Multimedia Integration of Mathematical Internet Memes into Mathematics Classrooms in Secondary School Curriculum

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Abstract: Mathematics is a core subject in almost all secondary education curricula. In improving performance in mathematics, there is a need to consider developing new teaching and learning pedagogies that tap the students' interests and enhance the classroom environment. This study focuses on integrating mathematical internet memes into mathematics classrooms to determine their effect on students' performance, understanding, engagement, motivation, and excitement. It also examines memes' impact on learning experiences, the potential to provide alternative formative assessments and investigate students' readiness to learn with memes in the mathematics classroom. The study revealed that integrating mathematics internet memes in the mathematics classroom has no significant impact on student's performance in mathematics. Moreover, research showed experiment group performance in meme-aided and traditional assessment tests was statistically similar, indicating that both tests provide identical feedback on students' performance. The study further revealed that integrating memes in the mathematics classroom improves students' engagement, motivation, and excitement in the mathematics classroom.

Keywords: Formative Assessment, Integration, Internet Memes, Mathematics, Multimedia Resource, Pedagogy

1. INTRODUCTION

Statistics show that in Kenya, mathematics performance in secondary schools is relatively low compared to other curriculum subjects. The study's findings by Amunga and Musasia (2011) revealed wide disparities in mathematics performance among students from different categories of schools. The general mathematics performance of students in national exams is usually lower than other curriculum subjects (Kanja et al., 2001). Such lower performance in mathematics may be attributed to students' negative attitude toward mathematics, inadequate or lack of implementation of multimedia resources in mathematics instruction, and poor classroom environment and atmosphere. For instance, students have been found to associate their declining performance in mathematics with negative attitudes and harsh and unfriendly classroom environments (Amunga & Musasia, 2011; Kania et al., 2001).

Multimedia resources have proven to be very productive learning resources in mathematics. Multimedia resources involve all digitally handled information, represented in a combination of some or all of the following: text, graphics, animation, video, still images, audio, et cetera (Kalizhanova et al., 2013; Pavithra et al., 2018). According to previous studies, multimedia resources improve performance in mathematics, improve attitude and interest, and enhance understanding, engagement, and student motivation, thus improving the effectiveness of instruction (Ahmad, 2010; Akinoso, 2018; GebreYohannes et al., 2016; Mosonik, 2021; Ogochukwu, 2010). Therefore, the lack or inadequate integration of multimedia resources can contribute to declining or poor mathematics performance. Some of the previous research work on mathematical internet memes has recommended further studies on internet memes (Matias, 2020; Purnama, 2017). Only a little about mathematical internet memes have been studied, specifically on improving learning experiences and outcomes, classroom environment, and learning outcomes assessment.

Bini and Robutti (2019) stated that mathematical internet memes connect with students' emotions, foster further reflection on mathematical concepts, and improve language awareness. According to Benoit (2018), mathematical memes can influence learners' identity mathematically; hence, it calls for exploring more educational benefits of

memes in mathematics classrooms. This research integrates memes in the mathematics classroom to explore their potential to improve mathematics instruction, performances, and classroom environment and provide alternative formative assessments in mathematics. Integration of memes in mathematics is teaching and learning pedagogy applied in this study in instruction presentation and formative assessment. Formative assessment is conducted throughout the learning process. It involves all activities the teacher may undertake to assess learners and provide feedback to adjust teaching and learning activities to further students' learning (Chapter 1, The importance of formative assessment, n.d.; Resource pack to support remote learning, n.d.). The research categorizes formative assessment into two: meme-aided or meme-integrated formative assessment, which involves the mathematical interpretation of memes, and traditional formative assessment, which focuses only on the computational knowledge of the student.

Statement of Objectives

The aims of this study include the following:

- Explore Learners' familiarity, readiness, and potentialities for learning with memes.
- Examine mathematical internet memes on possible use as a formative assessment tool, a 21st-century readily available multimedia resource as an alternative tool for convenience.
- Investigate whether integrating mathematical internet memes in mathematics instruction may be used to enhance learning experiences and understanding.
- Examine the impact of integrating mathematical internet memes on learners' engagement, excitement, and motivation in mathematics classrooms.
- To investigate if integrating memes in a mathematics classroom can improve learners' performance in mathematics.

2. BACKGROUND OF THE STUDY

A. Mathematics

Mathematics is a crucial subject and is usually compulsory in secondary schools. As a core subject, the teaching and learning pedagogies must boost students' understanding and grasp of mathematical concepts. Teaching and learning pedagogy, in this case, refers to the teacher's method and practices or the way students are taught both in theory or practice in the classroom (MasterSoft, n.d.; What are the different pedagogical approaches to learning? 2021). Therefore, the *pedagogy* cuts across the teaching styles, including the presentation of instruction and assessment strategies.

The study focuses on teaching and learning pedagogy that integrates mathematical internet memes as a multimedia resource in mathematics classrooms, specifically on the presentation of instruction and provision of formative assessment. According to studies, mathematics teaching and learning pedagogies should take care of both computational knowledge of the subject and mathematical content and communication that facilitates understanding and applying mathematical concepts (Pokharel, 2020). Therefore, integrating mathematical internet memes in mathematics classrooms can serve this pedagogical purpose as students enjoy learning mathematics concepts using multimedia resources (Mosonik, 2021).

The performance of students in basic mathematical concepts could be better. According to Kanja et al. (2001), students perform poorer in mathematics than in other curriculum subjects in national exams. Some contributing factors toward poor performance in mathematics include negative attitudes by students, insufficient practice, and the influence of poor performance in previous mathematics exams (Amunga et al., 2011). Students claim harsh and unfriendly classroom environments and that their interest in mathematics gradually disappears as the learning progresses. All these factors depend on the teaching and learning pedagogy as the given pedagogy may improve students' attitudes, promote practice, and influence performance.

Therefore, mathematics learning and teaching pedagogies need to be improved and tap new learner-centered practices that enhance students' interest in mathematics. Teaching pedagogies greatly influence the learners' mathematics performance (Adino, 2015). Studies indicate that the delivery criteria, students' active interaction with

learning experiences, and the learning environment determine their success in learning mathematics. Lessani et al. (2017) argue that the teaching pedagogies in mathematics classrooms should be student-centered and facilitate discussion as they promote learners' creativity and a better understanding of the subject.

B. Multimedia resources

Multimedia is a wide field that integrates computer-controlled resources such as text, graphics, drawings, still and moving images, animation, audio, speech, and other digitally handled resources (Pavithra, 2018). As a field of computer information technology, it uses different physical representations of information (Kalizhanova et al., 2013). Multimedia resources are one of the teaching tools that can be used in teaching mathematics. Kalizhanova et al. (2013) and Pavithra (2018) argue that multimedia resources are digitally handled and physically represent information in a combination of some or all of the following text, graphics, animation, video, audio, still images, drawings, et cetera. According to studies, multimedia-based teaching and mathematics learning is more effective than the traditional method many teachers use (GebreYohannes et al., 2016). Mathematics presentations using multimedia boost learners' understanding, enthusiasm, class attendance, and satisfaction; hence, students prefer multimedia presentations of mathematical lessons rather than traditional instruction (Ogochukwu, 2010). Multimedia tools are found to anchor learners' understanding and make it better compared to the traditional method, which is highly lecturing; as a result, other studies show that students would perform better when multimedia is integrated into the mathematics classroom (Ahmad et al., 2010). According to a study by Akinoso (2018), multimedia use improves students' interest and motivation and increases their participation in learning, thus improving their learning to a certain level. Therefore, integrating multimedia resources such as internet memes in mathematics classrooms can be teaching and learning pedagogy that boosts learning. As stated, boosting learning will result from taking care of the factors contributing to poor mathematics performance.

C. Mathematical Internet Memes

Mathematical internet memes are multimedia tools that can be utilized in a mathematics classroom. Internet memes are images or videos with a caption that carries a certain meaning or message based on context. They are, therefore, digitally made text, verbal, visual, or audio artifacts with common attributes and may undergo variation by multiple users (Gal, 2018). Moreover, memes are distributed and consumed on the internet and can easily be located through search engines and social media platforms such as the Pinterest app. With new challenges teachers face in understanding the best instructional practices and strategies that cater to learners' learning needs, meme-based learning can provide solutions to instruction approaches (Purnama et al., 2017). Research shows that internet memes can be useful tools for educational purposes (Osterroth, 2018). Internet memes are educative, provide humor, and reduce stress and anxiety in the classroom, even though their effectiveness in teaching and learning is tied to students' media consumption and popular culture (Harshavardhan et al., 2019). According to a study by Gumilang and Juanda (2018), Internet memes act as a medium of message delivery and entertainment simultaneously and, therefore, can be used to improve the classroom environment.

Studies have also shown that incorporating an internet meme in mathematics classrooms promotes students' critical thinking (Matias, 2020; Bini & Robutti, 2019). As a result, integrating internet memes will, therefore, improve mathematical cognition. Teachers should consider using memes in mathematics classrooms based on findings that internet memes further mathematical reflection, enhance students' emotional drive, and boost their motivation (Bini & Robutti, 2019; Purnama et al., 2017). Using memes in classroom teaching changes students' perception of the given subject or course content, instilling the right attitude toward the subject. The numerical and statistical analysis of previous studies by Reddy et al. (2020) shows that students like memes, which can alter their perceptions. Meme-based learning practices such as creation and interpretation extract students' interest and can enhance students' participation, engagement, and understanding through enjoyable techniques (Purnama, 2017; Purnama et al., 2017). However, with such potential, according to studies, meme-based learning cannot replace traditional learning pedagogies but can act as a supplemental learning tool (Reddy et al., 2020). Acting as a supplemental learning tool will mean integrating mathematical internet memes to enhance existing pedagogies but not replace them. *Traditional learning pedagogies* are existing instructional strategies which are highly teacher-centered and less learner-centered (Ardeleanu, 2019). This study focused on the integration of mathematical internet memes in the mathematics classroom, which means a combination of both traditional learning approaches with a meme-based approach, a pedagogical approach known as meme-aided or meme-integrated instruction.

3. RESEARCH METHODOLOGY

A. Research design

The study used a mixed methods research approach, applying both quantitative and qualitative approaches. The basic research statistical design employed both descriptive and inferential statistics. The research targeted secondary schools in Kenya, but sampling was conducted in Nairobi County. Seven public schools with basic Information and Communication Technology (ICT) infrastructure were randomly selected from Extra County and National schools population (population of nineteen schools).

Two class streams were randomly selected from each of the seven schools, from which 30 students were randomly selected from each class stream. Therefore, the total number of participants from all seven schools was 420. However, it is worth noting that some streams had more than 30 students. In such streams where students were more than 30, the learning would go on as a whole class, but 30 students would randomly be selected for experiment purposes. The students from one stream acted as an experimental group while the other control group. The experimental group integrated mathematical internet memes to help investigate students' mathematics performance in a meme-integrated mathematics classroom (meme-aided mathematics classrooms) compared with traditional mathematics classrooms. For validity purposes, memes were kept from the students after the mathematics classroom period to prevent students' interaction across the streams.

Traditional formative assessment test was administered to both the experimental and control groups. The experimental group also undertook a meme-aided formative assessment test in which they were expected to interpret memes mathematically based on the topic of the study.

Mathematics courses of study used for the experiments were Squares and Square roots in Form one class, equations of the straight lines in Form two, Surds in form three, Integration in form four, Trigonometry in form four, Logarithm in form three, Quadratic Expressions and Equations in form three. An example of mathematics internet memes used for each course can be accessed by clicking on the link inserted on each course above. The seven topics were shared randomly among the seven schools selected. The items in the traditional formative assessment were adapted from the secondary mathematics curriculum course book published by Kenya Literature Bureau publishers and printers approved by the Kenya Department of Education (Kenya Institute of Curriculum Development - nurturing every learner, n.d.). All the formative assessments used in the experiment adhered to Kenya's secondary curriculum-approved assessment policies and criteria provided in the Basic education curriculum framework (2017).

Mathematical internet memes were integrated based on the course. The learners were expected to interpret memes mathematically based on the course during classroom instruction and meme-aided assessment tests. Some memes were self-made, while others were obtained from search engines and social media platforms like the Pinterest app. The study used both experimental and non-experimental methods for data collection. Instruments of data collection used included questionnaires, focus groups, and observation. Questionnaires were designed and developed for validity and reliability based on scientific guidelines provided in the previous study (Arora, 2017). Following the guidelines, the questionnaires were tested for reliability. The first questionnaire to be administered to the participants just before integrating mathematical internet memes into the classroom was found to meet the standard for reliability. The Cronbach's Alpha coefficient was indicated to be above 0.7, as shown in table 1.1 below as extracted from SPSS software.

Table 1. 1 Reliability test for the First Questionnaire

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.792	.756	3

Similarly, the second questionnaire, administered after the integration of mathematical internet memes in mathematics classrooms, met the criterion for validity and reliability. Below, table 1.2 is extracted from SPSS software, giving the Cronbach's Alpha coefficient of reliability of the questionnaire.

Table 1.2 Reliability test for the Second Questionnaire

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.701	.653	5

Before integrating the mathematical memes, the experimental group of thirty students in each of the seven schools was administered a questionnaire to investigate their familiarity with internet memes.

While integrating mathematical internet memes in the mathematics classroom, observations were done on students' behavior and reactions. A Focus group was conducted after the integration of mathematical internet memes, and a questionnaire was conducted to investigate students' views on the integration of memes.

B. Integration of mathematical internet Memes in classroom

Mathematical internet memes were made available to the mathematics classroom students by displaying them on the whiteboard through a projector.

In the seven different schools, memes were integrated based on the mathematics topic of the study in the given school. There were both image and video-based memes. The table 1.3 below describes the schools, the mathematics topic studied, and the class forms selected in the given school.

Table 1.3 Schools description

SCHOOL	CATEGORY	CLASS FORM	MATHEMATICS TOPIC
A	Girls	Three	Quadratic Expressions and Equations
B	Boys	Two	Equations of the Straight lines
C	Boys	Four	Trigonometry
D	Boys	Four	Integration
E	Girls	One	Squares and Square roots
F	Girls	Three	Surds
G	Boys	Three	Logarithms

C. Data collection

Observations, questionnaires, and focus groups were used to collect data on integrating mathematical internet memes in the mathematics classroom. Experiments were conducted to compare students' performance when subjected to meme-aided instruction (experimental group) and traditional instruction (control group). The experimental group and the control group in each given school sat for similar 30 marks on traditional formative assessment tests after the end of the topic. However, the experimental group simultaneously set for an extra thirty marks meme-aided formative assessment test. Performance mean scores for the students per school were recorded.

D. Data analysis

The study used both descriptive and inferential methods in data analysis. Quantitative and qualitative data analysis were both applied. The research employed the following common statistical techniques; the measure of central tendency and parametric test. In the measure of central tendency, arithmetic means performance for the tests in both experimental and control groups in each school was obtained. In the parametric test, the T-test was employed to determine the significant difference between the mean performances of the control and experimental groups in traditional assessment tests in all schools.

Moreover, the T-test was used to determine the significant difference between mean performances in meme-aided formative assessment tests and traditional formative assessment tests for experimental groups. Comparing the performances in the two tests is to investigate whether the two provide similar feedback on learners' performance. The similarity of learners' performance feedback will substantiate meme-aided formative assessment as an alternative to traditional formative assessment. The level of significance was taken to be 0.05. Microsoft Excel application was used for data analysis while SPSS software was used to test validity and reliability of Questionnaires.

E. Limitations of the study

One of the study's limitations is that the research should have considered students' entry behavior, digital skills, and media exposure for the students from the different schools. Bearing that the schools involved were national and extra county schools, which are also classified at different levels, their students' entry behaviors, digital skills, and media exposure can be significantly different. Generally, the study did not consider the different learning abilities of the students from different schools. Such can affect the findings, especially on the interpretation of memes and performances in the tests administered.

The research also only reached out to students from some categories of secondary schools, and therefore, its research findings are limited to students in national and extra county school categories. The study cannot be generalized to all students from all secondary school categories.

F. Findings of the study

- *Learners' familiarity, readiness, and potentialities on learning with memes*

On exploring students' familiarity, readiness, and ability to learn with memes, the following finding was obtained;

A questionnaire was filled out before integrating memes into the mathematics classroom. Students were expected to respond about their prior exposure to general and mathematical memes inside or outside the school. A total of 210 students from 7 different schools were participants, for which 89.05% (187 students) stated they had been exposed to memes regardless of whether they were mathematical. Of the 89.05% of the students who responded to having exposure to memes, 53.48% of them stated they had been exposed to mathematical memes, representing 100 students out of 187. These results indicate that many students are familiar with the memetic world. Moreover, slightly more than the 50% of students who filled the questionnaires were familiar with mathematical internet memes.

Moreover, in the same questionnaire, the students who had prior exposure to mathematical memes were asked to rate how comfortable they were with memes being integrated into the mathematics classroom. The results from the 100 students who had prior exposure to mathematical memes are represented in the pie chart figure 1.2 below. On the comfort level, students were expected to rate whether they were highly, moderately, less, or uncomfortable with integrating memes in mathematics classrooms.

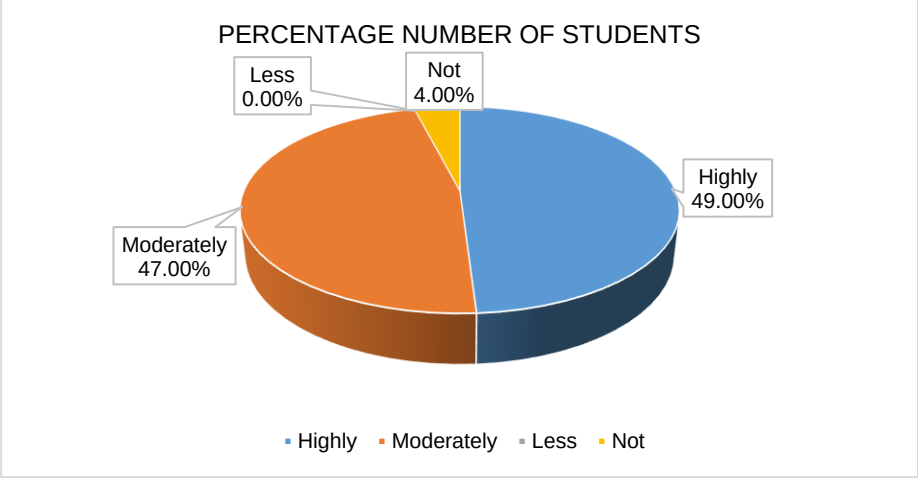

Figure 1.1 Students' percentage distribution on level of comfort with the integration of memes in the mathematics classroom

Eight students from the experimental group in each of the seven schools participated in the focus group. All stated that they had prior exposure to memes regardless of whether they were mathematical; however, the exposure did occur in any classroom. Such reveals that students are familiar with memes. The experimental group of 30 students from each of the seven schools was administered 30 marks meme-aided test based on the mathematics topic of study experimented on in the given school. The total mean performance of the students in the meme-aided tests, which were purely based on the interpretation of memes, was found to be 12.96, which is a 43.19% in percentage score. These results show less than the 50% score which is statistically mean performance score.

- *Use of Meme-aided formative assessment*

In examining the potential use of meme-aided formative assessment as an alternative to traditional formative assessment, an experimental group of 30 students in each of the seven schools participated in both 30 marks meme-aided and 30 marks traditional formative assessment tests. The test statistics on the mean performances in two tests for all seven schools showed no significant difference in the mean performances in both traditional and meme-aided formative assessment tests. The t-test was based on a p-value of 0.05. This result indicates that both meme-aided and traditional formative tests produce similar results or feedback on students' performance, and therefore meme-aided can be used as an alternative formative assessment tool. Tables 1.4 and 1.5 below provide the mean performances of the experimental groups in the seven schools and a T-test for the two assessment tests' mean performances, respectively.

Table 1. 4 Mean performances

SCHOOL	A	B	C	D	E	F	G
MEME-AIDED TEST MEAN	13.5	10.3	5.3	16.3	20.1	16.8	8.3
TRADITIONAL TEST MEAN	12.7	10.7	4.9	19.1	19.8	16.7	8.4

Table 1.5 T-test for mean performances in traditional and meme-aided for the 7 schools

t-Test: Two-Sample Assuming Unequal Variances		
	MEME-AIDED	*TRADITIONAL*
Mean	12.95714243	13.21428471
Variance	27.35026266	31.48143817
Observations	7	7
Hypothesized Mean Difference	0	
df	12	
t Stat	-0.088698611	
P(T<=t) one-tail	0.465392277	
t Critical one-tail	1.782287556	
P(T<=t) two-tail	0.930784555	
t Critical two-tail	2.17881283	

- *Meme integration impact on students' engagement, excitement and motivation*

The following findings were obtained on the impact the integration of mathematical internet memes has on learners' engagement, excitement, and motivation in the classroom, generally in the classroom environment;

Based on observations done during meme-aided mathematics instructions, students were actively engaged in interpreting memes and answering questions regardless of whether they were correct. They were curious, and memes invoked humor in students. Therefore, based on observations, integrating mathematical internet memes improves students' classroom engagement, excitement, and motivation.

A questionnaire filled out after the integration of mathematical internet memes by an experimental group of 30 students from each of the seven schools (210 students) provided the following results given in the pie charts figure 1.3 and 1.4 below where students were expected to rate how engaged and motivated they were in a meme-aided or meme integrated mathematics classroom. On the level of engagement, students were expected to rate whether they were highly, moderately, neutral, less, or not engaged.

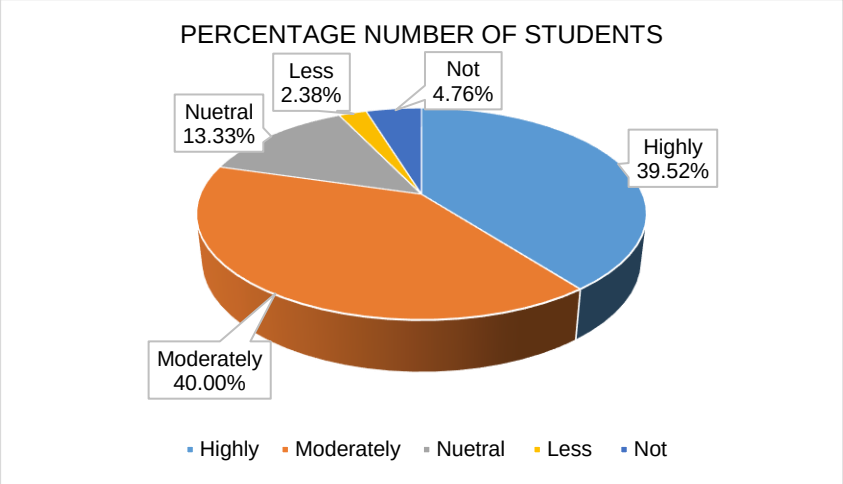

Figure 1.2 students' percentage distribution on level of engagement in meme integrated classroom

The results show that a higher percentage of learners were highly and moderately engaged in the meme-aided classroom.

On the level of motivation, students were expected to rate whether they were highly, moderately, neutral, less, or not motivated.

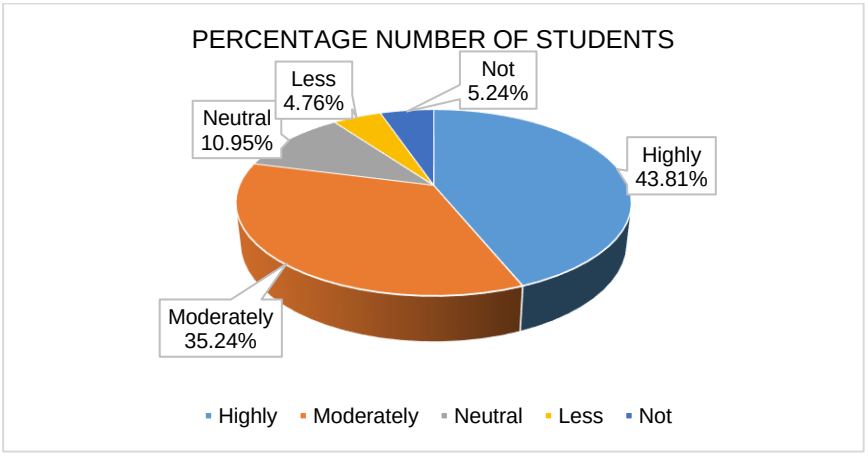

Figure 1.3 Students' percentage distribution on level of motivation in meme integrated classroom.

The results show a higher percentage of moderately and highly motivated learners in the meme-aided classroom. Moreover, from the questionnaire, of the 210 students, 77.14% representing 162 students, said they prefer meme-aided instruction over traditional instruction. This result indicates that integrating mathematical internet memes improves students' excitement and motivation.

In the focus group conducted after integrating internet memes in mathematics classrooms on eight students in each of the seven schools, all students stated that they would prefer a meme-integrated classroom over the traditional classroom. Moreover, students viewed meme-integrated mathematics classrooms as more engaging, motivating, and enjoyable than the traditional way of teaching mathematics. For instance one of the common response by the student was ""Bringing memes in math classroom breaks the monotony of being in the classroom and having the teacher on the board teaching math and that math can get boring to some extent but introducing memes in math class it is a lot more fun, makes you a lot more curious to know what this meme means which requires the knowledge you have. Memes make math classes a lot more fun, make you get all excited, have laughter and being happy during math lesson which is not very relevant or common in traditional math teaching" and "Meme integrated classroom is more engaging in terms of learner and teacher, more than the traditional classroom of teaching mathematics and this is because meme-integrated classrooms where the teacher brings in certain memes and finds several views about the

specific meme so that enhances more interaction between the teacher and the learner. Meme-integrated classroom learners are more motivated because memes bring the aspect that mathematics is not just about numbers."

- *Effect of integration of mathematical internet memes on performance*

The test statistics indicated no significant difference in mean performances in 30 marks traditional test administered to 30 students from experimental and control groups in each of the seven schools selected for the study. The result, therefore, indicates that mathematics performance is the same regardless of whether the teacher employs either meme-aided or traditional instruction. Hence, no evidence supports that meme-aided instruction or classroom improves students' performance in mathematics. The tables 1.6 and 1.7 below indicate the mean performances of the seven schools for experimental and control groups and the t-test for the mean performances. The t-test was based on a p-value of 0.05.

Table 1. 6 Mean performances for both experimental and control groups

SCHOOL	A	B	C	D	E	F	G
EXPERIMENTAL GROUP MEAN	12.7	10.8	4.9	19.1	19.8	16.8	8.4
CONTROL GROUP MEAN	11.2	11.5	8.0	15.7	17.1	17.7	7.7

Table 1. 7 T-test for mean performances in traditional tests by the Experiential and Control groups.

t-Test: Two-Sample Assuming Unequal Variances		
	EXPERIMENTAL GROUP	*CONTROL GROUP*
Mean	13.21428614	12.70476186
Variance	31.48143001	17.36311629
Observations	7	7
Hypothesized Mean Difference	0	
df	11	
t Stat	0.192888293	
P(T<=t) one-tail	0.425280822	
t Critical one-tail	1.795884819	
P(T<=t) two-tail	0.850561644	
t Critical two-tail	2.20098516	

- *Effect of memes on learning experiences and understanding*

Findings from experimental groups of 30 students from each school, who filled questionnaire after integrating mathematics memes in mathematics classrooms, showed that out of 210 students, 94.29% (198 students) indicated differences in learning experiences between traditional and meme-integrated mathematics classrooms. Of the 198 students who indicated differences in learning experiences between traditional and meme-integrated classrooms, 81.31% (161 students) stated that meme-integrated classrooms provide learning experiences that enhance understanding of mathematical concepts. A focus group of 8 students from the experimental groups in each of the seven schools stated that a meme-integrated mathematics classroom improves learning experiences and understanding of mathematical concepts.

Below are some of the students' statements from focus groups. These statements further provide evidence of memes' effect on learning experiences, understanding, engagement, motivation, and excitement in the mathematics classroom. The students were asked to say something about the memes. The student statements included

- "Memes are important because they open up our minds to the same concepts in a different way."
- "Integration of these mathematical memes in mathematics lesson is important because it makes lesson interesting where learners are amused and the same time learning concepts so like it also retains their memory on whatever they learn."
- "Memes are important because it exposes us to some of the mistakes that people make like in Integration (calculus), we tend to forget adding the C, so hence noting the basic concepts."
- "In my opinion, integrating memes in a math classroom makes math, easier to understand and fun."

- “Integration of mathematics memes in mathematics class makes it easy to understand than the traditional way.”
- “Memes in math have brought more understanding in mathematics….”
- “Integration has done more good than harm. This because, some students tend to have a negative attitude toward mathematics but if we have memes in mathematics class people will be lively because they make people understand better and they also make mathematics seem easier and lively so students will try and neutralize the negative attitude towards mathematics and it brings easier understanding.”
- “Memes are educative and help understand math.”
- “Memes make students think critically, relate the memes with different situations, they are interesting and they make students love math.”
- “Using memes in mathematics is fun, mostly like when you look at students they usually remember things that are actually fun, for example when you look at social media the ones that are funnier are the ones actually can remember so in math the memes are great and you understand more, you have fun and makes learning much fun than the normal learning.”

4. DISCUSSION

The results from this study reveal the educational significance of integrating mathematical internet memes in a mathematics classroom. It agrees with the previous studies that internet memes as a multimedia resource improves students' engagement, motivation, understanding, excitement, and learning experiences (Ahmad et al., 2010; Akinoso, 2018; Bini & Robutti, 2019; Cronby, 2022; Harshavardhan et al., 2020; Ogochukwu, 2016; Ramadhika, 2020). Meme-aided instruction, therefore, is teaching and learning pedagogy that improves multiple aspects of students' mathematics learning. In teaching and learning mathematics, teachers must embrace innovation and classroom practices that enhance learners' interest in learning (Mwelesi, 2014). Based on research findings, it is vividly evident that incorporating mathematical internet memes is an innovative classroom practice that is learner-centered. The meme-aided classroom is preferable for teaching and learning mathematics to a traditional classroom (GebreYohannes et al., 2016; Oguchukwu, 2010). The findings reveal that meme-aided formative assessment can be an alternative to traditional formative assessment in a mathematics classroom. This further approves meme-aided formative assessment as one of the educational uses of mathematics memes (Chongqing et al., 2020).

The literature provides no evidence of students' exposure to mathematical internet memes. Therefore, this study provides a unique finding that a higher percentage of the learners have mathematical meme-based exposure and can learn using memes. Moreover, the study's findings disagree with previous multimedia-based studies that use multimedia resources to improve learner academic performance (Akinoso, 2018). Unlike some previous studies, the study revealed that integrating mathematics internet memes as a multimedia resource has no significance on mathematics performance. Instead, previous studies have revealed that using multimedia resources somewhat improves students’ academic performance.

Most of the data collection instruments used in the study resulted in similar findings; for instance, observation, questionnaires, and focus groups all revealed that integrating memes improves students' engagement, motivation, and excitement in the classroom. The consistency of result findings from multiple instruments further validates the reliability of the study findings.

In the research, students were only subjected to the interpretation of mathematical internet memes. However, for the comprehensive analysis of mathematical internet memes, research should focus on all meme integration aspects: creation and interpretation. Such will provide more substantive and detailed evidence on using memes in the classroom. Moreover, the long-term effect of using mathematical internet memes in mathematics classrooms is subject to further study. Investigation of the impact of continued use of the mathematical internet will reflect on the nature of expected long-term repercussions and how to prevent or control any negative effects on the learning process. The findings in this study are short-term and may not be reliable for continued long-term integration, considering the digital revolution may cause internet memes to be irrelevant depending on the nature and generation of learners.

5. CONCLUSIONS

Mathematical internet memes have educational benefits that improve teaching and learning pedagogy, catering to learners' interests. Teaching and learning practices in mathematics classrooms should enhance students' focus and motivation and enrich learning experiences and understanding of mathematics concepts. Therefore, the integration of mathematical internet memes proves to be a better-suited pedagogy in teaching and learning mathematics than traditional learning pedagogy. This study, through multiple instruments, has produced evidence that supports the integration of mathematical internet memes as a teaching and learning pedagogy that is learner-centered and improves learning. It is a pedagogy that promotes both computational knowledge and formative assessment. The study has revealed that mathematical internet memes can be used as a formative assessment tool besides promoting students' engagement, motivation, excitement, and understanding and improving learning experiences. Even though based on the study, internet memes do not improve academic performance, it has other very critical educational benefits as indicated by the study. The study implies that mathematics internet memes will be useful multimedia resources for mathematics educators.

6. RECOMMENDATIONS

Based on the study, mathematical internet memes can improve mathematics learning and the classroom environment generally; however, this does not mean memes can be used independently in teaching and learning mathematics. Memes can only be used to supplement the traditional practice of teaching mathematics. The study by Matias (2020) stated that the meme-based learning method could not be justified to be employed independently in teaching and learning. Future research should reflect on the long-term effects of using mathematical internet memes in teaching and learning mathematics. Further research can be carried out on creating mathematical internet memes for students who lack digital skills. The study also recommends that the same study be conducted on all categories of schools.

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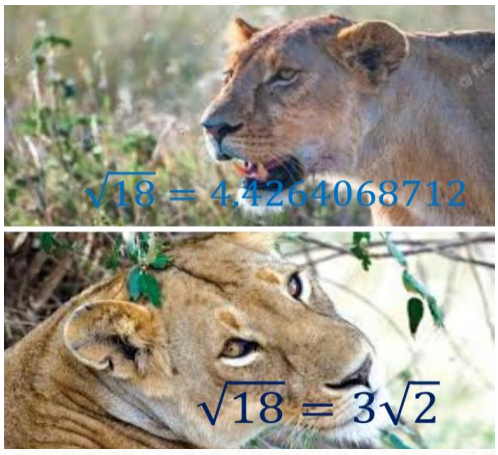
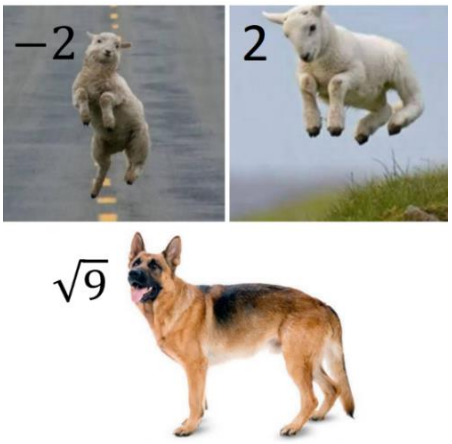
APENDIX

Some of the image-based mathematical internet memes used in the research





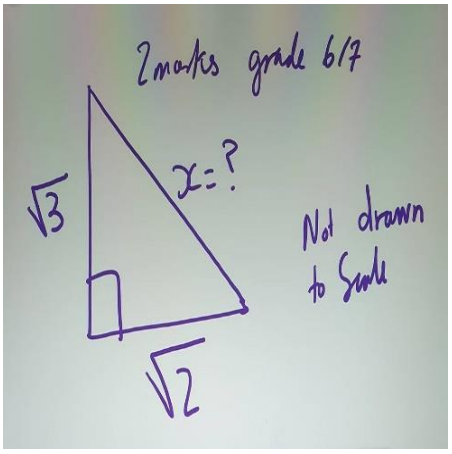
If Log $_4$ (x) = 12, then log $_2$ (x / 4) is equal to

A. 11

B. 48

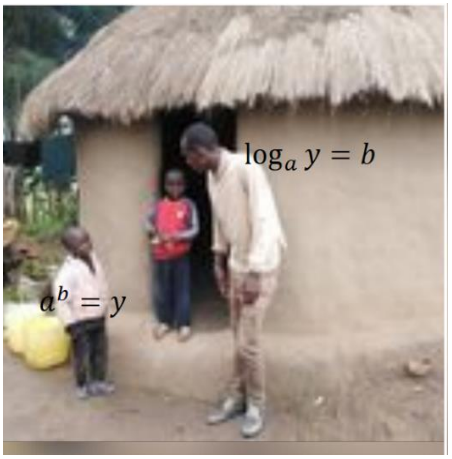
C. -12

D. 22

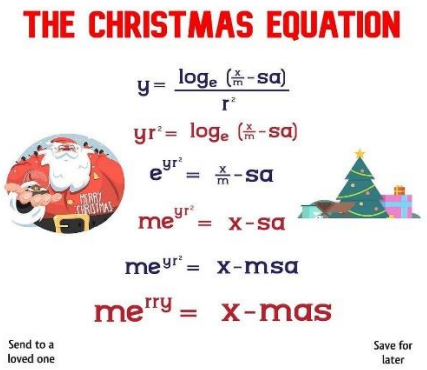


$$x^2 - 489x + 28980$$

A nice quadratic equation I found...



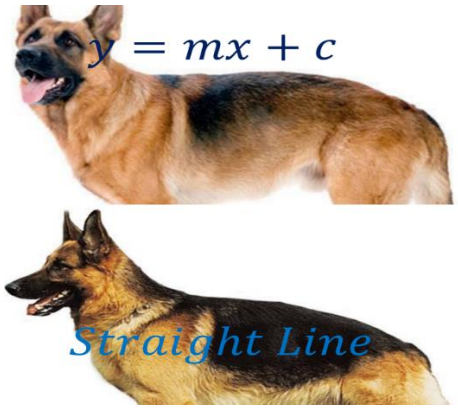

Sign in
Log in
Give me the lögs, brøther.


THE CHRISTMAS EQUATION
$y = \frac{\log_e(\frac{x}{m} - sa)}{r^2}$
$yr^2 = \log_e(\frac{x}{m} - sa)$
$e^{yr^2} = \frac{x}{m} - sa$
$me^{yr^2} = x - sa$
$me^{yr^2} = x - msa$
$me^{rry} = x - mas$
Send to a loved one
Save for later


There are
$4(\log_{36}6)$
types of people in this world:
Those who understand logarithms and those who don't.

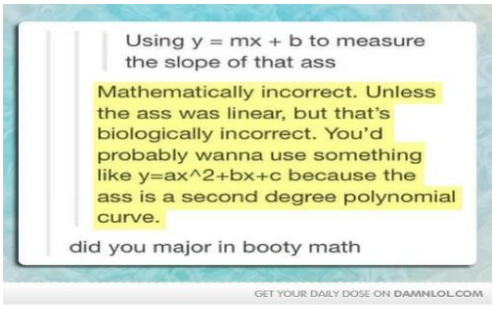

$y = mx + c$
$\frac{x}{a} + \frac{y}{b} = 1$


Straight Line
$y = mx + c$

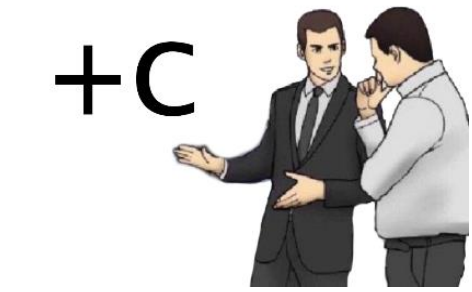

$y = mx + c$
Straight Line


$\sin\theta° = \cos(90 - \theta)°$
$\cos\theta° = \sin(90 - \theta)°$

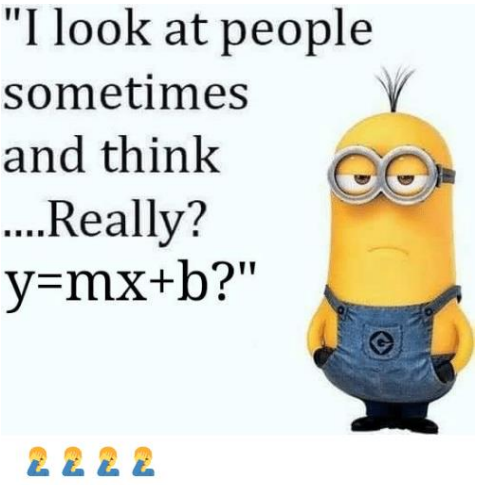

Phase angle = θ
$y = k\sin(bx \mp \theta)°$
Amplitude = k
????



Butt Math



math meme HAD TO BE DONE SHOUTOUT TO EVERYONE IN MR. B'S CLASS



Some of the video-based mathematical internet memes used in the research

The link below is access to some of the video-based mathematical internet memes used in this study; https://studio.youtube.com/channel/UCchmP-d6o-cZuNWWtlxz68w/videos/upload?filter=%5B%5D&sort=%7B%22columnType%22%3A%22date%22%2C%22sortOrder%22%3A%22DESCENDING%22%7

DOI: https://doi.org/10.15379/ijmst.v10i1.2691