacher of mathematics, like any other teacher, has a responsibility to coordinate both the verbal and written classroom dialogue in a manner that improves the learners' grasp of mathematics concepts [11]. It is also the duty of the teacher of mathematics to plan the way he or she will order instruction and coordinate their students in class in terms of what experiences they ought to expose them to, which caters for their varied individual differences, while ensuring that the learners do not stop thinking [13]. An inquiry-based mathematics way of life is what National Council of Teachers of Mathematics (NCTM) champions. This mathematics tradition is advocated for because it is regarded as an active and productive way through which learners are asked to create ways of solving mathematical problems. The students are also encouraged to work together as one team and report their answers as a team of learners while not forgetting to involve their teacher of the subject [13]. Proposes a learning environment where the learner is actively involved in the learning process. This is achieved by creation of environments where students make inquiries, reason, and develop their own understanding as a group of learners [13].

In contrast, several studies show that the teaching style that dominate secondary school classroom is one that is centered around the teacher and not student-centered. A teacher centered instruction such as lecturing can neither help a learner to critically think nor make him apply knowledge learnt to daily life [14]. Most teachers of mathematics at secondary schools think that mathematics is a compact pierce of knowledge which, in their view must be passed onto the learners as a solid body of knowledge [15].

In Kenya, the concern on making students better problem solvers by the Ministry of Education (MOE) through Strengthening Mathematics and Science Education (SMASE) workshops is on high gear. The message preached to teachers in these workshops is that teachers must embrace 'hands on' approach to teaching Mathematics. This approach encourages classroom discourse that sees learners involved actively in the process of learning. 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 [16, 17]. The Kenya National Examinations Council (KNEC) examines secondary school learners' Mathematics content recall, comprehension, application as well as general reasoning. Some few students perform well while majority fail [18]. According to the Kenya National Examinations Council 2019 [18], Kenya Certificate of Secondary Education (KCSE) Mathematics means scores for 2012 to 2018 were as summarized in Table-1.

Table-1: National Performance in Mathematics in KCSE from 2012 to 2018

Year	Candidature	Mean Scores (%)	Standard Deviation
2012	433,014	28.66	18.83
2013	444,792	27.58	20.01
2014	483,630	24.79	22.15
2015	522,870	28.66	23.10
2016	577,079	27.58	23.36
2017	615,773	23.1	20.41
2018	660,204	24.23	21.11

Source: Kenya National Examinations Council 2019 [18]

From the performance displayed in Table-1, the performance in KCSE Mathematics on average is below 30%. This shows low achievement in Mathematics as a core subject in Kenyan curriculum.

Mathematics is an essential prerequisite for joining colleges, for communicating ideas and research findings, and for industrialization as well as for employment [4]. Unfortunately in Kenya, Mathematics as taught at secondary school level is performed poorly, going by the KCSE results of the last seven years [18]. Kakamega County is one of the most affected in this regard, as students in public secondary schools continue to perform dismally in the subject, which has been the case for the last five years as asserted by Kakamega County Director of Education. The cited KCSE Mathematics performance in Kakamega County and the Country as a whole is by all standards poor. This poses a very worrying scenario for the fact that should the poor performance in Mathematics persist, 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.

The main reason behind the dismal performance in Mathematics is the lack of sufficient pedagogical and content knowledge by Mathematics teachers [19]. To reverse this trend, policy on the implementation of Mathematics discourse needs to be revisited. However, current research on assessment of teachers' Pedagogical Knowledge and learners' achievement in Mathematics in Kakamega County is scanty, which makes policy action a toll order. It is on these premises that the present study was carried out. Ideas for teaching arising from research conducted in classrooms may support Mathematics teachers to assist students to become good solvers of day to day complex problems [20].

The purpose of this study was to assess the effects of Mathematics teachers' knowledge in pedagogy on achievement in Mathematics among secondary school students in Kakamega County, Kenya. Specifically, this study sought to assess the association between Mathematics teachers' level of knowledge in pedagogy of Mathematics instruction and student achievement in Mathematics. The following null research hypothesis was formulated from the objective and tested at 95% confidence level.

Ho1: There is no statistically significant association between Mathematics teachers' level of knowledge in pedagogy of Mathematics instruction and student achievement in Mathematics

This study based its research on the TPACK theory which was developed by Mishra and Koehler [21]. They explained that they came up with the model after their 5 years experimental studies on the way teachers of varied cadres operated in their classroom. Their commencement thought was based on Shulman's work [6]. Initially, Shulman banked on the notion that every teacher has a set of Content Knowledge (CK) which is knowledge of some specification regarding the subject taught and a set of knowledge regarding the way teaching is done thus pedagogy. Shulman adds on this by saying that a teacher needs to blend the two sets of knowledge to come up with an amalgamated knowledge that effectively serve to teach. He referred this to as PCK meaning pedagogical content knowledge.

In a span of 20 years later on [21], realized a big revolution with regards to the emergency of technology use in the teaching process. At that juncture, technological knowledge was taken as another set of knowledge not connected to content and pedagogy sets of knowledge. Within the 5 years of their study [21], came up with a fresh model which they referred to as TPACK representing combined Technology knowledge, Pedagogy knowledge and CK. This model included technology in the first PCK model. The new outfit formed blends of the three domains of knowledge (Technology, Pedagogy and Content) which stresses on their interactions and connections as the knowledge regions which the teachers work with as illustrated in Figure-1.

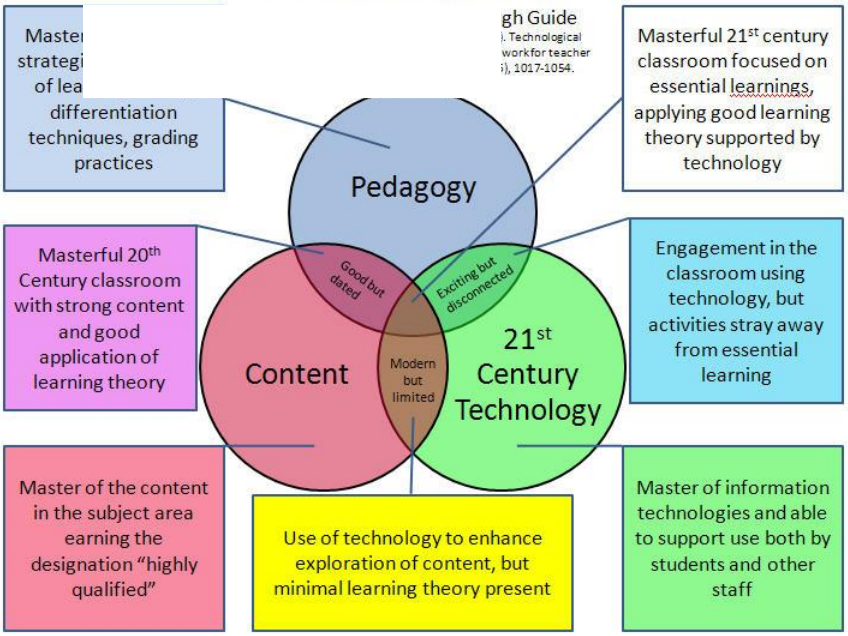

Fig-1: The TPACK Model of Mathematics Instruction
Source: Mishra, P *et al.*, [21]

Figure-1 shows a model that gives us room to construct and come up with blends of knowledge that creates the most desirable atmosphere for learners. The model illustrates teachers' Knowledge in technology, Pedagogy and content required for teaching learners a subject and teaching it effectively. The TPACK model simply explains why a much known teacher in the world may not be the best teacher in the subject for a simple justification that he does not make the subject easily learnt [22]. The current study therefore assesses the teachers' Pedagogical Knowledge and their effects on the learners' achievement in Mathematics at secondary schools in Kakamega County in Kenya, with a view of encouraging effective teaching that would improve student academic achievement in Mathematics.

Teacher's PK is said to enhance an effective practice of teaching. It is defined as the knowledge that interacts with CK and provides a blend of knowledge that gives an exemplary understanding of the subject which empowers the teacher in terms of designing, applying and evaluating a suitable strategy for teaching a given topic effectively [23]. On the other hand, learners' achievement as used in this study refers to the correct leaner responses to questions on content taught during a Mathematics lesson as well as their scores in tests and examinations. A number of studies reviewed show that while much research is still needed to fully support this relationship, as well to test a cross-cultural conceptualization of general PK, research so far is beginning to show that teachers' general PK is relevant to understanding quality teaching as understood by its impact on student learning outcomes [24].

A good pedagogical decisions hinges on the quality of the PK held by the teacher [25]. A study by [26] investigated the relationship between teachers' PK and student achievement. Their study of early career teachers identified a significant positive relationship between middle grade teachers' mathematics PK and their students' achievement in the subject, with and without controlling for teacher-levels. Similarly, the importance of understanding the interplay between teacher pedagogy and student achievement was investigated by [27]. They analyzed the effects of teacher mathematics pedagogy on student achievement using longitudinal data from rural Guatemalan primary schools. After presenting a conceptual framework for linking the work of the teacher with student learning in mathematics together with an overview of the different forms of mathematical pedagogy, their Guatemalan study provided some empirical support for a widely held, if infrequently tested, belief in mathematics education: effective teachers have different kinds of mathematical pedagogy.

Rockoff, J. E [20] examined how professional development of content authoring influences Mathematics teachers TPACK development and in turn affects their students' algebra achievement scores. After a one-year professional training spent creating curriculum that integrates TI-Nspire technology, four Algebra teachers from a New York City public high school were evaluated for their TPACK developmental levels. Researchers utilized their developed TPACK Levels to measure teachers' artifacts and their teaching practices. Their results indicated the importance of lesson plan preparation in teacher effectiveness and the impact of teachers' TPACK levels on student achievement.

Measuring teacher's knowledge is hard because of its invisibility. The teacher's TPACK can therefore be measured by measuring the students'

achievement [28]. According to [23] teacher's knowledge in pedagogy gives an impression of a teacher who is effective in the classroom. PK is a domain of knowledge that deals with methods of teaching. It encompasses the teacher's capability to plan a lesson, execute it and make an assessment of learners' achievement that best fits the learner demands. The question is what is the level of teachers' PK of Mathematics instruction in Kakamega County? This study sought to assess Mathematics teachers' knowledge in pedagogy of Mathematics instruction. To assess this, the researcher evaluated the teaching artifacts of the teachers as recommended by [29].

The Gap in the Literature is that lack of sufficient PCK by Mathematics teachers is the reason behind the dismal academic achievement in Mathematics [20]. To reverse this trend, policy on the implementation of Mathematics classroom discourse needs to be revisited. Thus, current research on assessment of teachers' pedagogical knowledge and learners' achievement in Mathematics in Kakamega County is scanty. It is on these premises that the present study was carried out.

METHODOLOGY

A descriptive survey research design of explanatory nature was adopted in this study. Explanatory studies are advantageous when not much has been written about the topic or the population being studied, and that the design also allows the use of mixed research methodology that combines elements of qualitative and quantitative methods [30]. This study combined both elements of qualitative and quantitative methods in data analysis. Descriptive research design is concerned with describing, recording, analyzing and interpreting conditions that exists or without the researcher having any control of the variables studied [31]. The design was therefore appropriately used to; describe record, analyze and interpret information about Mathematics teachers' PK and learners' achievement in Mathematics without the researcher having any control of those variables.

The study was conducted in Kakamega County, Kenya which is in western part of Kenya with its headquarters in Kakamega town. According to [18], Kakamega County is one of the counties that perform poorly in Mathematics. This prompted the researcher to carry out a study in this location with a view of coming up with recommendations that may improve on KCSE performance in Mathematics in the County and in Kenya as a whole. The study sample comprised of 80 mathematics teachers of form one which was selected from the target population of 801. It also included 334 form one students selected from a target population of 32012. This sample size formed 10% of the targeted respondents, which was deemed sufficient to represent the entire population as suggested by [32] for educational researches. This sample was arrived at through multi-stage sampling technique. 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	429	276
Simple random sampling of schools to participate.	276	80
Purposive sampling of form one teachers	801	174
Simple random sampling teachers to participate	174	80
Purposive sampling of students to participate	32012	334

Source: Researcher, (2019)

Data were collected using the teacher questionnaire, document analysis guide and observation schedule. The teacher questionnaire was used to collect teachers' background information while document analysis guide was used to collect information on Mathematics Teacher's Pedagogy Knowledge and Students' achievement in Mathematics. Therefore, through analysis of selected professional records, pedagogical knowledge of the teacher was established. On the other hand, analysis of students' progress records established academic achievement of the learners in Mathematics. An observation schedule was therefore used to collect data during the actual teaching and learning process in the classroom. These instruments enabled the researcher to collect desired information of the PK level of the sampled teachers.

The collected raw data was sorted, edited, classified and tabulated ready for analysis. Data analysis involved the use of descriptive and inferential statistics computed by aid of SPSS version 23. Descriptive statistics involved computation of frequencies and percentages to analyze data of the demographic information of respondents and respondents' PK. Inferential statistics used involved Pearson's correlation to test the null hypothesis. The correlation was brought on board to establish the strength and direction of association between the two variables.

The researcher put into account several measures which ensured that rights of respondents were not violated. Among those ethical considerations were; the researcher obtained a research permit and authorization letter from the National Commission for

Science, Technology and Innovation (NACOSTI) before going to the field to collect data. This implied that the study was legal under Kenyan Law. The researcher was therefore bound by the rules and regulations pertaining to the permit issued. Secondly, the researcher sought consent from all respondents before using them in the study. Also, the researcher accurately reported findings of this study while acknowledging all sources of information used to develop this work so as to avoid plagiarism.

FINDINGS

The demographic data was collected on school type, age of participants and gender distributions. The county comprised of 429 secondary schools. Of the 276 out of 429 schools sampled, 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 334 students, 156 were male while 178 were female. This comprised 10.43% of the total form one students' population in the County.

Descriptive Analysis of Teachers' PK and Achievement

Several descriptive measures were computed on data that were collected by the research instruments. The computations established trends and patterns that gave explanations to some of the observations made in the analysis of quantitative data. Teachers' PK as measured by the Mathematics Teacher Pedagogical Knowledge Document Analysis Guide and the Students Mathematics Achievement Document Analysis Guide were analyzed descriptively to generate Means and Standard Deviations (S.D) and the outcome was as presented in Table-3.

Table-3: Means & Std. Deviations of Teachers' PK and Achievement

Variable	Mean	Standard Deviation
Teachers' Pedagogical Knowledge Scores	95.34	8.84
Teachers' Students' Mathematics Achievement Scores	56.85	5.75

As observed in Table 3, the results show that Teachers' PK mean score was 95.34 and a standard deviation of 8.84 units. Additionally, it can be observed from the Table that the selected Teachers' Students' Mathematics Achievement mean Score was 56.85 and a standard deviation of 5.75 units. The teachers' PK had the highest mean score. The selected teachers' students' Mathematics achievement mean score was 56.85 and a standard deviation of 5.75 units as the table further reveals.

Inferential Statistics

The objective of this study was to assess the association between Mathematics teachers' level of knowledge in pedagogy of Mathematics instruction and student achievement in Mathematics. Data concerning teachers' level of knowledge in pedagogy and their students' achievement in Mathematics were collected by the relevant document analysis guides. Both instruments were administered to the sampled respondents as per the research design. The null hypothesis Ho1 was formulated from this objective as follows;

> *Ho1: There is no significant association between Mathematics teachers' level of knowledge in pedagogy of Mathematics instruction and student achievement in Mathematics.*

This null hypothesis was tested inferentially using parametric test at the 0.05 alpha level of statistical significance using bivariate Pearson's correlation to determine the direction and strength of association between the two variables under investigation. Results were as presented in Table-4 thus:

Table-4: Correlation between Teachers PK and Students' Achievement

Variable	Students' achievement score	Teachers' PK score	Descriptives	
			Mean	S.D
Teachers' PK score	0.708*	-	95.34	8.84
Students' achievement score	-	0.708*	56.85	5.75

* p = 0.007, α = 0.05

Table-4 shows that there was a strong positive association between the selected teachers' pedagogical knowledge scores and their students' Mathematics achievement scores [r=.708, p=.007 at α=.05]. This is because the Pearson's correlation coefficient obtained is closer to 1 than to 0, hence the description of the association as 'strong. Moreover, Table-4 reveals that the sign of the correlation coefficient (r) is positive, which implies that teachers with high PK are likely to produce higher Mathematics achievement mean scores from their students as compared to teachers with lower PK scores and vice-versa.

Since the p-value associated with the Pearson's correlation coefficient was less than 0.05, the stipulated alpha level of significance, the said association between the two variables was deemed to be significant. It can therefore alternately be asserted that *there is a significant strong positive association between Mathematics teachers' level of Mathematics*

pedagogical knowledge and their students' achievement in Mathematics.

DISCUSSION OF FINDINGS

It was established that there was a strong positive association between Mathematics teachers' level of Mathematics PK and students' achievement in Mathematics. This association was statistically significant at the 0.05 alpha levels. The positive value of the correlation coefficient implies that a teachers' high level of Mathematics pedagogy knowledge would also lead to a high students' Mathematics achievement mean score and vice-versa. This association is statistically significant because the p-value associated with the calculated correlation coefficient is less than the stipulated alpha value.

These findings are however in disagreement with those of [33], whose second research objective investigated the influence of teachers' PK on students' achievement in algebra. Using a test re-test quasi-experimental design with a 3x3x2x2 factorial matrix, the researchers purposively sampled 421 senior secondary school II students and 12 mathematics teachers from eight public and four private schools in Education District 5 of Lagos State. They used quantitative instruments for data collection and analyzed their data using graphs and ANCOVA. The results indicated that students were not equally affected by teachers' pedagogical knowledge in algebraic achievement test. However, findings of this study show that there was a strong positive association between Mathematics teachers' level of knowledge in pedagogy of Mathematics instruction and student achievement in Mathematics

CONCLUSION

Based on empirical evidence arising from data that were collected by this study's research instruments and the subsequent statistical data analyses, one major conclusion has been arrived at: -Students who are taught Mathematics by a teacher with a high level of knowledge in pedagogy of Mathematics instruction are more likely to obtain higher achievement scores in the subject than those who are taught by a teacher with a relatively lower level of knowledge in pedagogy of Mathematics instruction.

Implications of the Findings

Mathematics teachers' PK is a variable that plays a vital role in determining whether or not the objectives of Mathematics education will be met or not. All pedagogies that are relevant in Mathematics education should therefore be taken very seriously by every Mathematics teacher, as it might just be the difference between an average and below average class in terms of achievement in the subject. Consistent training and re-training is therefore mandatory, if the national goals of Mathematics are to be fully attained to satisfaction of all stakeholders.

Recommendations from the Study

Recommendations to Ministry Of Education

Findings from this study have implications for the MOE, specifically the Kenya Institute of Curriculum Development (KICD). Curriculum planners need to develop a greater awareness and understanding of the various variables that have significant effect on Mathematics achievement among secondary school students, like teachers' pedagogical knowledge as it was found in this study, and thus integrate them into the existing curriculum. To design a secondary school curriculum that aims to churn out high achievers in the subject of Mathematics, the MOE should therefore closely monitor and evaluate all Mathematics teachers' PK and pass over their feedback to KICD, who should in turn use the feedback to improve the current Mathematics curriculum.

Recommendations for Secondary School Principals

Limitations aside, results of this study emphasize the importance of teachers' level of PK. Persistent monitoring and evaluation of the same is therefore very important measure, because it ensures that students' achievement is reliant on this variable. Principals of all secondary schools in the country schools therefore send all their Mathematics teachers for any in-service opportunity that arises, in order to boost their teachers' PK. This should guarantee high achievement in Mathematics, which is a compulsory subject in all secondary schools in Kenya.

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