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A COMPARATIVE STUDY OF INTERACTIVE LEARNING TOOLS AND VISUALIZATION TECHNIQUES IN MANAGING ALGEBRAIC ANXIETY AMONG YOUNG CHILDREN

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Abstract
The study investigated a comparative analysis of interactive learning tool and visualization techniques in managing algebraic anxiety among young children. This study adopted a quasi-experimental design, specifically a non-randomized pre-test post-test design. This study was carried out in Nsukka Local Government Area of Enugu State with a population of 3,014 primary 5 pupils in 113 public primary schools, comprising 1,528 males and 1,486 females. The sample comprise of 67 primary five pupils made up of 32 and 35 pupils in the visualization and interactive groups respectively. The instrument for data collection was a 15-item scale titled "Pupils Algebra Anxiety Scale (PAAS)" which was adapted from Math Anxiety Scale for Young Children by Ganley and McGraw (2016). The instrument was subjected to face validation by three experts. An overall reliability coefficient of 0.86 was obtained using Cronbach Alpha. Mean and Standard deviation were used to answer the research questions while ANCOVA was used to test the hypotheses at 0.05 level of significance. The findings of the study revealed that visualization technique is slightly more effective than interactive learning tools technique in reducing algebraic anxiety among young children. Further analysis shows that there is a significant difference in the mean rating scores of algebraic anxiety of young children exposed to visualization technique and those exposed to interactive learning tools technique with children exposed to visualization technique having a higher mean score in the posttest. It was recommended among others that government and its agencies should provide the required teaching materials for effective use of these techniques to ensure that algebraic anxiety is reduced

Keywords: Interactive learning tools, visualization techniques, managing algebraic anxiety

Introduction

Algebra is a fundamental branch of mathematics that uses mathematical statements to describe relationships between variables that change over time. It serves as a basis for mathematical thinking and problem-solving. Algebra involves the use of symbols, usually letters, to represent numbers and quantities in formulas and equations. It is essential to introduce young children to algebraic thinking at an early age. This exposure to algebraic reasoning represents a significant cognitive transition for young children, which can be challenging to them. This transition requires pupils to move from concrete numerical operations to more abstract mathematical thinking, a process that can be challenging for many learners. However, the conceptual shift from dealing with specific numbers to working with variables and generalized expressions is one of the primary challenges in this transition. Radford (2023) argued that this transition from concrete learning to abstraction requires a fundamental change in how children perceive and interact with mathematical ideas. Radford added that many children struggle to grasp the concept of representing a range of possible values with variables rather than a single, specific number. Another challenge is the transformation of the equality sign as learning progresses from arithmetic to algebra. Knuth, Stephens, Blanton, & Gardiner (2023) emphasized that children's understanding of the equals sign advances from a signal to operate (as used in arithmetic) to symbol of equivalence

between expressions. This shift is essential for algebraic thinking but can be challenging for many young children to internalize. These challenges cause anxiety in learning algebraic expressions in mathematics.

Algebraic anxiety is a major challenge among young children. Young children experience increased worry and uncertainty as they encounter more abstract mathematical concepts, which could hinder their mathematical knowledge and academic outcomes. This algebraic anxiety could result in fear, avoidance or a negative attitude towards Mathematics, resulting in poor performance. The prevalence and consequences of algebraic anxiety among learners have been proven by the literature. Mediana and Hinacay (2025) revealed that most of the students sampled exhibited very high levels of algebraic anxiety and difficulty. Also, Johnson et al. (2023) found that approximately 30% of primary school pupils exhibited moderate to high levels of algebraic anxiety, with these feelings intensifying as pupils progressed through grade levels. This anxiety can result in a continuous cycle of poor performance and increased stress, making them unwilling to engage in mathematical concepts. Hence, the need to adopt evidence-based strategies that support pupils in overcoming these noted challenges and algebraic anxiety to improve their performance in school. One of such strategies is visualization techniques.

Visualization involves the use of things one can see to aid learning. Visualization is the ability, process and product of creativity, interpretation, consideration of images, sketches, drawings, and diagrams that are in our mind, on paper or displayed on a computer (Tiwari, Obradovic, Rathour, Mishra, & Mishra, 2021). Visualization leads to the development of new ideas from old knowledge. Visualization can be seen as a skill of mental programming by which goals are achieved, such as solving a mathematical problem. Mathematical concepts, ideas, and methods, have great richness and connection with visualization in many different ways. Every expert is aware of how useful visualization is to connect concrete cases when studying appropriate abstract objects. According to Yilmaz and Argun (2018), mathematical visualization is the process of working, with special emphasis on possible concrete representations of objects that an individual manipulates in order to have the most effective access to more abstract connections that can be managed.

Visualization acquires its true, essential meaning only if visual representations are connected with algebraic, numerical, and verbal representations shifting focus from a teacher-centred approach to child-centred approach. Examples of visualization techniques are algebra tiles, graphs, colour coding, among others. Salifu (2022) emphasized that in order to learn algebra, there is need to use the appropriate manipulatives such as algebra tiles. Hence, for this study, algebra tiles will be used. Algebra tiles are rectangular shapes that provide area models of variables and integers. They are used to build concrete area representations of algebraic concepts. The concrete representation of abstract mathematical ideas offers opportunities to facilitate translation between the manipulation of algebraic expressions and manipulation of concrete examples through the use of algebra tiles. This may help to arouse and sustain the interest of the children in the learning process. A study by Larbi (2011) on the effect of algebra tiles manipulative on students' performance in algebra, found that there was a significant difference between the two groups used in favour of the group that was taught using algebra tiles manipulative. Also, Carbonneau, Marley and Selig (2013) found that there is statistically significant difference in the scores of those taught with the use of manipulatives when compared with instruction that only used abstract mathematics symbols in favour of those instructed using manipulatives. However, the effect size is moderate using Cohen's d. Hence, visualization in mathematics can be seen as very efficient and effective in

understanding mathematical concepts and activities. Another strategy considered in this study is interactive learning tools.

Interactive learning tools are digital resources that engage learners and enhance active participation in the learning process. Reeves (2012) conceptualized interactive learning tools to mean a process involving some form of digitally enabled reciprocal action between a teacher and a learner. It requires access to content, task and problems by a learner using digital technology. Norsyiha, Omar, Samsudin and Shaziayani (2024) saw interactive tools as strategies that support learning by providing immediate feedback, fostering collaboration, and making learning more dynamic. These tools are digital or physical resources designed to engage learners actively in the learning process through interaction. These tools require input or participation from the users as it goes beyond passive consumption of information like reading or watching. The main goal is to enhance engagement, retention and making learning more participatory and hands-on. This could make the learning of algebra more enjoyable and less intimidating. Examples of interactive learning tools are educational apps, gamified and online platforms, among others. There are empirical evidences to support the use of interactive learning tools in the learning process. In a study by Allen and Vallee-Tourangeau (2015), it was found that engaging students in physical manipulation of mathematical problems helps reduce anxiety by distributing cognitive load and enhancing attention. In addition, the study by Ha and Im (2020) found that interactive online learning tools can facilitate student's active learning process by increasing attention, curiosity, and interest about the online activity and by reducing awareness of physical surroundings. This aligns with other findings to show that interactive learning reduces Mathematical anxiety. This reduction in algebraic anxiety could be influenced by gender.

Gender is a socially assigned roles and behaviours associated with being male and female. According to Ifelunni (2019) gender is regarded as those roles expected from an individual on the basis of being male or female. Chen (2023) also defined gender as a multi-faceted concept that goes beyond biological sex, encompassing how young children express and explore their identities, and how educators and institutions respond to and shape these expressions within the primary school setting. In this study, gender is used to connote the roles, expectations and behaviour a group of learners' exhibit on the basis of being a male or female. Many studies have found gender differences in managing algebraic anxiety among young children. Asomah, Kwabena, Assamah, Narh-Kert and Manu (2025) found that both males and females exhibited high prevalence of Mathematics anxiety, though males had a higher level of performance than their female counterparts. Many studies claim that Mathematics anxiety differs according to gender, with females reporting higher Mathematics anxiety than males, though this differences in Mathematics anxiety is not significant (Van Mier, Schleepen & Van den Berg, 2019). In addition, Szczygiel (2020) found that in comparison to males, females had a higher level of Mathematics anxiety. As research evidence has shown that both techniques have enhanced children's Mathematics anxiety, this study sought to find out the technique that is more effective in managing algebraic anxiety which is an aspect of Mathematics. Hence, this study sought to investigate a comparative analysis of interactive learning tool and visualization techniques in managing algebraic anxiety among young children. This is because the effectiveness of the two approaches in reducing algebraic anxiety have not been compared in the area of study.

Purpose of the study

The general purpose of this study was to investigate a comparative study of interactive learning tools and visualization techniques in managing algebraic anxiety among young children. Specifically, the study sought to determine the:

1. effect of interactive learning tools and visualization techniques in managing algebraic anxiety among young children.
2. influence of gender in managing algebraic anxiety among young children.
3. interaction effect of techniques and gender in managing algebraic anxiety among young children.

Research Questions

The study was guided by the following research questions:

1. What is the mean rating scores of algebraic anxiety among young children exposed to interactive learning tools and those exposed to visualization techniques?
2. What is the influence of gender in managing algebraic anxiety among young children?
3. What is the mean interaction effect of techniques and gender in managing algebraic anxiety among young children?

Hypotheses

The following null hypotheses guided the study and tested at 0.05 level of significance

H_{01}: There is no significant difference in the mean rating scores of algebraic anxiety of young children exposed to interactive learning tools technique and those exposed to visualization techniques.

H_{02}: There is no significant gender difference in the mean rating scores of algebraic anxiety of young children.

H_{03}: There is no significant interaction effect of technique and gender in the mean rating scores of algebraic anxiety among young children.

Methods

This study adopted a quasi-experimental design, specifically a non-randomized pre-test post-test design. This design is adopted because it is not feasible, ethical or practical to randomly assign participants to groups. Instead, intact class was used to prevent the disruption of normal classes. This study was carried out in Nsukka Local Government Area of Enugu State with a population of 3,014 primary 5 pupils in 113 public primary schools, comprising 1,528 males and 1,486 females. The sample comprise of 67 primary five pupils. Simple random sampling technique was employed to select 2 public primary schools in the study area. Simple random sampling technique was also employed to select one arm of primary five classes in each of the selected school. Simple random sampling technique was used to sample all the pupils in the selected classes made up of 32 and 35 pupils respectively. Therefore, the visualization and interactive groups are 32, made up of 15 males and 17 females and 35 pupils made up of 21 males and 14 females respectively. With a toss of the coin, each of the schools was assigned to the two experimental groups (interactive learning tools and visualization techniques). The instrument for data collection was a structured questionnaire titled “Pupils Algebra Anxiety Scale (PAAS)” The PAAS is a 15-item scale adapted from Math Anxiety Scale for Young Children by Ganley and McGraw (2016). It is a four-likert scale with response options of yes, kind of, not really and no. The instrument was subjected to face validation by three experts. An overall reliability coefficient of 0.86 was obtained using Cronbach Alpha. Mean and Standard deviation were used to answer the research questions while ANCOVA was used to test the hypotheses at 0.05 level of significance.

Results

Research question 1: What is the mean rating in managing algebraic anxiety among young children exposed to interactive learning tools and those exposed to visualization techniques?

Table 1: **Mean and Standard Deviation rating in managing algebraic anxiety among young children exposed to interactive learning tools and those exposed to visualization techniques**

Variable		Pre test		Posttest		Mean gain
Mode of Training	N		SD	$\bar{x}$	SD	
Interactive learning tools	35	53.14	3.43	32.54	5.13	20.60
visualization techniques	32	55.78	4.49	35.16	3.01	20.62

Key: SD = Standard deviation, N= Number, $\bar{x}$ =Mean

Results in Table 1 show that the group exposed to interactive learning tools technique had a pretest mean of 53.14 with a standard deviation of 3.43 and a posttest mean of 32.54 with a standard deviation of 5.13. The difference between the pretest and posttest mean for the group exposed to Interactive learning tools technique was 20.60. The group exposed to visualization technique had a pretest mean of 55.78 with a standard deviation of 4.49 and a posttest mean of 35.16 with a standard deviation of 3.01. The difference between the pretest and posttest mean for visualization technique group was 20.62. The difference between the pretest and posttest mean for the total group was 0.02. This is an indication that visualization technique is slightly effective than the interactive learning tools technique in managing algebraic anxiety of young children.

Hypotheses 1

H_{01}: There is no significant difference in the mean rating scores of algebraic anxiety of young children exposed to interactive learning tools technique and those exposed to visualization techniques.

Table 2: Analysis of Covariance (ANCOVA) of algebraic anxiety of young children exposed to Interactive learning tools technique and those of the visualization technique group.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	119.86[a]	2	59.93	3.28	.04	.09
Intercept	305.41	1	305.41	16.72	.00	.21
Pretest	5.69	1	5.69	.31	.58	.01
Groups	87.70	1	87.70	4.80	.03	.07
Error	1169.22	64	18.27			
Total	77792.00	67				
Corrected Total	1289.08	66				

a. R Squared = .093 (Adjusted R Squared = .065)

The result in Table **2** shows that the F-ratio is 4.80 with degree of freedom of 2 and 64. The hypothesis is rejected because the significant value of 0.03 is less than the probability value of 0.05. Therefore, there is a significant difference in the mean rating scores of algebraic anxiety of young children exposed to interactive learning tools technique and those exposed to visualization techniques.

Research question 2: What is the influence of gender in managing algebraic anxiety among young children?

Table 3: Mean and Standard Deviation of the influence of gender in managing algebraic anxiety among young children

Variable		Pre test		Posttest		Mean loss
	N	$\bar{x}$	SD	$\bar{x}$	SD	
Male young children	36	54.14	.72	32.69	.82	21.45
Female young children	31	54.71	.73	35.06	.60	19.65

Results in Table 3 show that the male young children had a pretest mean of 54.14 with a standard deviation of .72 and a posttest mean of 32.69 with a standard deviation of .82. The difference between the pretest and posttest mean for the male young children is 21.45. The male young children had a pretest mean of 54.71 with a standard deviation of .73 and a posttest mean of 35.06 with a standard deviation of .60. The difference between the pretest and posttest mean for the female young children is 19.65. The difference between the pretest and posttest mean for visualization technique group was 20.62. The difference between the pretest and posttest mean for the total group was 1.80. This is an indication that male young children slightly managed algebraic anxiety than their female counterparts.

Hypotheses 2

H_{02}: There is no significant gender difference in the mean rating scores of algebraic anxiety of young children.

Table 4: Analysis of Covariance (ANCOVA) of gender difference in the mean rating scores of algebraic anxiety of young children

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3.78[a]	2	1.89	39.11	.00
Intercept	13.23	1	13.23	273.79	.00
Pretest	.02	1	.02	.44	.51
Gender	3.74	1	3.74	77.42	.00
Error	6.62	64	.05		
Total	1187.79	67			
Corrected Total	10.39	66			

a. R Squared = .363 (Adjusted R Squared = .354)

The result in Table 4 shows that the F-ratio is 77.42 with degree of freedom of 2 and 64. The hypothesis is rejected because the significant value of 0.03 is less than the probability value of 0.05. Therefore, there is a gender difference in the mean rating scores of algebraic anxiety of young children.

Research question 3: What is the mean interaction of techniques and gender in managing algebraic anxiety among young children?

Table 5: Mean and Standard Deviation of interaction of techniques and gender in managing algebraic anxiety among young children

Variable	Gender	N	Pre test		Posttest		Mean loss
			$\bar{x}$	SD	$\bar{x}$	SD	
Interactive learning tools	Male	21	53.00	.78	32.38	1.41	20.62
	Female	14	53.36	.88	32.79	.57	20.01
	Male	15	55.73	1.24	33.13	.27	23.60

Visualization Technique	Female	17	55.82	1.05	36.94	.74	18.88

Results in Table 5 show that the male young children in the interactive learning groups had a pretest mean of 53.00 with a standard deviation of .78 and a posttest mean of 32.38 with a standard deviation of 1.41. The difference between the pretest and posttest mean for the male young children is 20.62. The female young children in the interactive group had a pretest mean of 53.36 with a standard deviation of .88 and a posttest mean of 32.79 with a standard deviation of 0.57. The difference between the pretest and posttest mean for the female young children is 20.01. In the same vein, the male young children in the visualization learning techniques had a pretest mean of 55.73 with a standard deviation of 1.24 and a posttest mean of 33.13 with a standard deviation of 0.27. The difference between the pretest and posttest mean for the male young children is 23.60. The female young children in the visualization learning techniques had a pretest mean of 55.82 with a standard deviation of 1.05 and a posttest mean of 36.94 with a standard deviation of 0.73. The difference between the pretest and posttest mean for the female young children is 18.88. The difference between the pretest and posttest mean for visualization technique group was 20.62. The interaction between techniques and gender slightly favoured male young children more than their female counterparts.

Hypotheses 3

H_{03}: There is no significant interaction effect of technique and gender in the mean rating scores of algebraic anxiety among young children.

Table 6: Analysis of Covariance (ANCOVA) of interaction effect of technique and gender in the mean rating scores of algebraic anxiety among young children

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1.16[a]	4	.29	5.97	.00
Intercept	7.82	1	7.82	160.63	.00
Pretest	.00	1	.00	.01	.90
Group	.35	1	.35	7.26	.01
Gender	.23	1	.23	4.67	.03
Group * gender	.01	1	.01	.22	.64
Error	6.57	61	.05		
Total	1391.84	66			
Corrected Total	7.73	65			

a. R Squared = .150 (Adjusted R Squared = .125)

The result in Table 6 shows that the F-ratio is 0.22 with degree of freedom of 4 and 61. The hypothesis is failed to be rejected because the significant value of 0.64 is greater than the probability value of 0.05. Therefore, there is no significant interaction effect of technique and gender in the mean rating scores of algebraic anxiety among young children.

Discussion

The findings of the study revealed that visualization technique is slightly more effective than interactive learning tools technique in reducing algebraic anxiety among young children. Further analysis shows that there is a significant difference in the mean rating scores of algebraic anxiety of young children exposed to visualization technique and those exposed to interactive learning tools technique with children exposed to visualization technique having a higher mean score in the posttest. This finding could be as a result of how visualization

technique helps to simplify complex information by presenting it in an easy visual format and because it reduces cognitive loan for the learners as information is easily processed and retained. This could be because visualization technique makes learning of algebraic expressions more enjoyable, and promote retention. As children engage in the learning process, they tend to experiment as this method encourages hands-on learning, thereby building their confidence and reducing anxiety. This finding is in line with the findings of Allen and Vallee-Tourangeau (2015), that engaging students in physical manipulation of mathematical problems helps reduce anxiety by distributing cognitive load and enhancing attention. The finding is at variance with the study by Ha and Im (2020) who found that interactive online learning tools can facilitate student's active learning process by increasing attention, curiosity, and interest about the online activity and by reducing awareness of physical surroundings, thereby reducing anxiety.

The finding of the study shows that male young children slightly managed algebraic anxiety than their female counterparts. The hypothesis also shows that there is a gender difference in the mean rating scores of algebraic anxiety of young children. This finding could be attributed to the stereotype on mathematics being for boys, and how boys are encouraged to study STEM courses. These expectations could put the males in a better position to manage algebraic anxiety. This finding corroborates that of Asomah, Kwabena, Assamah, Narh-Kert and Manu (2025) found that both males and females exhibited high prevalence of Mathematics anxiety, though males had a higher level of performance than their female counterparts. The finding is in line with the study by Van Mier, Schleepen & Van den Berg, (2019) who found that Mathematics anxiety differs according to gender, with females reporting higher Mathematics anxiety than males. The finding is also in agreement with that of Szczygiel (2020) who found that females had a higher level of Mathematics anxiety than their male counterpart. The finding of the study indicated that the interaction between techniques and gender slightly favoured male young children more than their female counterparts. The hypothesis further show that there is no significant interaction effect of technique and gender in the mean rating scores of algebraic anxiety among young children. Studies have shown that both techniques reduce algebraic anxiety among young children. However, visualization technique has been shown to reduce algebraic anxiety better. The reason could be that visualization technique makes learning algebra clearer, less distracting, build confidence as the children manipulate the learning materials. Visualization technique could help to address the causes of anxiety better, hence reducing algebraic anxiety better.

Conclusion

Both techniques have been shown to reduce algebraic anxiety. However visualization technique is more effective in reducing algebraic anxiety among young children. This does not mean that the use of interactive learning tools is not useful. To get a better result at reducing algebraic anxiety among young children, teachers may consider combining the two approaches as there have both been shown to be effective in reducing anxiety.

Recommendations

Based on the findings of the study, it was recommended that;

1. Government and its agencies should provide the required teaching materials for effective use of these techniques to ensure that algebraic anxiety is reduced.
2. Teachers should use both manipulatives and interactive learning tools to support understanding, help the children explore and get immediate feedback.

3. When the needed resources to instruct with these techniques are not available, teachers can improvise to help reduce young children's algebraic anxiety.

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