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Improving Students Procedural Skills And Conceptual Understanding On Algebra Through Zoltan Diene's Dynamic Principle In Colleges Of Education In Delta State

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ABSTRACT
The study focused on improving students' procedural skills and conceptual understanding on Algebra through the use of Zoltan Dienes dynamic principles in Colleges of Education in Delta State. Three research questions guided the study and three hypotheses were tested at 0.05 level of significance. The research adopted a quasi-experimental design, specifically, pre-test and post-test non randomized control group design. The population comprised one thousand, five hundred and ninety (1590) students in the three Colleges of Education in Delta State, out of which 252 students were sampled using a purposive sampling technique. The Algebra Procedural Skill Test (APST) and Algebra Conceptual Understanding Test (ACUT) validated by two experts was used as instrument for data collection. The reliability co-efficient value for the instrument is 0.85 which was calculated using the Kuder-Richardson Formula 20. The data generated from the study was analyzed using mean and standard deviation, paired t-test and analysis of covariance. The findings of the study revealed that there was significant difference in the pre-test and post-test scores of Colleges of Education students in terms of procedural skills and conceptual understanding of Algebra who have been exposed to Diene's dynamic principle. The study recommended among others that mathematics instructors should use Diene's dynamic principle as an integral part of the teaching and learning of mathematics in Colleges of Education in Delta State.
Keywords: procedural skill, conceptual understanding, Zoltan Dienes dynamic principle

INTRODUCTION

Mathematics is accepted as the partner of science in improving one's capacity, it plays a great role in any field of knowledge for it solve the numeric problems that may help in acquiring new set of invention. It is known to be the back bone of science, even the amazing works of engineers, architects, and technologist and in all other fields of knowledge are greatly associated with the concept of mathematics. Algebra is a fundamental branch of mathematics that involves the study of mathematical symbols and the rules of manipulating these symbols. It is a critical area of study that is essential for higher learning in mathematics and science. Algebra is a subject that is challenging for many learners due to its abstract nature. Many learners struggle to understand the concepts and develop procedural skills in algebra. As part of the vision of the department of mathematics in Colleges of Education is to continuously improve itself to better serve its stakeholders from the traditional way to more effective teaching strategies and

approach and every possible means were used by the institutions just to improve the performance of the students. However, study reveals that mastery in Algebra is important for laying the foundation of various other topics to be covered in the future like integers (Ipek, 2018). Also basic concepts and operations involving Algebra are among the mathematics concept that are difficult to understand (Lamb et al., 2018). Although Algebra is a mathematics topic, they are frequently used to represent many real world situations such as temperature, profits, losses of money and location (Cetin, 2019). According to many studies in mastering mathematical concepts like Algebra both procedural skills and conceptual understanding are needed this is because procedural skills is the cognitive process of following the mathematical procedures efficiently and appropriately (Wojcik, 2017). While conceptual understanding is the skill to evaluate the correctness of an example or procedure to providing definitions and explanations of concepts in mathematics (Dittle et al., 2019). Now, in cognizance of the conducted studies it is imperative for mathematics educators in Colleges of Education to employ strategies and approach in their classroom that will both improve the conceptual understanding and procedural skills of the students with concrete materials that are faded into abstract representations, one of the best strategies to employ is the Zoltan Diene's dynamic principle. This is because Diene's considers the learning process of mathematics as a process which covers abstraction, generalization and transfer, he contributed significantly to the cognitive psychological views on learning mathematics, he asserted that teaching of mathematical concepts one should make more use of manipulative materials and play, he developed a theory which focused on the use of discovery type activities and learner-centered manipulative materials being a learner-centered pedagogy. Zoltan Diene's Dynamic Principle offers a promising result in terms of fostering conceptual understanding and procedural skills of learner's in mathematics. The teaching method adopted by the teacher could boost students' academic achievement. It is against this background that this study sought to investigate if this approach Zoltan Diene's Dynamic Principle will improve the learner's performance in mathematics most especially on the concept of Algebra.

Statement of the Problem

Basic mathematical skills such as performing the four fundamental operations addition (+), subtraction (-), multiplication (×) and division (÷) are very important to be able to understand and solve computations in mathematics. Learning and the mastery of these four fundamental operations is as important as learning how to read and write. Moreover, these basic skills are always applied in our daily life. As the students reached college, they are expected to be confident in performing these basic skills. But many students enter college or university with severe gaps in their concepts and skills in mathematics, one of this basic foundational knowledge and skills is the Algebra, a necessary prerequisite skill to solve equations, this has create a great concern. This problem is very evident to many students in all levels including students in Colleges of Education, they can never perform any operations in mathematics if they fail to master operation on Algebra because these skills are always applied in all topics in mathematics. Therefore, mastery of the fundamental operation on Algebra is very important and required, many students struggle with developing both procedural skills and conceptual understanding in Algebra. The problem of this study, therefore is to investigate the effect of Zoltan Dienes' dynamic principle in improving student's procedural skills and conceptual understanding on Algebra?

Objective of the Study

The objective of the study is to investigate the effectiveness of Zoltan Diene's dynamic principle in improving students' procedural skills and conceptual understanding on Algebra.

Specifically, the study investigated the:

1. Effect of Zoltan Diene's dynamic principle in the procedural skills performance of Colleges of Education students on Algebra compared to those who have not been exposed to it.
2. Effect of Zoltan Diene's dynamic principle in the conceptual understanding of Colleges of Education students on Algebra compared to those who have not been exposed to it.
3. Effect of exposure to Zoltan Diene's dynamic principle in the pretest and posttest scores of Colleges of Education students in terms of procedural skill and conceptual understanding.

Research Questions

The following research questions guided the study:

1. What is the effect of Zoltan Diene's dynamic principle in the procedural skills performance of Colleges of Education students on Algebra compared to those who have not been exposed to it?
2. What is the effect of Zoltan Diene's dynamic principle in the conceptual understanding of Colleges of Education students on Algebra compared to those who have not been exposed to it?
3. What is the effect of exposure to Zoltan Diene's dynamic principle in the pretest and posttest scores of Colleges of Education students in terms of procedural skills and conceptual understanding on Algebra?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

1. There is no significant difference in the procedural skills performance of Colleges of Education students on Algebra who have been exposed to Zoltan Diene's dynamic principle, compared to those who have not been exposed to it.
2. There is no significant difference in the conceptual understanding of Colleges of Education students on Algebra who have been exposed to Zoltan Diene's dynamic principle, compared to those who have not been exposed to it.
3. There is no significant difference between the pretest and posttest scores of Colleges of Education students in terms of procedural skills and conceptual understanding on Algebra who have been exposed to Zoltan Diene's dynamic principle.

LITERATURE REVIEW

Algebra is considered one of the most challenging subjects for student, especially in terms of mastering both procedural skills and conceptual understanding. The teaching of algebra is critical for mathematics and science-based fields, as it is a foundation for higher-level mathematics, such as calculus and linear algebra. Zoltan Diene's dynamic principle is one of the innovative teaching methods that have been proposed to improve students' understanding in mathematics. This literature review aims to explore the use of Zoltan Dienes' dynamic principle in improving learners' procedural skills and conceptual understanding in mathematics. Zoltan Dienes was a Hungarian mathematician who developed a novel approach to teaching mathematics, known as the Zoltan Dienes' principle. This approach involves the use of manipulative, or physical objects, to help students understand mathematical concepts. Zoltan Dienes' principle emphasizes the use of concrete materials, such as blocks and tiles, to help students understand abstract concepts in mathematics. The approach is based on the idea that students understanding of mathematical concepts should progress from the concrete to the abstract. A recent study by Chen et al., (2021) investigated the effects of the Zoltan Diene's dynamic principle on college students' understanding of trigonometry. The study found that the use of the Zoltan Dienes dynamic principle significantly improved students' procedural skills and conceptual understanding of trigonometry. The study also found that the use of the Zoltan Dienes dynamic principle had a greater impact on students with low prior knowledge of trigonometry. Another study by Wang and Liu (2021), the researchers investigated the effects of Zoltan Dienes' dynamic principle on learners' procedural skills and conceptual understanding of surds. The study involved 100 high school students who were randomly assigned to either an experimental group that received instruction using Zoltan Dienes' approach or a control group that received traditional instruction. The results showed that the experimental group had significantly higher scores in both procedural skills and conceptual understanding of surds compared to the control group. In another recent study by Zhang and Liu (2022), the researchers investigated the effects of Zoltan Dienes' dynamic principle on learners' understanding of surds in a Chinese context. The study involved 120 Grade 8 students who were randomly assigned to either an experimental group that received instruction using Zoltan Dienes' approach or a control group that received traditional instruction. The results showed that the experimental group had a better understanding of surds compared to the control group, indicating the efficacy of Zoltan Dienes' approach in a Chinese context. These findings suggest that the Zoltan Diene's dynamic principle is a promising teaching method for improving students' understanding of mathematics.

Despite large amount of research on the use of Zoltan Diene's dynamic principle on student academic achievement in mathematics, none of the studies to the researcher's best of knowledge has adopted the Zoltan Diene's dynamic principle in improving Colleges of Education student's procedural skills and conceptual understanding on Algebra in Delta State. Therefore, the need for this current study cannot be overemphasize as it will help provide additional empirical evidence of improving learner's procedural skills and conceptual understanding on Algebra through Zoltan Diene's dynamic principle. It is this gap this study will seek to fill.

RESEARCH METHODOLOGY

The research adopted a quasi-experimental pre-test, post-test non randomized control group design. Thus, intact classes were used and the researcher adhered to the rules of the school. The study was conducted in Colleges of Education of Delta State. The population consists of 1590 students in the three Colleges of Education of Delta State, out of which 252 students were sampled using a purposive sampling technique. The Algebra Procedural Skill Test (APST) and Algebra Conceptual Understanding Test (ACUT) validated by two experts was used as instrument for data collection. A table of specifications (Test-blue print) was used to draw up the 10-items APST and ACUT. This is to ensure content validity of the test items. The reliability co-efficient value for the instrument is 0.85 which was calculated using the Kuder-Richardson Formula 20. The data generated from the study was analyzed using mean and standard deviation, paired t-test and analysis of covariance.

The experimental aspect of the study was conducted in four stages. The first stage was briefing of the research assistant who were the regular mathematics lecturers in the college. The regular mathematics lecturers were used to avoid faking of behaviours on the part of the students. The regular mathematics lecturers were given one (1) week briefing by the researcher to ensure uniformity of instructional delivery for a better experimental outcome. The second stage was pre-testing and familiarization when both groups (Experimental and Control) were given pretest before the commencement of the experiment. The third stage was teaching of students by the regular mathematics lecturers. The mathematics lecturers taught the experimental group using the Zoltan Dienes dynamic principle. On the other hand, the control group was taught the same lessons using conventional method. After teaching the students, the final stage (stage 4) was post-testing. Here, both the experimental and control groups were given post-test using APST and ACUT. The scores of the experimental and control groups in both the pre-test and post-test were recorded. Decision rule for the hypothesis is that null hypothesis is rejected when the probability value is less than or equal to the significant value of 0.05 ($p \leq 0.05$) otherwise ($p \geq 0.05$) the hypothesis is not rejected.

RESULTS

Research Question 1: *What is the effect of Zoltan Diene's dynamic principle in the procedural skills performance of Colleges of Education students on Algebra compared to those who have not been exposed to it?*

Table 1. Mean and Standard Deviation of Pretest and Posttest Procedural Skills Performance Scores Between Students Exposed to and Those not Exposed to Diene's Dynamic Principle

Group	N	Pretest		Posttest		Mean Gain	Mean Gain Difference
		Mean	SD	Mean	SD		
Exposed	128	29.78	6.31	60.03	12.55	30.25	11.02
Not Exposed	124	30.03	7.63	49.26	10.83	19.23	

Table 1 shows a mean procedural skills performance pretest score of 29.78, with a standard deviation of 6.31, for students exposed to Diene's dynamic principle, and a mean procedural skills performance pretest score of 30.03, with a standard deviation of 7.63, for students not exposed to Diene's dynamic principle. Mere comparison of the mean scores shows that the students in both groups are approximately equivalent on the procedural skills performance before treatment. As for the posttest scores, Table 1 indicates a mean

procedural skills performance score of 60.03, with a standard deviation of 12.55, for students exposed to Diene's dynamic principle, while their counterparts not exposed to Diene's dynamic principle had a mean procedural skills performance score of 49.26, with a standard deviation of 10.83. The students exposed to Diene's dynamic principle had a higher mean gain of 30.25, compared to their counterparts not exposed to Diene's dynamic principle which had a mean gain of 19.23. The difference between the mean gain of both groups of students is 11.02. Thus, a difference of 11.02 exists between the procedural skills performance of students exposed to and those not exposed to Diene's dynamic principle, in favour of those exposed to Diene's dynamic principle.

Research Question 2: *What is the effect of Diene's dynamic principle in the conceptual understanding of Colleges of Education students on Algebra compared to those who have not been exposed to it?*

Table 2. Mean and Standard Deviation of Pretest and Posttest Conceptual Understanding Scores Between Students Exposed to and Those not Exposed to Diene's Dynamic Principle

Group	N	Pretest		Posttest		Mean Gain	Mean Gain Difference
		Mean	SD	Mean	SD		
Exposed	128	23.30	9.34	57.42	7.22	34.12	1.51
Not Exposed	124	22.50	9.72	55.11	9.93	32.61	

Table 2 shows a mean conceptual understanding pretest score of 23.30, with a standard deviation of 9.34, for students exposed to Diene's dynamic principle, and a mean conceptual understanding pretest score of 22.50, with a standard deviation of 9.72, for students not exposed to Diene's Dynamic Principle. Mere comparison of the mean scores shows that the students in both groups are approximately equivalent on the level of conceptual understanding in Algebra before treatment. As for the posttest scores, table 2 indicates a mean conceptual understanding score of 57.42, with a standard deviation of 7.22, for students exposed to Diene's dynamic principle, while their counterparts not exposed to Diene's dynamic principle had a mean score of 55.11, with a standard deviation of 9.93. The students exposed to Diene's dynamic principle had a higher mean gain of 34.12, compared to their counterparts not exposed to Diene's dynamic principle which had a mean gain of 32.61. A difference of 1.51 exists between the mean gains of both groups of students, in favour of students exposed to Diene's dynamic principle.

Research Question 3: *What is the effect of exposure to Diene's dynamic principle in the pretest and posttest scores of Colleges of Education students in terms of procedural skills and conceptual understanding on Algebra?*

Table 3. Mean and Standard Deviation of Pretest and Posttest Procedural Skills and Conceptual Understanding Scores Between Mathematics Students Exposed to and Those not Exposed to Diene's Dynamic Principle

Variables	N	Pretest		Posttest		Mean Difference
		Mean	SD	Mean	SD	
Procedural skills	128	29.78	6.31	60.03	12.55	30.25
Conceptual understanding	124	23.30	9.34	57.42	7.22	34.12

Data in Table 3 compared the pretest and posttest mean procedural skills score of students exposed to Diene's dynamic principle, as well as the pretest and posttest mean conceptual understanding score of students exposed to Diene's dynamic principle. Table 3 shows a pretest and posttest score of 29.78 and 60.03, for students exposed to Diene's dynamic principle. The difference between the posttest and pretest scores is 30.25. This implies that students scored higher posttest procedural skills scores due to exposure to Diene's dynamic principle. Table 3 further shows a mean conceptual understanding pretest and posttest score of 23.30 and 57.42, for students exposed to Diene's dynamic principle. The difference between the posttest and pretest scores is 34.12. This implies that students scored higher posttest conceptual understanding scores due to exposure to Diene's dynamic principle.

Hypothesis 1: There is no significant difference in the procedural skills performance of Colleges of Education students on Algebra who have been exposed to Diene's dynamic principle, compared to those who have not been exposed to it.

Table 4. ANCOVA Summary of Pretest and Posttest Mean Procedural Skills Performance Scores of Students Exposed to and Those not Exposed to Diene's Dynamic Principle

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	7442.409[a]	2	3721.204	27.011	.000
Intercept	43250.826	1	43250.826	313.949	.000
Pretest	132.375	1	132.375	.961	.328
Methods	7272.271	1	7272.271	52.788	.000
Error	34303.242	249	137.764		
Total	796584.000	252			
Corrected Total	41745.651	251			

Table 4 indicates a significant difference between the mean procedural skills performance scores of students exposed to and those not exposed to Diene's dynamic principle, $F(1, 249) = 52.788$, $P(0.000) < 0.05$. Thus, null hypothesis one is rejected. Therefore, there is a significant difference in the procedural skills performance of Colleges of Education students on Algebra who have been exposed to Diene's dynamic principle, compared to those who have not been exposed to it, in favour of students exposed to Diene's dynamic principle.

Hypothesis 2: There is no significant difference in the conceptual understanding of Colleges of Education students on Algebra who have been exposed to Diene's dynamic principle, compared to those who have not been exposed to it.

Table 5. ANCOVA Summary of Pretest and Posttest Mean Conceptual Understanding Scores of Students Exposed to and Those not Exposed to Diene's Dynamic Principle

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	337.265[a]	2	168.632	2.241	.109
Intercept	116225.063	1	116225.063	1544.444	.000
Pretest	1.474	1	1.474	.020	.889
Methods	333.338	1	333.338	4.430	.036
Error	18738.164	249	75.254		
Total	817432.000	252			
Corrected Total	19075.429	251			

Table 5 indicates a significant difference between the mean conceptual understanding scores of students exposed to and those not exposed to Diene's dynamic principle, $F(1, 249) = 4.430$, $P(0.036) < 0.05$. Thus, null hypothesis two is rejected. Therefore, there is a significant difference in the conceptual understanding of Colleges of Education students on Algebra who have been exposed to Diene's dynamic principle, compared to those who have not been exposed to it, in favour of students exposed to Diene's dynamic principle.

Hypothesis 3: There is no significant difference between the pretest and posttest scores of Colleges of Education students in terms of procedural skills and conceptual understanding on Algebra who have been exposed to Diene's dynamic principle.

Table 6. Paired Samples t-test Comparison of Pretest and Posttest Mean Procedural Skills and Conceptual Understanding Scores of Students Exposed to Diene's Dynamic Principle

Group	N	Pretest		Posttest		df	t-cal	sig. (2-tailed)	Remark
		$(\bar{x})$	SD	$(\bar{x})$	SD				
Procedural skills	128	29.78	6.31	60.03	12.55	127	23.324	0.000	HO_3 is rejected
Conceptual understanding	124	23.30	9.34	57.42	7.22	127	33.376	0.000	

$P < 0.05$

Table 6 shows that there is a significant difference between the pretest and posttest scores mean procedural skills scores of students exposed to Diene's dynamic principle (t_{cal} = 23.324, P(0.000) < 0.05), and there is a significant difference between the pretest and posttest scores mean conceptual understanding scores of students exposed to Diene's dynamic principle (t_{cal} = 33.376, P(0.000) < 0.05). With this result, HO_3 is rejected. Thus, there is a significant difference between the pretest and posttest scores of Colleges of Education students in terms of procedural skills and conceptual understanding on Algebra who have been exposed to Diene's dynamic principle.

DISCUSSION

The study revealed that there is a significant difference between the pretest and posttest scores of Colleges of Education students in terms of procedural skills and conceptual understanding of Algebra who have been exposed to Diene's dynamic principle. This is predicated on the fact that the posttest scores compared to the pretest scores of all the students increased significantly after exposure to Diene's dynamic principle. This significant increase in the posttest scores of students with respect to procedural skills and conceptual understanding is as a result of treatment, that is, teaching Colleges of Education students' Algebra using Diene's dynamic principle. This finding lends credence to that of Wang and Liu (2021) who reported that Diene's dynamic principle improved students' procedural skills and conceptual understanding of surd.

The study also revealed that there is a significant difference in the procedural skills performance of Colleges of Education students on Algebra who have been exposed to Diene's dynamic principle, compared to those who have not been exposed to it, in favour of students exposed to Diene's dynamic principle. This observation is predicated on the fact that Diene's dynamic principle promotes active learning by encouraging students to manipulate physical objects and engage in hands-on activities. This active participation allows students to explore mathematical concepts, develop procedural skills and deepen their understanding by experiencing mathematical concepts in a tangible way. This finding agrees with that of Chen et al., (2021) who reported that the use of the Dynamic principle significantly improved students' procedural skills and conceptual understanding of trigonometry than traditional instruction.

The finding of the study showed that there is a significant difference in the conceptual understanding of Colleges of Education students on Algebra who have been exposed to Diene's dynamic principle, compared to those who have not been exposed to it, in favour of students exposed to Diene's dynamic principle. This observation is predicated on the fact that Diene's dynamic principle utilizes concrete manipulative, such as base-10 blocks, which provides a visual and tactile representation of mathematical concepts. These concrete representations help students develop a solid foundation of understanding before moving onto more abstract representations, aiding in the development of conceptual understanding. This finding supports that of Zhang and Liu (2022) who reported that students exposed to Diene's approach had a better understanding of surds compared to those exposed to traditional instruction, indicating the efficacy of Dienes' approach in a Chinese context.

CONCLUSION

The study concluded that Diene's dynamic principle have the potency to improve Colleges of Education students' procedural skills and conceptual understanding in Algebra. The use of Diene's dynamic

principle promotes Colleges of Education students' procedural skills and conceptual understanding in Algebra than the use of the traditional teaching method.

RECOMMENDATIONS

The following recommendation were made based on the findings and conclusion of the study:

1. Mathematics instructors should adopt the use Diene's dynamic principle in teaching mathematics in Colleges of Education in Delta State.
2. Government should provide adequate educational resources that will facilitate easy implementation of Diene's dynamic principle.
3. Colleges of Education administrators should organize in-service training to mathematics instructors to acquaint them with the benefit of active teaching-learning strategies.

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