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Diagnosis and remediation of Mathophobia among junior secondary school students using Polya's problem solving strategy

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Abstract
The study diagnosed and remediated mathophobia learning disability among junior secondary school students using Polya's problem solving strategy. Quasi-experimental research design of the pre-test and post-test type was used for the study. The population of the study was 5200 students. A sample of 61 mathophobia junior secondary class three students obtained by purposive sampling technique was used for the study. Mathophobia Diagnostic Questionnaire (MDQ) and Algebra Performance Test (APT) were the instruments for data collection. The reliability coefficients of 0.84 (84%) and 0.76 (76%) were obtained for MDQ and APT respectively using test-retest method and Pearson's Product Moment Correlation (PPMC). Mean and standard deviation were used to answer the two research questions while Analysis of Covariance (ANCOVA) was used to test the two hypotheses at 0.05 level of significance. The results of the study indicated that mathophobia students taught with Polya's problem solving strategy significantly performed better than mathophobia students taught using deductive learning strategy. However, the difference in the performance of mathophobia male and female students was not significant when taught using Polya's problem solving strategy. Polya's problem solving strategy is recommended for use by teachers of Mathematics to remediate mathophobia among students and promote gender equity in Mathematics learning.

Keywords: Diagnosis, remediation, mathophobia, Polya, problem solving, strategy

Introduction
Mathematics is one of the subjects perceived difficult to learn by most students because of its abstract nature and pedagogy. Majority of students perceived Mathematics as dreaded, bored, difficult, unfriendly, absolute and very abstract with the different perceptions of Mathematics by students reflecting during classroom instruction through their attitudes and performance (Daso, Zalmon & Sillaa, 2021) [2]. According to Daso, Zalmon and Sillaa (2021) [2], students with negative perception in Mathematics exhibit inattentiveness, class avoidance, teacher avoidance, mathophobia, poor study habit and abysmal performance. Mathophobia is an attitudinal learning problem resulting from perceived difficulty in Mathematics. Phobia is a state of fear or anxiety for something uneasy. Tang (1990) as cited in Puteh and Khalin (2016) [13] defined anxiety as an emotional state when there is fear, anxious and uneasy passions associated with a fear of something.

Mathophobia refers to Mathematics phobia, which implies fear of Mathematics or Mathematics anxiety. Mathophobia is a learning disability due to specific fear of Mathematics. Puteh (2002) [14] as cited in Puteh and Khalin (2016) [13] defined Mathematics anxiety as a feeling of being stressed and anxious when faced with numbers and mathematical problem solving in everyday life or when learning Mathematics. Arem (2003) [1] as cited in Puteh and Khalin (2016) [13] also described mathophobia or Mathematics anxiety as a feeling of worry, anxiety, denial, resistance and rejection in Mathematics. According to Bursal and Paznokas (2006) as cited in Marianne and Noel (2016) [8], Mathematics anxiety is a state of discomfort that occurs in response to situations involving mathematical tasks that are threatening to self-esteem and the panic, helplessness, paralysis, and mental disorganization arising among some people when they are required to solve a mathematical problem.

Mathematics anxiety is a disabling condition when students struggle with Mathematics, exhibiting a specific and real fear for Mathematics that causes them to have obsessive urge to avoid Mathematics completely (Oxford & Vordick, 2006 as cited in Marianne & Noel, 2016) [8]. Victims of mathophobia manifest symptoms of mathematical fear, anxiety, boredom, worry, poor performance, failure to do assignment and class and teacher avoidance. Puteh and Khalin (2016) [13] identified the symptoms of mathophobia as sweating, dizziness, nervousness and increased heart rate. Mathophobia can occur at all levels of the educational system and once established, can persist in life, interfering with every day activities involving numeracy experiences in working with teachers, tutors, classmates, parents or siblings (Yenilmez, Girginer, & Uzun, 2007) [16]. Most students begin experiencing mathophobia from elementary school (Henslee & Klein, 2017) [6]. Many factors leads to mathophobia such as curriculum weakness, classroom climate, mathematical abstraction, mathematical incompetence, Mathematics test, past experience, negative experiences in Mathematics, pressure and family expectations, teacher's personality and teaching style, dreams and expectations of family, peer influence, the experience of being humiliated in front of the class, teaching techniques and many more (Henslee & Klein, 2017; Arem, 1993; Puteh, 2002; Puteh & Khalin, 2016) [6, 1, 13, 14]. Perceived difficulty in Mathematics, negative student-teacher relationship, lack of basic mathematical skills, job-mismatch, use of inactive instructional strategies and poor pedagogy are some of the causes of mathophobia among students.

There are several suggestive measures to curbing mathophobia among students such as use of diagnostic and remedial instruction, encouraging positive student-teacher relationship, enhancing students' basic mathematical skills, employment of qualified Mathematics teachers, utilization of active learning and innovative instructional strategies and use of effective pedagogy. Puteh and Khalin (2016) [13] suggested that teachers need to establish teaching and learning environment that is able to invite a sense of excitement and fun for students to learn; an interactive teaching and learning environment that is conducive. Woodard (2004) as cited in Puteh and Khalin (2016) [13] recommended the following measures of reducing students' anxiety levels:

(1) Create an excellent learning environment and create excitement in students and avoid a stressful environment in the students.
(2) Using techniques in cooperative groups. This can help students reduce their anxiety because they are working in a group who shared the same problem.
(3) Teach students according to their ability and using effective teaching tools.

Tang (1990) as cited in Puteh and Khalin (2016) [13] also suggested a number of ways that can be practiced by the teacher to help reduce anxiety in students which includes:

(1) Give encouragement and praise to the students so that they can build their confidence and encourage them in a positive way.
(2) Reduce the threat. Avoid using threatening words and intimidate the students.
(3) Showing love, warmth, trust, empathy and acceptance for students.
(4) Provide rehabilitation to the less advanced students.

Hembree (2010) [5] distinguished two components of test phobia as worry and emotionality. According to Hembree (2010) [5], worry is the cognitive component of phobia, consisting of self-deprecatory thoughts about one's performance while emotionality is the affective component of phobia; including feelings of nervousness, tension and unpleasant physiological reactions to testing situations. Morris, Davis and Hutching (2011) [9] showed that these two components of phobia are empirically distinct, though they are correlated, and that worry relates more strongly than emotionality to poor performance. Zain, Ahmad and Erlina (2012) [17] found out that Mathematics anxiety is one factor that affects student achievement in Mathematics. Hembree (2010) [5] reported that there is a significant negative relationship between mathophobia and Mathematics performance of students. Puteh and Khalin (2016) [13] reported that there is a negative relationship between Mathematics anxiety and Mathematics achievement in which students with high Mathematics anxiety showed poor Mathematics performance and vice versa. Zaslavsky (1994) [20] also noted that many students are not able to deliver a good performance in Mathematics when they are feeling worried or anxious in applying their mathematics skills. Many students who suffer from mathophobia have little confidence in their ability to do Mathematics and tend to take the minimum number of required Mathematics courses, greatly limiting their career choice options. Considering the effects of mathophobia on the performance of students in Mathematics from the empirical reviews of literature, a study seeking to diagnose and remediate mathophobia among students using Polya's problem solving strategy is a step in the right direction.

Problem solving is a stepwise process of solving a problem while problem solving strategy involves the process of problem identification, analysis and solution (Zalmon & Arokoyu, 2021) [18]. The general stages of problem solving strategy are problem identification, planning, implementation and evaluation (Zalmon & Arokoyu, 2021) [18]. The following problem solving strategies have been identified: Polya (1957), Schoenfeld (1985), Mayer (1992), Dewey (1933), Krulick and Rudnick (1989), Mason, Burton and Stacey (1982), Perkins (2000), Ozalkan (2010), Kolawole (3013), Ekwueme (2013), and Bransford and Stein (1989) [3] (Zalmon & Arokoyu, 2021; Zalmon & Charles-Ogan, 2021) [18, 19]. Polya's problem solving strategy is widely used in Mathematics instruction because of its minimal four steps which correspond to the four principles of problem solving in the theory of problem solving postulated by Jiri Dostal in 2015. The theory states that the problem solving process requires the ability to perceive the problem, the willingness to deal with the problem and the willingness to solve the problem (Jiri, 2015) [7]. Jiri's problem solving theory defines theoretically the four process of problem solving as problem awareness, perceptibility of the problem, willingness to deal with the problem and willingness to solve the problem in-line with the four-step process of Polya's problem solving strategy: understanding the problem, devising a plan, carrying out the plan and looking back.

Polya's problem solving strategy is a problem solving strategy characterized by the process of solving mathematical problems through four steps: Understanding the problem, Devising a plan, Carrying out the plan, and Looking back (UDCL). George Polya in his famous book: "How to Solve It" postulated the UDCL strategy of mathematical problem solving (Polya, 1957). Zalmon and Charles-Ogan (2021) [19] offered a concise explanation of Polya's four steps problem solving strategy as follows:

Understanding the problem: Studying the given mathematical problem to identify what to solve for - the unknown.

Devising a plan: Selecting from the list of positive plans: methods, formulae or the best plan to solve the problem.

Carrying out the plan: Implementing the plan devised in actually solving the problem.

Looking back: Evaluating the given problem in the context of the solution obtained to justify its correctness. A new plan is re-devised if the answer to the problem is not correct and the processes continued until the solution to the problem is obtained.

According to Polya (1957), the four step method of problem solving works systematically to reach the solution of a mathematical problem as follows:

Step-1 Understanding the problem: You have to understand the problem. To understand the problem, you have to determine the unknown and the given conditions and draw relevant diagrams as well as introducing suitable notations.

Step-2 Devising a Plan: Find the connection between the data and the unknown. Consider auxiliary problems if an immediate connection cannot be found. Obtain eventually a plan of the solution.

Step-3 Carrying out the Plan: Carry out your plan of the solution and checking each step.

Step-4 Looking back: Check your result. Derive the result differently where possible. Use the result or method for some other problem.

Problem solving is the goal of Mathematics and Mathematics Education (Zalmon & Charles-Ogan, 2021) [19]. According to Odogwu (2015) [10], problem solving is a dominant activity in Mathematics and the ability to solve problems is the goal in Mathematics teaching. Problem solving strategies assist learners to create a thorough understanding of mathematical ideas and procedures by exploring, testing and verifying (Zalmon & Arokoyu, 2021) [18]. The use of problem solving strategies in instructional delivery promotes creativity, mathematical reasoning, mathematical thinking, retention and performance. Research reports revealed that the use of Polya's problem solving strategy enhances the performance and retention of students in Mathematics (George & Enefu, 2019; Olaoye & Iroko, 2018; Fajemidagba & Suleiman, 2012; Zalmon & Arokoyu, 2021; Zalmon & Charles-Ogan, 2021) [4, 11, 3, 19] [18]. However, ascertaining the effectiveness of Polya's problem solving strategy in remediating mathophobia among junior secondary school students is the focus of this study. Polya's problem solving strategy is the experimental strategy while deductive learning strategy is the control strategy in this study.

Deductive learning strategy is a strategy of learning in which learning proceeds from general to particular, abstract to concrete, and formulae to examples. Deductive learning strategy refers to the method of learning from general to particular (Zalmon & Arokoyu, 2021) [18]. In teaching with deductive learning strategy, already constructed formulas, rules, methods or principles are taught to the students and they apply them to solve the problems. This study attempts to diagnose and remediate mathophobia among junior secondary students in using Polya's problem solving strategy. The study also explored the effectiveness of the Polya's problem solving strategy in improving the performance of the male and the female mathophobia junior secondary students in algebra.

Statement of the Problem

Mathophobia is an attitudinal learning problem resulting from perceived difficulty in Mathematics. Mathematics is one of the subjects students develop phobia for because of its abstract nature, deficiency in basic mathematical skills and use of teacher-centered ineffective conventional instructional strategies. Most students viewed Mathematics as dreaded, bored, difficult, unfriendly, absolute and very abstract with the different perceptions of Mathematics by students reflecting during classroom instruction through their negative attitudes and poor performance. Students with mathophobia exhibit inattentiveness, class avoidance, teacher avoidance, poor study habit and abysmal performance. Ascertaining the effectiveness of Polya's problem solving strategy in remediating mathophobia among junior secondary school students is the focus of this study.

Aim and Objectives of the Study

Diagnosing and remediating mathophobia among junior secondary school students using Polya's problem solving strategy is the aim of the study. The objectives of the study were to:

1. Determine the difference in the performance of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy respectively.
2. Determine the difference in the performance of the male and the female mathophobia students taught algebra using Polya's problem solving strategy.

Research Questions

The following questions guided the study:

1. What is the difference in the performance mean scores of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy respectively?
2. What is the difference in the performance mean scores of the male and the female mathophobia students taught algebra using Polya's problem solving strategy?

Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance to guide the study:

1. There is no significant difference between the performances mean scores of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy respectively.
2. There is no significant different between the performance mean scores of mathophobia male and female students taught algebra using Polya's problem solving strategy.

Methodology

The quasi-experimental design was adopted for the study. A population of 5,200 students from 10 public junior secondary schools in Etche local government area of Rivers State was used for the study (Rivers State Post Primary Schools Board, 2019). The sample of the study consisted of 61 mathophobia junior secondary school class three students. Purposive

sampling technique was used with students from two intact classes from two schools. Mathophobia Diagnostic Questionnaire (MDQ) and Algebra Performance Test (APT) were the instruments for data collection. MDQ contained 20 items questionnaire structured after Likert's four point scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). With a criterion mean of 2.50, MDQ was used to diagnose (identify) students with mathophobia. Students with mean 2.50 and above were mathophobia while students with mean below 2.50 were non-mathophobia. APT contained 20 multiple choice objective test on algebra contents areas of factorization of algebraic expressions, simple equations involving fractions and simultaneous linear equations. Students in the experimental group were taught these contents using Polya's problem solving strategy while student in the control group were taught the same contents using deductive learning strategy. APT was administered to students as pre-test (before treatment) and post-test (after treatment). Two experts in Mathematics Education validated the instruments (face and content). The reliability coefficients of 0.84 (84%) and 0.76 (76%) were obtained for MDQ and APT respectively using test-retest method and Pearson's Product Moment Correlation (PPMC). Mean and standard deviation were used to answer the two research questions while Analysis of Covariance (ANCOVA) was used to test the two hypotheses at 0.05 level of significance.

Results

Research question one: What is the difference in the performance mean scores of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy respectively?

Table 1: Mean (M) and Standard Deviation (SD) on the performance of mathophobia students taught algebra using Polya's Problem Solving Strategy (PPSS) and Deductive Learning Strategy (DLS)''

Strategy	Pretest			Posttest			Performance Difference			
	n	M	SD	n	M	SD	M	SD	M	SD
PPSS	34	31.03	10.36	34	93.82	9.54	67.79	0.82	20.94	4.34
DLS	27	47.04	13.17	27	93.89	8.01	46.85		5.16	

Data in table 1 showed that the difference in the performance mean scores of mathophobia students taught algebra using Polya's problem solving strategy (M=67.79, SD=0.82) and deductive learning strategy (M=46.85, SD=5.16) was 20.94, SD=4.34 in favour of the PPSS group.

Research question two: What is the difference in the performance mean scores of the male and the female Mathophobia students taught algebra using Polya's problem solving strategy?

Table 2: Mean difference in the performance mean score of the male and the female mathophobia students taught algebra using Polya's problem solving strategy

Gender	Pretest			Posttest			Performance Difference			
	n	M	SD	n	M	SD	M	SD	M	SD
Male	19	30.79	9.47	19	95.79	5.07	65.00	4.40	5.00	3.10
Female	15	31.33	11.72	15	91.33	13.02	60.00		1.30	

Data in table 2 showed that the difference in the performance mean scores of the male (M=65.00, SD=4.40) and the female (M=60.00, SD=1.30) mathophobia students taught algebra using Polya's problem solving strategy was 5.00, SD=3.10 in favour of the male mathophobia students.

Hypotheses

H_{01}: There is no significant difference between the performance mean scores of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy respectively.

Table 3: Summary of ANCOVA on the difference between the performance mean scores of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Strategy	1.364[a]	2	.682	.008	.992
Intercept	42345.780	1	42345.780	526.112	.000
Pretest	1.299	1	1.299	.016	.899
Design	501.194	1	501.194	6.227	.000
Error	4668.308	58	80.488		
Total	541975.000	61			
Corrected Total	4669.672	60			

Data in table 3 showed that there is a significant difference between the performance mean scores of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy ($F_{(1,58)}$ =6.227, p <0.05). Hence, the null hypothesis one is rejected and the alternate hypothesis retained at 0.05 level of significance.

H_{02}: There is no significant different between the performance mean scores of mathophobia male and female students taught algebra using Polya's problem solving strategy.

Table 4: Summary of ANCOVA on the difference between the performance mean scores of mathophobia male and female students taught algebra using Polya's problem solving strategy

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Strategy	352.657[a]	2	176.328	2.062	.144
Intercept	24685.514	1	24685.514	288.743	.000
Pretest	186.207	1	186.207	2.178	.150
Gender	175.780	1	175.780	2.056	.162
Error	2650.285	31	85.493		
Total	302300.000	34			
Corrected Total	3002.941	33			

Data in table 4 showed that there is no significant difference between the performance mean scores of Mathophobia male and female students taught algebra using Polya's problem solving strategy ($F_{(1,31)}$ =2.056, p>0.05). Therefore, the null hypothesis two is retained and the alternate hypothesis rejected at 0.05 level of significance.

Discussion of Findings

Remediating mathophobia among students using Polya's problem solving and deductive learning strategies

Data in table 1 showed that the difference in the performance mean scores of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy was 20.94, SD=4.34 in favour of the group taught with Polya's problem solving strategy. Data in table 3 showed that there is a significant difference between the performance of mathophobia students taught algebra using Polya's problem solving strategy and deductive learning strategy. Mathophobia students taught with Polya's problem solving strategy significantly outperformed their counterparts taught with the conventional deductive learning strategy. Polya's

problem solving strategy successfully remediated mathophobia among students. The effectiveness of Polya's problem solving strategy in improving the Mathematics performance of students were reported by George and Enefu (2019) [4], Olaoye and Iroko (2018) [11], Fajemidagba and Suleiman (2012) [3] and Zalmon and Arokoyu (2021) [18].

Effects of Polya's problem solving strategy on the performance of the male and the female mathophobia students

Data in table 2 showed that the difference in the performance mean scores of the male and the female mathophobia students taught algebra using Polya's problem solving strategy was 5.00, SD=3.10 in favour of the male mathophobia students. Data in table 4 showed that there is no significant difference between the performance of Mathophobia male and female students taught algebra using Polya's problem solving strategy. Polya's problem solving strategy remediated mathophobia among the male and the female students. George and Enefu (2019) [4] and Zalmon and Arokoyu (2021) [18] found out that Polya's problem solving strategy promotes gender parity among students in Mathematics.

Conclusion

This study on diagnosis and remediation of mathophobia among junior secondary school students using polya's problem solving strategy revealed that Polya's problem solving strategy successfully remediated mathophobia among students. Polya's problem solving strategy also remediated mathophobia among the male and the female students.

Recommendations

Polya's problem solving strategy is recommended for use by teachers of Mathematics to remediate mathophobia among students and promote gender equity in Mathematics.

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