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EFFECT OF MULTIMEDIA ON MATHEMATICS TO ENHANCE STUDENT ACHIEVEMENT AND RETENTION AT SECONDARY LEVEL STUDENT

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Abstract: The growth of multimedia technology in society is reflected in policies to encourage the use of multimedia in education and the development of educational multimedia. Multimedia learning of mathematics encompasses learning from instructional material, both traditional and computer-based that combines words and pictures in the domain of mathematics. In secondary school, the instructor should consider the cognitive growth of the students when utilizing media to teach mathematics in addition to these two concepts. Because if arithmetic instruction is tailored to pupils' cognitive development, it will be more relevant. The development of multimedia-based mathematics learning media was included in research and development. This study investigates the effectiveness of multimedia on students' performance in mathematics. The goal of this study is to determine of employing multimedia on students' academic performance. Therefore, the purpose of this study was to examine secondary school students' performance and retention in mathematics was influenced by a multimedia instructional technique. Two groups conventional (control) and experimental (based on multimedia) were generated from the research sample. While the students in the control groups were exposed to the traditional teaching approach on the same contents, the students in the experimental group were taught mathematics using a "multimedia instructional package" that had been installed on their school computers. The instrument's items were rearranged and given to both the experimental and control groups as a post-test after the treatment. Here, a total of 409 secondary school students' data were collected for study and were exposed to ANCOVA and t-Test statistics. However, intact classes were consciously divided into experimental and control groups. Consequently, adopted a quasi-experimental design. The study's pre-test, post-test, non-randomized, control group design is a type of quasi-experimental design. As a result, the quasi-experimental pre-test and post-test control group design was employed for this research. It employed the KR-20 Mathematics Achievement Test with a reliability coefficient. Students can learn at their own pace because of the inclusion of multimedia components in instructional materials. Student progress in maths disciplines is improved by learning with the incorporation of multimedia-mediated content, and it has also assisted students in better understanding science concepts and ideas. The findings of this study, depict that the integration of multimedia instructional strategy in mathematics is used to arouse students' interest in mathematics, and the multimedia instructional package helps to concretize the learning of mathematics and makes learning more effective.

Keywords: Multimedia, Mathematics Learning, Secondary Level Student, Quasi-Experimental Design, Student Achievement, and Student Retention Level.

1. INTRODUCTION

The primary concerns of education are teaching and learning. The efficiency of traditional direct education techniques versus computer-based, fully interactive, multimedia systems is compared in aptitude testing [1]. Additionally, regardless of the coaching learning methods used, a student's rate of learning, performance, and retention is influenced by a variety of elements, including the methods of instruction, the material being covered, the facilities offered by both schools and colleges, the learner's traits, and many other aspects of the student [2]. The significance of learner traits in the learning and teaching process is investigated in this study. To student academic achievement and memory, the relative efficacy of the interactive multimedia program and conventional direct techniques has been investigated [3]. ICT, which is referred to as the convergence of computer, communication, and content technologies, is attracting interest from the corporate world, governments, and communities to be used for novel and lucrative ideas [4]. The majority of tools, techniques, and lessons are available on the open internet [5]. There were many opportunities for sense-making and mathematical investigations given to the students through learning activities that encouraged them to analyze or create images, visualizations, and simulations. These activities also encouraged the students to connect multiple representations, such as graphics, numbers, algebra, and language [6].

Computer algebra systems, dynamic geometry environments, interactive applets, handheld computing, data collecting, computerized applications, and analytical devices are some examples of technology used in mathematics education [7]. Students discover classified concepts of mathematics and relationships enabled by these technologies [8]. Concerning other school subjects, mathematics is said to be the language used to express problems in most areas of science and technology [9]. The results demonstrated a student's math activities will rely on how interested they are in the material and how they feel about the grading system. Characteristics of students and their environments, teaching-learning models, and use of teaching materials [10]. The resources for learning and teaching in schools are convenient by the packages of multimedia [11]. Encyclopedias on CD-ROM, drill and practice programs, educational games, role-playing games, fun games, tutorials, and instructional software like Microsoft PowerPoint for class presentations utilizing a digital projector are all included in the multimedia packages [12]. The chalk-and-talk technique and printed books are the traditional teaching and learning tools [13]. Using the designed IT program that combined IT capabilities, students may study mathematics successfully. Increasing maths student proficiency might provide a more competitive workforce as Malaysia aspires to earn more income and advanced the nation. Mathematics is a piece of vital knowledge for many disciplines [14]. Researchers have shown that the instructional strategy teachers use while teaching mathematics is one of the problems contributing to this below-average performance. If pupils' weak maths performance persists, it may be impossible to achieve educational objectives for the country's scientific and technical advancement [15]. The research was done to learn more about how multimedia teaching techniques impact secondary school students' performance and retention in mathematics. The rest of the work is organized as follows, Section 2 reveals the literature survey of the work, section 3 portrays the materials and methods, section 4 depicted the result and discussion, and section 5 demonstrates the conclusion of the research.

2. LITERATURE SURVEY

Rahman *et al* [16] studied how the rehearsal mechanism impacted the performance of novice CAD learners during practice. The outcomes demonstrated that the rehearsal mechanism decreased learning time and increased drawing accuracy in comparison to the non-rehearsal option. A model describing the relationship between the characteristics of students, instructors, and parents and high school accomplishment was concealed by Nunes *et al* [17] using the self-reported final Math and Portuguese grades of 220 students. The findings indicate that obtaining an educational subsidy and prior retention lower maths achievement but not Portuguese. According to Deng *et al* [18], embedded questions have an impact on video engagement, students' perceptions, and academic achievement when used in pre-class educational movies. The findings indicated that the pre-class films' embedded questions had no discernible influence on satisfaction, assessment, emotional engagement, cognitive load, learning total views, information retention, or knowledge transfer. The goal of this qualitative investigation by Alshehri *et al* [19] was to comprehend how undergraduate maths students view their learning in an online learning environment. The research revealed that kids viewed technology as an additional tool that could not replace the need for teacher participation and interaction with students.

The sixth graders' "mathematical problem-solving skills" are encouraged via a comprehensive, interactive website, according to studies by Alkhatatneh *et al* [20]. The results showed that students' capacity to solve mathematical problems was statistically significantly affected by systematic approach-based interactive online training at the significance level. The effectiveness of Indigenous Knowledge Systems on student biology achievement and retention was studied by Josephine *et al* [21]. According to the findings, employing indigenous knowledge systems has an impact on students' academic success and biology memory skills. Sagge *et al* [22] proposed to determine how the established Computer-Generated Instructional Materials (CGIM) in academic calculus affected students' performance, thinking patterns, and problem-solving abilities including 36 students from each class that used work text, slide text, or both as an intervention. The outcome demonstrates that regardless of the type of intervention utilized, students' performance before the intervention was "average," their mind was "low," and their problem-solving skills were "basic." In their investigation of the relationship between Augmented Reality (AR) and gender, Alkhabra *et al* [23] focused on how the design of AR technology interacted with learners' ability to develop practical skills and Critical Thinking (CT). The findings demonstrated that augmented reality has an effect on students' long-term planning when used in educational contexts. Elfeky *et al* [24] wanted to determine if virtual classrooms were successful at fostering academic motivation among assortments of girls and boys pursuing professional master's degrees. according to the results, no statistically significant difference in the utilization of virtual classrooms was found in the development of academic motivation between different groups of girls and boys. Bulut *et al* [25] analyzed the existing literature on the artificial environment in mathematics education by using publications from 10 databases, including Web of Science Core Collection, Scopus, IEEE Xplore Digital Library, ERIC, Teacher Reference Centre, zbMATH Open, SpringerLink, JSTOR, MathSciNe, and Taylor & Francis Online Journals. The results of every article showed that using AR in mathematics instruction had positive outcomes.

3. RESEARCH PROBLEM DEFINITION AND MOTIVATION

The many areas involved in a country's development are changing quickly along with the rest of the globe today. One of these areas is education, which likewise moves in the same direction as the instrument of excellence for national development. Due to its advantages for society, ways to improve maths education should be a top priority for everyone involved in the education sector. Multimedia use may have a real impact in this area. Therefore, the focus of this study is on students' performance in senior secondary mathematics and whether there are any differences between students who were taught mathematics using multimedia materials and taught mathematics without using multimedia. Maths is thought to be a challenging topic that is less enjoyable and that only a select few students can master. Less gratifying learning outcomes are a result of these students' perspectives. Due to this, students are less enthusiastic about taking maths classes and find learning mathematics to be less appealing. Unsatisfactory learning outcomes in mathematics are thought to be caused by a lack of media use. As a result, mathematics educators and all other stakeholders in the educational system have grave concerns about the low performance of students in mathematics. Researchers have determined that one of the issues causing this subpar mathematical performance is the instructional approach teachers utilize while teaching mathematics. If students' weak maths performance persists, it may be impossible to achieve educational objectives for the country's advancement in science and technology.

Information and communication technology has significantly altered the learning environment in the classroom, making it more engaging for students and conducive to active participation during courses as opposed to a passive setting that is ineffective for learning and memory retention. The digital age has increased and will continue to grow the use of multimedia in education, including mathematics instruction. These resources are necessary for teachers to facilitate learning, help students understand, and bring concepts into reality. The advantages of using multimedia tools in the classroom go beyond simply making teachers' jobs easier, especially when it comes to supporting the formation of positive concepts, but also extend to assisting students in connecting their learning to real-world situations. Providing the teacher with access to multimedia learning resources enables the teacher to be more focused when instructing the subject and aids the students in having complete comprehension of the concept. By allowing students to learn at home and enhancing their learning abilities, multimedia also helps to make learning easier. Text, graphics, video, sound, and animation are just a few of the multimedia components that assist create an interactive learning environment that can aid in teaching and learning for both teachers and students. It promotes in-depth contemplation.

4. RESEARCH PROPOSED METHODOLOGY

Policies to promote ICT use in education and the creation of instructional multimedia reflect the evolution of information and communication technology in society. To create courses for students at various educational levels, multimedia comprises the use of text, graphics, animation, video, and audio. The use of multimedia technology can increase student interest in their studies and help them comprehend what they are studying. Students' Adaptive Learning involvement in science classrooms exposed to multimedia was examined to determine the correlations between the learning environment and student involvement. The scales are Learning Goal Orientation (the extent to which students have the drive/desire to develop skills and competencies by mastering tasks), Task Value (the extent to which students value the tasks that have been assigned to them), Self-efficacy (the beliefs or judgments that students hold about their capabilities to perform a task), and Self-regulation (the extent to which students engage in metacognitive and motivational learning). To make the instrument appropriate for use in maths classes, all scales were kept, but individual item wording was changed.

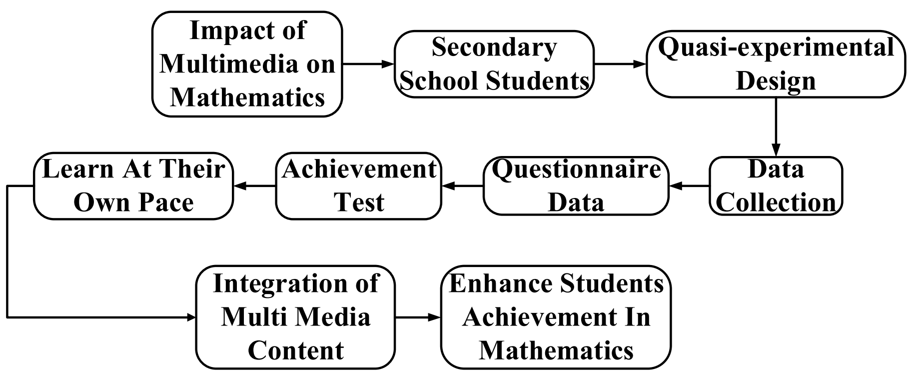

Figure 1: Block Diagram of the Research Work

In secondary school, the instructor should consider the cognitive growth of the students when utilizing media to teach mathematics in addition to these two concepts. Because if arithmetic instruction is tailored to pupils' cognitive development, it will be more relevant. Figure 1 depicts the flow diagram of the research work. Students in secondary schools fill out questionnaires to provide the data. Higher secondary school pupils can learn at their own pace by using the achievement test. The inclusion of multimedia content is utilized to raise students' math achievement.

4.1. Research Data Collection

A questionnaire is used to assess both groups before treatment. The experimental group receives instruction in multimedia instructional strategy, whereas the control group receives instruction using the traditional method. Both groups get a post-tested questionnaire after treatment. The success of the new treatment is assessed based on the outcomes of the post-test for both groups.

4.1.1. Samples

409 secondary school students were selected as a sample for the study, which was conducted on them. The experimental group and the control group are split up into two groups from the randomly chosen sample. Each group has 50% pupils in it. 409 students from 16 complete mathematics classrooms throughout the school were selected from the classroom. 179 male students and 230 female students made up the sample. Two criteria were used to determine which mathematics classes would receive frequent exposure to multimedia.

Table 1: Demographic Details of Respondents

Demographic	Characteristics	No. of Respondents	Percentage
Gender	Male	179	43.7%
	Female	230	56.3%
Age	13-14	98	23.96%
	14-15	217	53.06%
	15-16	94	22.98%
Standard	9	287	70.1%
	10	122	29.9%
School	Public	229	55.9%
	Private	180	44.1%
Test	Pre-test	207	50.5%
	Post-test	117	28.6%
	Retention-test	85	20.9%

First, only classrooms with frequent access to multimedia tools (such as interactive whiteboards, iPads, and computers via access to a computer lab) were regarded as having exposure to multimedia. Table 1 displays the respondents' demographic information by gender, age, standard, school, and test. In this survey, secondary students from both public and private secondary schools, aged 13–14, 14–15, and 15–16, comprised 230 female and 179 male participants. Second, it was determined whether the teacher was utilizing multimedia in relevant and integrated ways for students in courses where it was available over six weeks by observing specific sessions. In total, 221 students were considered to be regularly exposed to multimedia, while 188 students' classrooms were not. In every instance, the school's teachers taught classes for both of the groups those who were regularly exposed and those who weren't.

4.2. Research Design

To provide a generic mathematics accomplishment test that is valid, trustworthy, and contains high-quality items. This will be used to evaluate the subject-matter proficiency of senior high school students. The Development and Validation model was used in this study. The conceptualization, test development, test trial, and testing phases of the model are divided into these four steps.

4.2.1. Hypothesis of the Research

When compared to students who were not exposed to multimedia teaching strategies, there was a difference in the retention levels of the two groups of students, and the difference was in the former group's favor. The following is a presentation of the research's hypotheses.

- There is a positive relationship between Multimedia and students' interest in learning mathematics.
- There is a positive relationship between Expose to Multimedia and Student Engagement.
- Multimedia has a positive influence on students' Mathematical Achievement and their Retention Level.

Conceptualization: Understanding general mathematics ideas is the first stage. The created items for the General Mathematics Achievement test must accurately reflect each construct. The 409 General Mathematics learning competencies were used to create a test with 80 questions. All learning competencies were thus represented in the developed test.

Development of Test: The General Mathematics Achievement Test is the assessment developed for this study. The examination is a multiple-choice exam since this format is appropriate for the grade level being examined. Multiple choice questions are frequently used in schools to evaluate students, and teachers like them since they are simple to grade.

Drafting Questions of Test: The first stage was to decide which General Mathematics topics and keywords will be included in the accomplishment test. Functions and their graphs, business mathematics, and logic are the three categories of general mathematics elements used in this course.

Compilation of Items of Test: The General Mathematics Achievement Test's draught contained questions of varying degrees of difficulty. At the beginning of the compilation, there were 120 draught questions. Following a series of rechecks, readings, and references to the learning skills and table of specifications, a total of 80 items were utilized.

Content Validation of Test: Several specialists (validators) analyzed the General Mathematics Achievement Test draught to ensure that the content was accurate. Eight specialists from the domains of mathematics and mathematics education participated in the content validation. Both mathematics and mathematics education are their fields of expertise. In the area of assessment and evaluation, they are engaged researchers. Numerous specialists were asked to participate, and those who did confirm the test's validity. The exam questions, the table of specifications, and the syllabus outlining the learning competencies were given to the validators. They were questioned about their opinions on the developed items' quality. Some questions were rephrased for face validity, while others were changed or left out. Some people offered suggestions for improving the format of the questions. The validators fixed every issue and offered superior item detractors to ensure content correctness. They also offered criticism and ideas for enhancing the test that had been created. The final 80-item General Mathematics achievement test incorporated these comments and suggestions.

Trial of Test (Construct Validation): Construct validation was ensured when the General Mathematics Achievement draught was deemed face and content legitimate. Construct validity was guaranteed by ensuring that each test question accurately assessed students' proficiency in general mathematics. So, it was ensured that the exam was carefully constructed to validate the group of experts. Additionally, pertinent metrics and indicators were carefully created based on pertinent prior research regarding general mathematics exams.

General Mathematics Achievement: In the academic year 2021–2022, 60 secondary school students participated in this step. Here, the pupils were requested to answer a questionnaire about their general mathematics achievement. This stage's goal is to evaluate the usefulness and efficacy of the established General Mathematics achievement test.

4.3. Research Methodology

The study required to compare the study results for the experimental and control groups to determine how well students learned mathematics through the use of multimedia instructional strategies. Therefore, the researcher decided to use a quasi-experimental approach for this particular investigation.

A quasi-experimental pre-test, post-test, non-randomized, control group design was the research method used in the study. The factorial design of $2 \times 2 \times 1$ was used. The first two represents the control and experimental groups, the second two represent the genders (men and women), and the first represents the retention rate. Before the treatment, the groups had pre-testing to determine their capacity for equivalency. A week after the post-test, the students took a post-post-test to gauge their memory capacity. One intact class served as the experimental group that received the treatment, while a second intact class served as the control group that did not get the treatment. 179 male and 230 female students from the experimental and control groups total of 409 students in the sample. The "Multimedia Instructional Package (MIP)" and "Mathematics Performance Test (MPT)" were the tools employed in the study. For the MPT questions, the topics of logarithm, probability, proportion, and circle theorems were chosen. The five ADDIE processes of analysis, design, development, implementation, and evaluation were used to build the "Multimedia Instructional Package (MIP)".

The researcher created the instrument with the assistance of a qualified computer programmer, and a computer analyst assessed it. The "Mathematics Performance Test (MPT)" test instrument consisted of 25 multiple-choice questions with four possible answers each, drawn from the legitimate West African Senior Secondary School Examination. The Mathematics Performance Test was used to evaluate the pre and post-test performance of pupils in the experimental and control groups. The multimedia teaching package was used to provide the treatment to the experimental group. The second group received instruction using a traditional teaching strategy.

On 30 students from non-participating schools, the test-retest procedure was used to determine the reliability of the instruments. The Pearson Product Moment Correlation Coefficient was used to assess the data. A result of 0.87 was found. Utilizing mean and standard deviation, research questions 1, 2, 3, and 4 were addressed. Hypotheses 1, 2, and 3 were examined using ANCOVA statistics, also these hypotheses were checked using a t-test. While the students in the control groups were exposed to the traditional teaching approach on the same contents, the students in the experimental group were taught mathematics using a "multimedia instructional package" that had been placed on their school computers. The instrument's items were rearranged and given to both the experimental and control groups as a post-test after the treatment.

4.3.1. Tools Used for Analysis

For the pre-test, post-test, and retention tests in this study, the researcher used a questionnaire. The researcher created an instructional package using multimedia. It contains the information found in standard mathematics books IX and X about the number system. It includes images, audio, and video.

4.3.2. Statistical Techniques

This study examines the value of multimedia instructional strategies for teaching maths. Determining whether there were any notable differences between the two groups is crucial. For statistical analysis, the t-test and test of significance of the difference between means were calculated. The gain score is determined using the formula below.

$$Gain\ Score\ =\ Post-test\ -\ Pre\ test \tag{1}$$

4.3.3. Assessing Student Engagement

Multimedia technology was thought to be crucial for adaptive mathematics learner engagement. The scales are Learning Goal Orientation (the extent to which students have the drive/desire to develop skills and competencies by mastering tasks), Task Value (the extent to which students value the tasks that have been assigned to them), Self-efficacy (the beliefs or judgments that students hold about their capabilities to perform a task), and Self-regulation (the extent to which students engage in metacognitive and motivational learning). To make the instrument appropriate for use in maths classes, all scales were kept, but individual item wording was changed.

4.4. Data Analysis

To ascertain whether there were any variations between the perspectives of students in their classrooms who often engaged in multimedia, an analysis of covariance (ANCOVA) was utilized. The set of scales served as the dependent variable, and Frequent/Infrequent Exposure to Multimedia served as the independent variable. The univariate ANOVA results were analyzed for each of the dependent variables because the ANCOVA produced statistically significant results using Wilks' lambda criteria. The significance level that was generally used was 0.05. To estimate the number of differences between the two groups, the effect size (derived by dividing the difference between the average item means for the two groups by the pooled standard deviation) was determined. The formula utilized was as follows:

$$Cohen'sd = (M_1 - M_2)/\sigma_{pooled} \text{ Where,} \sigma_{pooled} = \sqrt{[(\sigma_1^2 + \sigma_2^2)/2]} \quad (2)$$

Using data from 221 students in classes that regularly used multimedia, simple correlation, and multiple regression analyses were carried out to look into correlations between students' impressions of the learning environment and their engagement with mathematics. The bivariate association between each learning environment scale and each engagement measure was investigated using simple correlation analysis. To establish the combined impact of the set of WIHIC scales on each engagement scale, multiple regression analyses were performed. In all instances, analyses were carried out separately using the class means and the individual means as the unit of analysis.

To assess the test's content validity, the insights of numerous professionals in the fields of mathematics and mathematics education were employed. Both content validity and construct validity were utilized as measures of validity in this study. Expert judgment was used during content validation to evaluate the language, construction, and material characteristics. This was done to make sure that every product developed by the students is fully understood by them and that every math construct used measures what it is supposed to measure. Before the experts suggested using the created test for pilot testing, it underwent three checks and revalidations. Participants in the pilot study came from a random sample of 409 secondary school pupils. Item analysis was done following the test's pilot testing with students to determine the test items' level of difficulty and uniqueness. Values for the validity and reliability coefficients, which must always be positive and between 0.00 and 1.00, were guaranteed. Inappropriate and deceptive questions were not accepted. The reliability coefficient, KR-20, was calculated. The KR-20 was used to examine the internal consistency of the scores from the concurrently administered test. The achievement test was then analyzed on this final shape.

5. RESULTS AND DISCUSSION

Statistical Package for Social Sciences (SPSS) version 23.0 was used to do descriptive and inferential statistical analysis of the data. Four research hypotheses for each of the four research topics were investigated in this study utilizing the t-test and Analysis of Covariance (ANCOVA). The independent sampling t-test was used to test research hypotheses 1 and 2 at the 0.05 level of significance, while ANCOVA was used to test research hypothesis 3.

Table 2: Simulation System Configuration

SPSS Statistical Tool	Version 23.0
Operation System	Windows 10 Home
Memory Capacity	6GB DDR3

Processor	Intel Core i5 @ 3.5GHz

Table 2 depicts the simulation configuration table. The data were subsequently analyzed to test the null hypothesis that, when taught via multimedia courseware, there is no discernible difference between male and female senior school students' performance in word problems requiring linear equations.

5.1. ANOCOVA Test

Analysis of covariance combines regression analysis and analysis of variance (ANOVA). From each experimental unit, observations are occasionally made on one or more independent variables aside from the research variable. Ancillary or concomitant variables are the term(s) used to describe the independent variables. ANOCOVA is used in these situations to determine whether the change in the study's (dependent) variable across classes is attributable to class effects or its dependency on the accompanying variable(s) (x). By accounting for the reliance, the ANOCOVA manages experimental error.

Table 3: Tests of Between-Subjects Effects

Dependent Variable: MA					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	722.311[a]	24	30.096	.828	.701
Intercept	10293.314	1	10293.314	283.306	.000
LSE	3.243	1	3.243	.089	.765
EM	721.230	23	31.358	.863	.649
Error	13951.836	384	36.333		
Total	154414.000	409			
Corrected Total	14674.147	408			
a. R Squared = .049 (Adjusted R Squared = -.010)					

Table 3 demonstrates the tests of between-subjects effects, that there were no interaction effects found in the ANCOVA data. To test the null hypothesis that there are no interaction effects between multimedia courseware, gender, and student performance levels in linear equations involving word problems, the data was subjected to additional analyses using ANCOVA. The results are shown in Table 9. The analysis findings show that the F-value was not significant because the p-value of 0.35 was higher than the 0.05 alpha threshold ($F(1,23) = 0.828$, $p>0.05$). This result shows that when students were taught linear equations including word problems, there was no significant interaction effect of treatment on gender or scoring levels, and thus addresses study concerns. As a result, the hypothesis was upheld, which meant that the treatment multimedia courseware was unaffected by the moderating variables of gender or level of score. As a result, the performance of the students was significantly affected by the use of multimedia courseware as a major treatment.

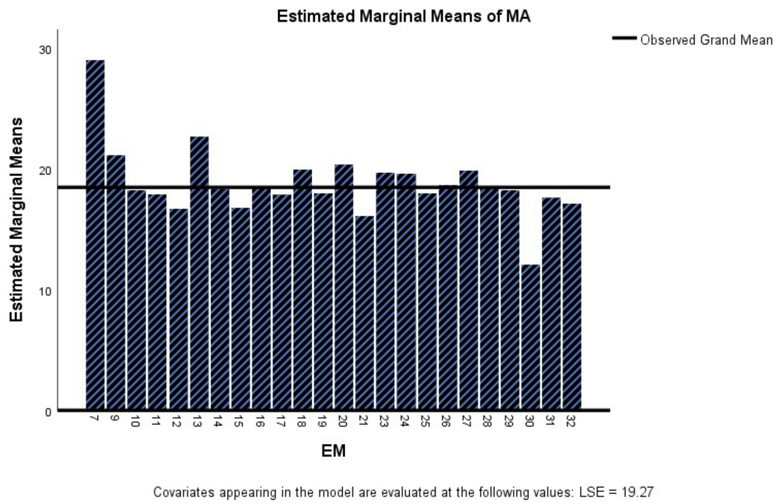

Figure 2: Estimated Marginal Mean Graph

The Estimated Marginal Mean Graph of mathematical achievement is shown in Figure 2. The calculated marginal means are displayed as a profile plot of one element, which indicates whether they are rising or falling across levels. Parallel lines for two or more factors show that there is no interaction between the factors, hence just one factor's values should be examined. The calculated marginal means are displayed as a profile plot of one element, which indicates whether they are rising or falling across levels. Parallel lines show that there is no interaction between variables for two or more components, therefore investigate the values of the individual elements. Nonparallel lines signify a relationship.

5.2. T-Test

The ratio of the difference in group means over the combined standard errors of both groups is used by the t-test to evaluate the genuine difference between the two group means.

Table 4: One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
EM	409	19.03	5.852	.289
SIM	409	18.90	5.733	.283
SE	409	18.83	5.900	.292
LSE	409	19.27	5.868	.290
RL	409	19.10	6.017	.298

MA	409	18.48	5.997	.297

Table 4 portrays the one-sample statistics test. To ascertain whether a sample originates from a population with a particular mean, apply the one-sample t-test. Although not always known, this population means is occasionally hypothesized. This is necessary because a one-sample t-test should only be used if your data "passes" the four criteria that must be met to produce a reliable result. The measured difference is divided by the scatter in the sample data to determine the t-value. This contradicts the null hypothesis more strongly the bigger the size of t. The null hypothesis is rejected if the estimated t-value exceeds the crucial t-value.

Table 5: One-Sample Test

	Test Value = 45					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EM	-89.748	408	.000	-25.968	-26.54	-25.40
SIM	-92.075	408	.000	-26.100	-26.66	-25.54
SE	-89.710	408	.000	-26.174	-26.75	-25.60
LSE	-88.692	408	.000	-25.733	-26.30	-25.16
RL	-87.048	408	.000	-25.897	-26.48	-25.31
MA	-89.417	408	.000	-26.516	-27.10	-25.93

Table 5 shows that the t-value was statistically significant at the 0.05 alpha level. This finding provides an answer to research question 2 since it shows that male students outperformed female students when they were taught linear equations including word problems utilizing multimedia courseware. The second hypothesis was thus disproved, suggesting that multimedia courseware benefits maths students. The t-values produce negative values and negative mean difference values, and the significance level is 0.000.

5.3. Reliability Test

The degree to which test results hold across testing sessions, test iterations, or raters evaluating test takers' responses is referred to as test score reliability.

Table 6: Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.161	.159	6

Reliability statistics test Results are shown in Table 6. It consists of reliability statistics that were used to assess the instruments' dependability over the study period. There are six items used in this analysis. However, Cronbach's alpha values were 0.159 based on standardized items and overall Cronbach's alpha value is 0.161.

Table 7: Summary Item Statistics

	Mean	**Minimum**	**Maximum**	**Range**	**Maximum / Minimum**	**Variance**	**N of Items**
Item Means	18.935	18.484	19.267	.782	1.042	.073	6

The reliability test's summary item data are shown in Table 7. It demonstrates that summary statistics, which are a subset of descriptive statistics, provide an overview of the sample data. By determining the minimum, maximum, range, and variance of the observations, statisticians frequently attempt to describe and characterize them. In this case, the range is 0.782 and the minimum and maximum values for 6 items are 18.484 and 19.267. The mean values are 18.935, the variance is 0.073, and the maximum/minimum value is 1.042.

Table 8: ANOVA with Friedman's Test

		Sum of Squares	**df**	**Mean Square**	**Friedman's Chi-Square**	**Sig**
Between People		16383.531	408	40.156		
Within People	Between Items	148.762[a]	5	29.752	4.419	.491
	Residual	68692.405	2040	33.673		
	Total	68841.167	2045	33.663		
Total		85224.698	2453	34.743		
Grand Mean = 18.94						
a. Kendall's coefficient of concordance W = .002.						

The ANOVA and Friedman's test are shown in Table 8. The non-parametric substitute for the one-way ANOVA with repeated measures is the Friedman test. In situations when the dependent variable being measured is ordinal, it is utilized to examine changes across groups. It can also be applied to continuous data that deviates significantly from normality and hence cannot be utilized to perform a one-way ANOVA with repeated measures. The significance level for Friedman's chi-square is 0.491, and its value is 4.419.

Table 9: Intraclass Correlation Coefficient

	Intraclass Correlation	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.031[a]	.005	.061	1.193	408	2040	.009
Average Measures	.161[c]	.029	.281	1.193	408	2040	.009

Two-way mixed effects model where people effects are random and measures effects are fixed.

a. The estimator is the same, whether the interaction effect is present or not.

b. Type C intraclass correlation coefficients using a consistency definition. The between-measure variance is excluded from the denominator variance.

c. This estimate is computed assuming the interaction effect is absent because it is not estimable otherwise.

The intra-class correlation coefficient (ICC) is displayed in Table 9. When there are two or more independent raters and the outcome is measured on a continuous scale, the ICC is used to evaluate the agreement. The lower and upper bounds for average measures are 0.029 and 0.281, respectively, while the ICC has a value of 0.161 and a significance value of.009.

Table 10: Inter-Item Correlation Matrix

	EM	SIM	SE	LSE	RL	MA
EM	1.000	-.009	.103	.007	.033	.020
SIM	-.009	1.000	-.039	-.065	.046	.041
SE	.103	-.039	1.000	.077	.092	-.018
LSE	.007	-.065	.077	1.000	.045	.009
RL	.033	.046	.092	.045	1.000	.115
MA	.020	.041	-.018	.009	.115	1.000

Table 10 below contains the inter-item correlation matrix. A favorable outcome is shown by inter-item correlation values between 0.15 and 0.50. Items have poor correlation when the value is less than 0.15. Items that have a value higher than 0.50 are more strongly associated and may measure the same construct more than once.

Table 11: Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
EM	94.58	195.989	.065	.012	.138
SIM	94.71	209.735	-.010	.009	.203
SE	94.78	190.988	.093	.026	.113
LSE	94.34	201.202	.032	.012	.168
RL	94.51	181.236	.145	.026	.061
MA	95.13	193.106	.071	.016	.133

Table 11 above displays the work's item-total statistics. The correlation between the question score (e.g., 0 or 1 for multiple choice) and the overall scale variance is known as the item total correlation and it is 195.989. It is anticipated that participants who correctly answer a question will often receive higher overall evaluation scores than those who incorrectly answer a question. However, for EM and MA, their Cronbach's alpha values are 0.138 and 0.133.

Table 12: Scale Statistics

Mean	Variance	Std. Deviation	N of Items
113.61	240.934	15.522	6

Table 12 below displays the results of the scale statistics. The variables or quantities in statistics are defined and categorized using various measuring scales. Specific characteristics of each level of the measurement scale determine the diverse applications of statistical analysis. The quantitative variables, however, are either ratio variables or interval variables. There are six total elements used for analysis; their mean values are 113.61, 240.934 for variance, and 15.522 for standard deviation.

5.4. Correlation

The most popular method for determining a linear connection is the Pearson correlation coefficient (r). The intensity and direction of the link between two variables are expressed as a number between -1 and 1.

Table 13: Correlation Coefficient Results

Correlations							
		EM	SIM	SE	LSE	RL	MA
EM	Pearson Correlation	1	.009	.103*	.007	.033	.020
	Sig. (2-tailed)		.850	.037	.886	.511	.684

	A sum of Squares and Cross-products	13970.587	128.697	1456.257	99.535	467.665	288.707
	Covariance	34.242	-.315	3.569	.244	1.146	.708
	N	409	409	409	409	409	409
SIM	Pearson Correlation	.009	1	-.039	-.065	.046	.041
	Sig. (2-tailed)	.850		.433	.192	.358	.411
	A sum of Squares and Cross-products	128.697	13408.890	-536.117	-888.073	641.210	571.848
	Covariance	-.315	32.865	-1.314	-2.177	1.572	1.402
	N	409	409	409	409	409	409
SE	Pearson Correlation	.103*	-.039	1	.077	.092	-.018
	Sig. (2-tailed)	.037	.433		.119	.063	.717
	A sum of Squares and Cross-products	1456.257	-536.117	14204.675	1091.922	1334.291	-259.628
	Covariance	3.569	-1.314	34.815	2.676	3.270	-.636
	N	409	409	409	409	409	409
LSE	Pearson Correlation	.007	-.065	.077	1	.045	.009
	Sig. (2-tailed)	.886	.192	.119		.359	.863
	A sum of Squares and Cross-products	99.535	-888.073	1091.922	14047.951	654.807	123.232
	Covariance	.244	-2.177	2.676	34.431	1.605	.302
	N	409	409	409	409	409	409
RL	Pearson Correlation	.033	.046	.092	.045	1	.115*
	Sig. (2-tailed)	.511	.358	.063	.359		.020
	A sum of Squares and Cross-products	467.665	641.210	1334.291	654.807	14769.687	1695.667
	Covariance	1.146	1.572	3.270	1.605	36.200	4.156
	N	409	409	409	409	409	409
MA	Pearson Correlation	.020	.041	-.018	.009	.115*	1
	Sig. (2-tailed)	.684	.411	.717	.863	.020	

	A sum of Squares and Cross-products	288.707	571.848	-259.628	123.232	1695.667	14674.147
	Covariance	.708	1.402	-.636	.302	4.156	35.966
	N	409	409	409	409	409	409
*. Correlation is significant at the 0.05 level (2-tailed).							

The results of the Pearson correlation coefficient are shown in Table 13. Using Pearson correlation statistics with a 0.05 alpha level of significance, this coefficient of 0.850 was found. This shows that exposure to multimedia and pupils' enthusiasm for learning mathematics are positively correlated. Its correlation coefficient is 0.009. It also shows that there is a strong link between EM and SE. As a result, there is a link between student involvement and multimedia exposure. It generates correlation coefficients of 0.103* with a significance level of 0.037. As a result, students' achievement in mathematics and their degree of retention are both positively impacted by multimedia exposure. Its significant values are 0.511 and 0.684, and its correlation values are 0.033 and 0.020.

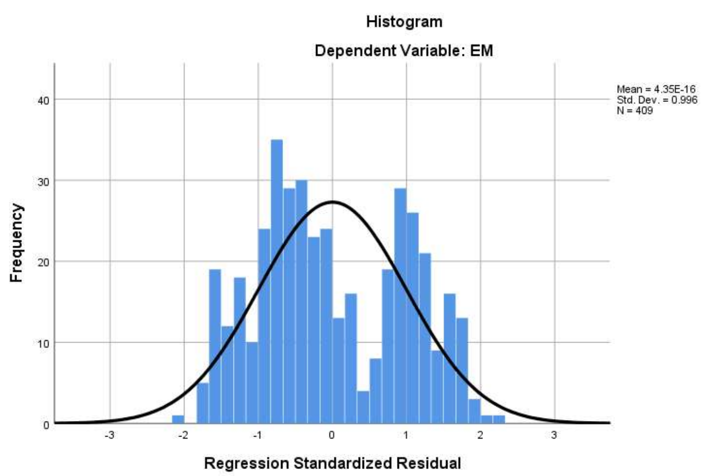

Figure 3: Regression Standardize Residual Graph

Residual plots show fitted values, or another variable, on the x-axis, and the residual values on the y-axis are presented in Figure 3. Checking the residual plots is essential after fitting a regression model. It cannot rely on the regression coefficients and other numerical results if the plots show undesirable patterns.

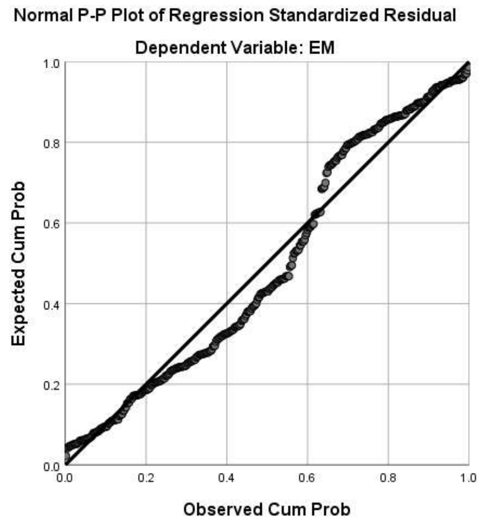

Figure 4: P-P Plot for Regression Standardize Residual

Figure 4 depicts the P-P plot, which contrasts the standardized residual's observed cumulative distribution function (CDF) with the normal distribution's anticipated CDF. The scatters should fall on or very closely next to the normal distribution line if the Standardised residuals are normally distributed.

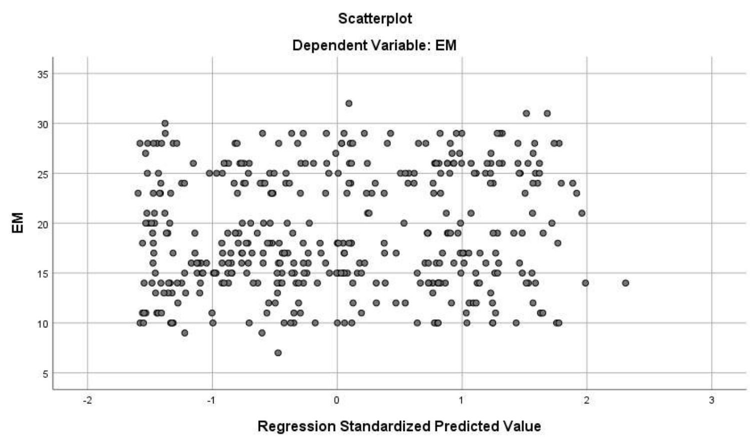

Figure 5: Scatterplot of Regression

Figure 5 demonstrates that a normal distribution of residuals exists since the scatters of the residuals essentially lie along the normal distribution line. The graph demonstrates that there is no significant divergence of residuals from the normal line. Additionally, the data set is visible to be passing through the origin. Therefore, it suggests that the residuals are roughly regularly distributed. The observed data may therefore be regularly distributed.

6. RESEARCH CONCLUSION

Mathematics is a subject in structured first understand the material that is easiest to material hardest. Mathematics lessons are useful in everyday life this is a subject that still feared learners. Mathematics is a science of using reason so mathematics is considered to be something difficult to learn. In this study, the multimedia-based mathematics learning model is presented. It consists of a quasi-experimental design to analyze the student's performance and retention level by using multimedia technology. The uses of interactive multimedia in teaching mathematics indeed give a great impact on the students 'understanding of mathematics. The experimental group showed a performance improvement and this improvement was statistically significant since the students got better achievement in their mathematics understanding by using interactive multimedia-based learning media. However, using multimedia can enhance students' maths learning to a certain level. However, there was no statistically significant difference between the means of the experimental and control groups. The mathematics curriculum may incorporate multimedia instructional techniques, which can also be utilized to spark students' interest in the subject. This multimedia approach improved pupils' academic performance in mathematics to a considerable extent. Finally, student involvement in math classrooms that used multimedia was related to the learning environment. These findings provide potentially significant information on the student exposure to multimedia might encourage more supportive learning settings and improve student engagement in learning mathematics. The results of this study also demonstrated that learning maths for secondary education was suitable for the student-centered learning strategy. In the post-test results, students were discovered to be more actively involved in their learning, which contributed to higher academic achievement. Based on the results of research and development, it can be concluded that the multimedia-based learning model is suitable for improving students' retention levels and their achievement in mathematics, respectively.

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