

INSTRUCTIONAL OUTPUTS IN JIGSAW AND PROBLEM-SOLVING APPROACHES OF MATHEMATICAL ASPECT OF STATISTICS

By

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Abstract

The study examined the efficacy of instructional outputs of Jigsaw IV and problem-solving approaches of mathematical aspect of statistics. As a quasi-experimental study, one research question and hypothesis were raised for the study with purposively sampled of 35 mathematics teachers and 2,454 SS2 students from senior secondary schools in Lagos State, Nigeria. A 30-item multiple choice questions on mathematical aspect of Statistics was constructed via a test blue print along mean, median, mode, standard deviation and elementary probability. The Cronbach's Alpha reliability coefficient of the pre and post administration of instrument was 0.86. The statistical tools used for the study included mean, Bar-Chart, One-way ANOVA and Post-Hoc(Scheffe) of version 20 of Special Packages for Social Sciences(SPSS).. Finding showed that there was significant difference in the instructional outputs of students exposed to different groups($F(2,2451)=64.99;P<0.05$). The Scheffe Post-Hoc result further revealed that the Jigsaw IV accounted for the significant difference in students' instructional outputs. The discussions of the findings, conclusion and recommendations as embracing the use of Jigsaw strategy to enhance students' learning outcomes, mathematics teachers should learn to improvise, and the strategy should be adopted at all time, with or without instructional materials, among others, were proffered in the study.

Keywords- *Instructional Outputs, Jigsaws, problem-solving, mathematical aspects, statistics.*

Introduction

It is imperative to believe that achievement of the goals and objectives of teaching and learning of mathematics might remain elusive if adequate attention is not paid to the choice of instructions. The relevance of Mathematics to developing society is unquantifiable in relation to science and technology, and this is why high esteem is given to mathematics in some countries, as witnessed in the increased advancement in scientific knowledge and daily discovery of new theories and concepts. The decaying performance and escalating nature of malpractices have succeeded in impeding the purpose for which mathematics was introduced into secondary schools, and little wonder, the existence of a chasm between fathers land (Nigeria) and mothers land (the colonial masters and developed countries). Inefficient tutors have over the years been using any methods at their disposal or that they are accustomed to, which is against the teaching ethics of using the right method that makes a concept easier. Mathematics classes should be participatory and involve the use of appropriate method that suits the content in order to retain mathematics as the mother tongue of science and technology. It is expected that the educated man should be able to solve the immediate problem of the society by virtue of his training. This is why Frazer and Cassey (2000) regarded problem solving as the result of application of knowledge and procedures to a problem situation. As result problem solving approach involves transfer of knowledge from what is known to bring solution to what is unknown. Jigsaw IV is combination of multimedia and Jigsaw as developed by Aronson, Blaney, Stephan, Sikes and Snapp (2008). Hence, the

need to find the instructional outputs in Jigsaw IV and problem-solving approaches of mathematical aspect of statistics.

Historical Development of Jigsaw as an Instructional Strategy of teaching and learning

The origin of the jigsaw puzzle is generally attributed to a European cartographer named John Spilsbury, who cut a wooden map of the British Empire into pieces in the 1760s so the aristocracy's children could learn the geography of the lands which Britain ruled. These early wooden puzzles, called "Dissected Maps," began the history of the jigsaw puzzle, and their popularity among the upper class in both Europe and the U.S. grew steadily throughout the 1800s. By 1900, the wooden jigsaw puzzle in the U.S. had evolved from children's games into a form of entertainment for wealthy adults. The jigsaw puzzle found its way back across the Atlantic Ocean in the first decade of the 20th century, now as a popular form of adult entertainment rivaling bridge and lawn bowling, and would often be found at parties or in the parlors of weekend estates (Bliese, 2000).

Early in the 20th century, Parker Brothers began producing their handout, wooden Pastime Puzzle line in Salem, MA, which quickly became one of the best remembered puzzle lines in the history of the jigsaw puzzle. Soon after, Milton Bradley entered the market with their wooden Premier Jig Saw Puzzles. A host of others, such as Detroit Publishing Company's Travel Picture Puzzles, followed suit as the popularity of wooden jigsaw puzzles soared in the first three decades of the 20th century (Bauer, 2003). It was not until the Great Depression was underway that manufacturers of die-cut, cardboard Jigsaw puzzles sprung up to meet the market demand for the entertainment of puzzles at prices families struggling through the Great Depression could afford. The most popular of these cardboard puzzles during the 1930s was the Perfect Picture Puzzle, manufactured by the Consolidated Paper Company in Somerville, MA. Known as "Weeklies" because a new puzzle was released each week, Perfect Picture Puzzles sold for ten to twenty-five cents each in 1933, bringing puzzle prices well within reach of the middle and lower classes, and thereby greatly expanding the puzzle market (Bell & Kozlowski, 2002).

Throughout the Great Depression in the U.S., as the bottom dropped out of the economy and unemployment and poverty levels reached staggering heights, the Jigsaw puzzle took on a vital role as a positive source of family entertainment. Indeed, the jigsaw puzzle helped hold families together during the decade of strife-the wooden puzzle among the rich and the cardboard puzzle among the poor (Bliese, 2002). One exceptional and unique production method came to life in the 1930s when a man named Charles Russell of Auburn, Massachusetts, fashioned a saw blade to his wife's sewing machine and began cutting wooden jigsaw puzzles with it. That lamp enabled Mr. Russell to cut puzzles for well over another decade (Bliese & Hanges, 2004). Anne, an economics professor at Bates College and jigsaw puzzle collector and historian, wrote a thorough history of the jigsaw puzzle in 2011, *The Jigsaw Puzzle: Piecing Together a History*. Anne Williams' book is much more comprehensive than the historical summary of some authors (Bliese & Ployhart, 2002). In the latter part of 20th century, Jigsaw was developed by Elliot Aronson and his graduate students at the University of Texas and the University of California in the 1970s. According to Aronson, the technique was invented when he and his students were trying to establish ways to defuse an explosive situation, Aronson (2000-2008).

Research suggests that Jigsaw could be used across all grade levels in Nigerian/Foreign tertiary institutions and for professional courses in various content areas. Since the creation of jigsaw, several modifications have been introduced to account for concerns of both teachers and students who have participated in the classroom technique. In Jigsaw II, all students were

made to research specific topics as opposed to parts of one larger reading. This variation of the original technique requires that students complete “expert sheets” that provide notes for introducing the topic back to base group and are given individual assessments as opposed to a group evaluation (Holliday, 2002). Jigsaw III allows for a review process prior to assessment, Jigsaw IV has several additional features when teacher’s introduction of material, expert group quizzes, review process prior to individual assessment, and re-teaching of any material that was not adequately explored in the collaborative group work. This theoretical framework assumes homology across levels-that is, similar relationships between parallel constructs across levels of analysis (Kozlowski & Klein, 2000). In either case, explicit tests of homology help to highlight domains where inferences of homology are warranted and domains where they are not (Chen, Mathieu, & Bliese, 2004; Kozlowski & Klein, 2000). The primary role of the educator is to choose learning material, structure the groups, explain the cooperative nature of group work, provide an environment conducive for the type of work, monitor group work, and assist students in summarizing, synthesizing, and integrating material (Smith, 2001). It is also essential that the teacher effectively model and explain jigsaw prior to involving students in this type of teaching method. Sometimes teachers find that more talkative students tend to dominate discussions in the jigsaw groups. The second innovation refers to the interlocking style of the puzzles, which made it easier for puzzlers to assemble their puzzle without losing any pieces (Perkins & Saris, 2001). Furthermore, the satisfaction one gets when solving a puzzle that offered no clues is unique as one has seen how it looks like puzzles have an impressive history and here to stay (Clint, 2012)

The two concepts Jigsaw and Problem-solving were taking from the angle of Aronson and Polya respectively. They were considered as people who actually brought development to problem-solving and jigsaw puzzle that are useful till date. Learning how to solve problems in mathematics knows what to look for Mathematical problems often require established procedures and knowing what and when to apply them. To identify procedures, one has to be familiar with the problem situation and be able to collect the appropriate information, identify a strategy or strategies and use the strategy appropriately. According to Williams (2004) quoting Polya in a book titled 'How To Solve It' in the mid-20th century many of the ideas that worked then continue to work for us today but the steps below are very similar to those expressed in Polya's book. As one of the cooperative learning techniques where learners work in smaller groups to aid one and another’s learnings. It is a collaborative learning style which organizes learner into grouped work that helps in relying on one another. Repackaged by Aronson, Blaney, Stephen, Sikkess and Snapp (2017), the technique postulated that students were divided into smaller groups, where in students have to learn the given material in their groups. The material was divided into parts and the students in groups read the part of material allocated to each member of the group. Then Students come together in expert groups to discuss the material. After that they return to their groups to teach the group mates about the part of material which they had mastered in expert groups. This has been acclaimed to be helpful for discussion in particular the second language due to the elaboration of material to other group mate which is unseen for them. In the approach, the teacher presents a topic and its sub while students are divided into small groups of four, five to six, which is referred to as Jigsaw groups. Simultaneously, learning is sub-divided into different segments, and each student is assigned to a sub so as to enable specialize. By inference, all students with similar topic form expert groups, which reconvenes as soon as learning is over, in order to solve self-assessment questions individually. However, it is

necessary for the teachers to ensure that the students must have read and understand the assigned material.

Empirical Studies on Jigsaw as an Instructional Strategy

As one the techniques that enhance mastery learning it lends itself to almost every subject, but it is more suitable in mathematics instruction since it helps students to develop a solid foundation of mathematical understanding in order to solve mathematical problems which involve a higher-level thinking and reasoning. Prominent recent and available researches from 2013 upward that have applied this strategy included Gambari, Yaki and Olowe (2013), Gregory (2013), Mbacho (2013), Awofala, Arigbabu, and Awoyemi (2013), Naomi and Githua (2013), Slavin, Sheard, Elliot, Chambers and Cheung (2013), Gürel-Kaltakçı (2013), Wambugu, Changeiywo, and Ndiritu(2013), Karakuyu, Bilgin, Sürücü (2013), Karacop(2013), Kenya and Inglisa, (2014), Cheng, Lin, Chang, Li, Wu, and Lin(2014), Gillies (2014), Huang, Liao, Huang, Chen (2014), Slavin (2014), Serrano and Pons (2014), Buhr, Heflin, White, and Pinheiro (2014), Iweka (2015), Pompea, Dokter, Walker, and Sparks(2015), Tural (2015a), Tural(2015b), Areelu and Dawodu (2015), Timayi, Bolaji and Kajuru (2015), Capar and Tarim,(2015), Mohammadjani, and Tonkaboni (2015), Sharan(2015), Slavin(2015), Berger (2015), Demirci (2016), Hettmannsperger, Mueller, Scheid and Schnotz (2016), John, Molepo, Chirwa(2016),Wilcox(2016), Elaldı (2016), Venkateshwar (2016), Aronson, Blaney, Stephen, Sikess and Snapp (2017), Rachmah (2017), Wilson, Pegram, Battise, and Robinson (2017) and Ataman (2017), Alejandro (2017), Alejandro, Jesus, and Reguenes (2017), Iweka (2017)., Karacop (2017), .Areelu & Oladele (2018), Tukur, Nurulwahida and Madya (2018), Barr and Wessel (2018). Tukur, Nurulwahida and Madya (2018). Infact, Ataman (2017) whose work depicted the diagrammatic illustration of the strategy in physics laboratory among others lend a credence to the Jigsaw as shown below:



Figure 1. The work order formed for Jigsaw method adopted from **Ataman Karacop (2017)**

However, the major distinctions between the present study and the aforementioned ones was the embedded of the multimedia jigsaw, which was Computer Assisted instruction (CAI) or Computer Based Instruction model. Secondly, the present study felt that continuity of success is indispensable and that was why teachers of Mathematics needed to be taught for onward replication to the students, who different researches have made a focal point in the past. The training of a woman symbolizes a trained nation. Hence, its adoption promote a strategy that enhances academic achievement, attitude and other salient characteristics towards learning mathematics. Furthermore, jigsaw learning as an embedded mastery learning could be used in almost every subject, but it is more suitable in mathematics instruction since it helps students to develop a solid foundation of mathematical understanding in order to solve mathematical problems which involve a higher-level thinking and reasoning.

Empirical Studies on Multimedia forms of Instructional Strategy

On the other hand influence of Multimedia or Information and Communication Technology

(ICT) has played a tremendous role towards facilitating the teaching and learning of mathematics. This diverse studies which included Wouters (2013), Martinez and Stager (2013), Schweppe and Rummer (2014), Alcock, Attridgeb, Kenya, & Inglisa (2014), Areelu & Dawodu(2015), Takacs, Swart and Bus (2015), Bus, Takacs & Kegel (2015), Eitel and Scheiter (2015), Berney & Betrancourt, (2016), Leask (2016), Richter, Scheiter and Eitel (2016), McFarlane, Williams & Bonnett (2016), Zheng (2016), Supe & Lyer, (2016), Moreno & Mayer(2017), among others have employed methods that intensify understanding of mathematical concepts through a wide range of technologies could be available to teachers and whose applications could be designed to match user characteristics and the requirements of mathematics curriculum tasks on one hand; and gave an in-depth discussions on each of the components of the conceptual framework in Figure 2 are provided in the following sources: Ehmann, Gerhauser, Miller, Voggel and Wassermann (2017), Guedet (2015), Newby, Stepich, Lehman, Russel and Ottenbreich- Leftwhich (2015), and Research Centre (2015).

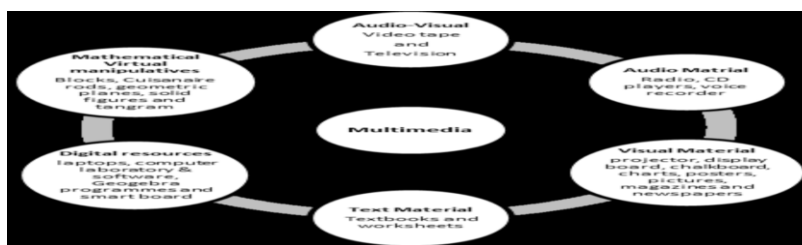


Figure 2 Classification of multimedia

Source: Masilo, M. (2016). *Teachers’ perspectives on a multimedia supported problem solving: focus on grade 8 algebra in the mount Ayliff District*. South Africa: University of South Africa Publication.

Hence, its application in a cooperative situations promote a strategy that enhances academic achievement and attitude towards learning mathematics Therefore, Jigsaw and mastery learning are crucial because they aid teaching and learning mathematics as the former would be employed to demystify problems of mathematical aspect of statistics.

Statement of the problem

Math’s phobia has affected students learning outcomes and alienate them from mathematics lessons on the other hand, and in some cases mathematics teachers seemed indifferent on choice of instructional strategies to solve prevailing students’ predicament on the other hand, necessitate the study to investigate instructional outputs in Jigsaw IV and problem-solving approaches of mathematical aspect of statistics.

Research Questions(R_{Q1}):

What are the pre and post instructional outputs in Jigsaws (Multimedia & Improvised) and problem-solving(Control) approaches of mathematical aspect of statistics

Research Hypothesis(H_{O1}):

There are no significant differences in the pre and post instructional outputs in Jigsaws (Multimedia & Improvised) and problem-solving (Control) approaches of mathematical aspect of statistics,.

Methodology

The study design was quasi-experimental in nature as it began with a 3-day workshop on Multimedia, Improvised and non-Jigsaw materials for the conventional group, even though they were taught the same grouped and ungrouped measures of central tendencies and dispersion in statistics.

Population

The population to the study comprised of all mathematics teachers and senior secondary school 2 students in Lagos State, which made up the six educational districts namely District I, with headquarter at Diary Farm Primary School Complex, Agege, and comprised Ifako-Ijaye, Agege, Alimosho; District II, with headquarter at Maryland, Ikeja, and comprised Shomolu, Ikorodu, Kosofe; District III, with headquarter at St George Primary School Opposite Shopping Complex, 123 Awolowo Road, Falomo, Ikoyi, and comprised Epe, Eti-Osa, Ibeju-Lekki, Lagos Island, Apapa; District IV, with headquarter at Domestic Science Centre, 8 McEwen Road, Sabo-Yaba, and comprised Surulere, Yaba, Apapa and Mainland; District V, with headquarter at Agboju School Complex, Agboju, and comprised Ajeromi-Ifelodun, Ajegunle, Amuwo-Odofin, Agboju, Ojo and Badagry; and District VI, with headquarter at Ewenla Near Charity Shop, Oshodi and comprised Oshodi and Isolo. Initially a total of eighty six mathematics teachers responded to the request made through the Lagos State Branch of Mathematical Association of Nigeria(MAN), but forty five of them were teaching at the senior secondary school levels, where topic of study was presently being taught. Through the messages sent to these teachers on the numbers of students handled at SSS level constituted where sample selection focused on SS2 students only.

Sample

Sample of six mathematics teachers was selected from each district, making a total of 36 mathematics teachers, though 35 mathematics teachers eventually turned up for the organized workshop, with one mathematics teacher sending an apology for not coming due to nature-bound excuse. With the thirty five mathematics teachers there were two thousand, four hundred and fifty four SS2 students that were indirectly involved in the study, based on the previous data submitted by those mathematics teachers on one hand, and the instruments given to them for onward administration to students after a 3-day workshop was titled 'Instructional outputs of Jigsaw approaches of mathematical aspect of statistics held at Lagos State University, Ojo.

Sampling Technique

Sampling into the different three groups was based on ballots with nine ballots for Multimedia, twenty one ballots for Improvised and ten ballots for the control. In the course of addressing teachers one of the adjunct researcher went round for each teacher to pick in a well shuffled nylon. The outcome was that eight teachers picked Multimedia (Computer Based Instruction-CBI or Computer Assisted Instruction-CAI), nineteen picked Improvised and eight picked control; and these formed the basis of final grouping. The Multimedia group was taught with Jigsaw software installed in LAPTOPs and

smartboard, Improvised group was taught with produced Jigsaw materials and Control group was taught without any produced Jigsaw materials at the Education Mathematics Workshop, hall one and two, respectively, within the Faculty of Education by different and trained research assistants to prevent interference. There were 516, 287 and 1651 SS2 students for the Multimedia, Improvised and Control respectively.

Instrumentation

A-30 item achievement test on grouped and ungrouped measures of central tendencies and standard deviation was administered to the entire SS2 students sampled. With the Cronbach’s Alpha reliability coefficient of the pre and post instrument at 0.86, which is not at variance with that obtained from the pilot study conducted in one of the council areas of Ojo local government of Lagos State, it was adopted.

Administration

After the pre-training of research assistants on Jigsaw instruction with addition of Multimedia to the study, another 4 day training was given to them after the procurements of necessary Jigsaw materials. Upon the mastery of the instruction a 3 day workshop was organized for the mathematics teachers who in turned assisted to administer pre-achievement tests to their SS2 students two weeks after their resumption from first term break. This was brought back, and they were given posttest achievement ones to be administered on students after they had taught them for the next twelve weeks. It was when they brought these results that teachers were given letter of participation, though they were rewarded each time submissions was made. The keys of pretest and posttest were given to the adjunct researchers for marking on separate day of submission by the teachers, and thereafter to other three adjunct researchers for coding, with an accompanied stipends. These exercises led to the transfer of entire documents to the analyst.

Data Analyses

Statistical tools used for the analysis included means, ANOVA and Scheffe Post-Hoc at 0.05 level of significance.

Pilot study result

Table 1: Mean and deviation scores of students in pre-test and two models

Groups	Pre-test scores	Problem-solving scores	Jigsaw scores
Number	20	10	10
Sum of scores	536	625	682
Mean Scores	2.68	62.5	68.2
Standard Deviation	26.08	2.28	2.53

Table 1 showed results of pilot study of means for pre-test, problem-solving and Jigsaw were 2.68, 62.5 and 68.2 respectively. Although pre-test score’s mean was low yet the two groups perform well in the post-test with Jigsaw better than the problem-solving. The implication was that the two methods were comparatively good and useful for teaching basic concepts in mathematical aspect of statistics even though one is better than other.

Table 2: t-test Analysis of students ‘Jigsaw and problem-solving scores

Methods	Total	Mean	Deviation	d.f	Number	t- calculated	Significant level
Jigsaw	682	68.2	2.53	18	10	16.736	P<0.05*
Problem Solving	625	62.5	2.28		10		

*Significant @ 0.05

Table 2 showed the t-test analysis of the two methods where it was found that there was a significant difference between the performance of students taught with Jigsaw and problem solving methods in mathematical aspect of statistics(t- (18) =16.74; P < 0.05).

Findings

Research Question (RQ₁): What are the pre and post instructional outputs in Jigsaws (Multimedia & Improvised) and problem-solving (Control) approaches of mathematical aspect of statistics?

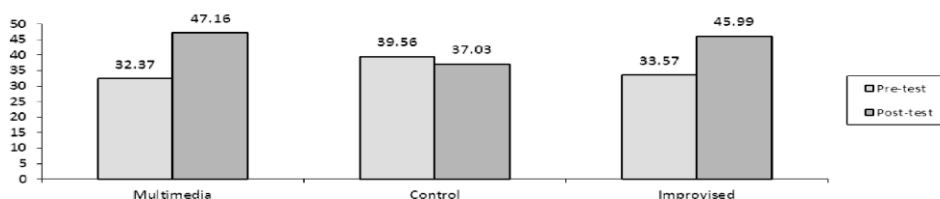


Figure 3: Pre-& post means instructional outputs of Multimedia, Control and Improvised approaches.

Figure 3 described the means instructional outputs of Multimedia, Control and Improvised Jigsaws of pre-test as 32.37, 39.56 and 33.57 respectively, and 47.16, 37.03 and 45.99 respectively as post-tests with overall gain score in means of Multimedia, Control and Improvised Jigsaws as 45.11, 34.39 and 43.56 respectively. What this implied was that Control Jigsaw had the highest score prior the treatments than other groups while Multimedia and Improvised Jigsaws had highest and higher scores, respectively, in the post-test.

Research Hypothesis: There are no significant differences in the performance of students exposed to Jigsaw IV and conventional problem solving methods in mathematical aspect of statistics.

Table 3-ANOVA of instructional outputs of Multimedia, Control and Improvised Jigsaws

Groups	Sum of Squares	df	Mean Squares	F-calculated	Significance
Between	56342.643	2	28162.321	64.989	0.000*
Within	1062115.046	2451	433.339		
Total	1118439.689	2453			

Significance @ 0.05

Table 3 described ANOVA of Multimedia, Control and Improvised Jigsaws where it was found that there was significant difference in the instructional outputs of students exposed to different groups(F(2, 2451) = 64.99; P<0.05). By implication a group did very well among the trio, and this necessitated post hoc analysis of Scheffe Post-Hoc in table 4.

Table 4: Scheffe Post-Hoc result of Multimedia, Control and Improvised Jigsaws

(I) Treatment Groups	(J) Treatment Groups	Mean Difference (I-J)	Standard Error	Significance.
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Multimedia	Control	10.72584*	1.04989	0.000
	Improvised	1.55459	1.53287	0.598
Control	Multimedia	-10.72584*	1.04989	0.000
	Improvised	-9.17125*	1.33130	0.000
Improvised	Multimedia	-1.55459	1.53287	0.598
	Control	9.17125*	1.33130	0.000

Table 4 described multiple comparisons of Multimedia, Control and Improvised Jigsaws where it was found that there was significant difference between Multimedia and Control (0.000), and no significant difference between Multimedia and Improvised (0.598) in the instructional outputs of students.

Discussions

As earlier pointed out, Jigsaw technique is one of the cooperative learning technique in which students equally participate, prepare and lead a group thus learning for themselves as well as preparing their group. When students are included in learning and participated fully, they tend to understand better and repeat the success recorded whenever they are confronted with similar or related challenges. Students' performances are significantly shaped via the method used by the teacher and their readiness to learn. The study showed that students that were taught using Jigsaw technique benefited more in the interaction with the technique than their counterparts of the conventional technique (problem solving). Particularly, students in the Multimedia group performed better than Improvised group as measured in their means score of 47.16 and 45.99 respectively. The implication is that students' performances are sharpened by the curriculum used in the class and by the decisions made by the teacher as they interpret the curriculum, organize aspects of the instructions and studies that monitored the impact of conceptually oriented mathematics materials, teach well and with consistency. This result was supported by Sahin (2010), Garcia, Abrego and Robert (2017) who found that students performed better when taught using Jigsaw instructional approach. However, the finding is not in agreement with Nneji (2013) who found that students performed better when taught using problem solving technique and in particular the George Polya's model.

Conclusion

The study revealed that Jigsaw instructional approach is a very useful technique. The superiority of this technique lies in its enhancement of the learning experience and the provocation of the students' interest in statistics, the creation of an atmosphere of interaction and cooperation among the students, and the near elimination of fatigue from classrooms. Teachers should employ the use of Jigsaw instructional technique in teaching difficult topics, since it has been established that they have potentials of improving students' performance.

Recommendations

The following recommendations were made based on the findings as teachers in general should embrace the use of Jigsaw strategy to enhance students' learning outcomes. Secondly, in the absence of actual instructional materials, mathematics teachers should learn to improvise, and finally, Jigsaw strategy should be adopted at all time, with or without instructional materials.

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