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THE EFFECTS OF SCHOENFELD PROBLEM-SOLVING INSTRUCTIONAL STRATEGY ON PERFORMANCE OF SENIOR SECONDARY II STUDENTS IN MATHEMATICS IN GOMBE STATE, NIGERIA

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Abstract

This paper explored the effect of Schoenfeld problem-solving instructional strategy on the performance of senior secondary II students in mathematics in Gombe state, Nigeria. The study was guided by two research questions and two hypotheses. The study employed a pre-test, post-test, non-equivalent control group quasi-experimental research design. The study sampled 202 students from four intact classes. Two classes with 100 students as control and another two as experimental with 102. The instruments were validated by two experts. The instrument used for data collection was a Geometry Performance Test (GPT) with a reliability coefficient of 0.76. Mean and standard deviation were used to answer research questions while Analyses of Covariance (ANCOVA) were used to test the null hypotheses at 0.05 level of significance. The findings of the study revealed that students taught with Shoenfeld Problem-Solving Instructional Strategy have a high mean score F (1, 201) = 70.904 at p=0.00, the findings also, indicated that there is no significant effect of treatment and gender on students' performance in mathematics. (F 1, 102) = 0.005; p-value 0.945 > 0.05). The paper recommended that curriculum planners, school administrators, and teachers, should explore the inclusion and use of the Shoenfeld Problem-Solving Instructional Strategy (SPSIS) for solving and teaching of mathematical problems.

Keywords: Schoenfeld Problem-Solving, Instructional Strategy, Performance, Gender

Introduction

Mathematics is a core subject taught at primary and secondary school levels of the Nigerian educational system. In addition, mathematical knowledge plays a crucial role in understanding the contents of other school subjects such as science, social sciences, and even music and arts. Mathematics is a major aspect of our educational system since its application cuts across all areas of human endeavour. Oludipe (2017) acknowledged that the gateway to the survival of a nation scientifically and technologically is science literacy which can only be achieved through mathematics and science education. Geometry is a branch of mathematics that studies the sizes, shapes, positions angles and dimensions of things. It is a branch of mathematics that is concerned with the properties and relations of points, lines, surfaces, solids, and higher dimensional analogues.

Despite the important position, mathematics occupies, it remains one of the subjects that students persistently perform low in, in Nigeria. The performance of senior secondary school students in mathematics has shown a declining trend. Abdullahi (2023) attributed the reasons for such persistent poor performance in the subject to methodology, attitude of students towards the subject, teachers- variables, school and class size, location, gender difference of the students, government, poorly motivated teachers, and students' level of mental development. However, outstanding factors have been attributed to poor or inefficient teaching methods, the effect is students have great difficulty in solving non-standard problems that require the application of domain knowledge and routines. Similarly, the performance of students in the Senior Secondary Certificate Examination (SSCE) in Gombe State between 2011- 2022 (with 5 credits and above, including mathematics) as analyzed by the Education Management Information System (EMIS) of Gombe State Ministry of Education (2022) shows that percentage pass was 23.50% which is poor.

Geometry is an aspect of mathematics which deals with the study of different shapes. These shapes may be plain or solid. Statistics have shown difficulty in teaching and learning of mathematics, geometry in particular. This has resulted in mass failure in examinations. According to WAEC chief examiners' report 2021, inadequate knowledge of bearing and circle geometry were mentioned among areas of weakness of students.

Performance is an observable or measurable behavior of a person in a particular situation, usually an experimental situation. Performance of students can be determined by the knowledge, skills and abilities they have developed after the teaching and learning process. Thus, it is the grade they have acquired that implies how well they perform academically in the subject. In addition, grades are not just the factors that determine how they excel during teaching-learning situations. The learner's ability to retain information is also dependent on the way a teacher teaches the subject. No teaching method could be considered the best. Sometimes a teaching method could be considered appropriate in a situation when it is

needed. No method could stand alone all the time. Good teachers must use a variety of methods to execute teaching effectively.

Schoenfeld's work on mathematical thinking and problem-solving in mathematics education according to Christopher (2018) is well-known and has been influential for decades. Schoenfeld Instructional Strategy is a goal-oriented teaching strategy that explores the knowledge base of the learner, guiding the learner to choose an appropriate strategy, helping the learner to monitor and self-regulate his thinking, where his belief systems and prior mathematical experiences are key in arriving at the solution. The steps are as follows:

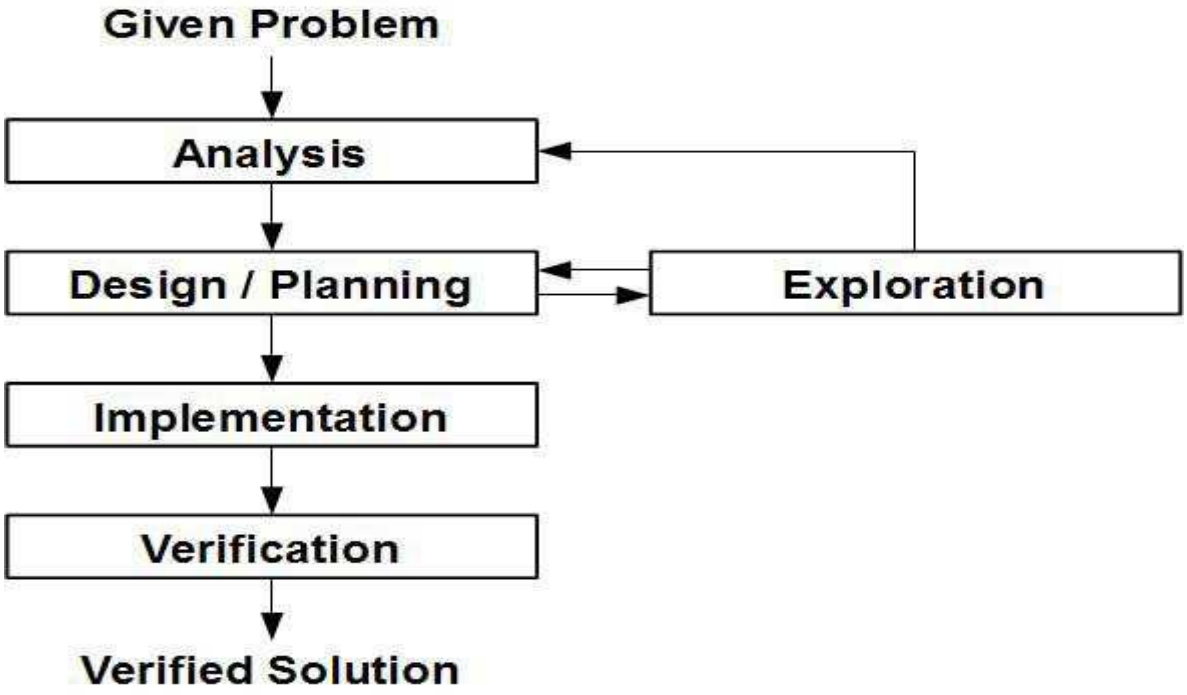

Figure 1: Steps in using Schoenfeld Problem Solving Instructional Strategy
Source: Benjamin, (2021|).

Schoenfeld (2011) in a study carried out to determine the measure of impact of problem-solving instructional strategy in comparison to the conventional method of instruction on some students grouped into controlled (taught with conventional method of instruction) and experimental (taught with Shoenfeld problem- solving instruction method), came up with the finding that the experimental group's performance indicated clearly that those students had better academic achievement than the controlled group. Schoenfeld hypothesis that the following are conditions for success in problem-solving:

1. A mastery of the basic problem-solving techniques
2. A "managerial strategy" helps to select appropriate approaches to problems and to terminate fruitless ones in general, to help one budget problem-solving resources efficiently.

According to Schoenfeld (1985) research, four categories of knowledge determine the quality and success of our problem-solving attempts:

1. Actual knowledge base: Although we typically realize that the content of our knowledge makes a difference to our ability to solve problems, we don't always consider how we know it, or recognize our interpretive filters. When working with students, Schoenfeld argued that we need to be able to evaluate the interpretive filters they have developed. That is, being a good teacher means more than being able to explain the same thing in multiple ways — good teachers need to recognize how students know the material and be able to intervene when their understandings falter
2. Problem-solving strategies: Problem-solving strategies, also called "heuristics," heuristics in mathematics, they include approaches like drawing a diagram, looking at individual cases, solving an easier related problem, and establishing sub-goals. Students can be taught these strategies and, in Schoenfeld's experience, as a result, they can learn to solve problems that the instructor cannot
3. Control, monitoring and self-regulation (i.e. metacognition): In order to solve problems effectively, we must control, monitor, and self-regulate our thinking. What we know matters, but how and when we use our knowledge matters even more. In mathematics, students often begin using techniques and strategies they know without evaluating how appropriate those strategies are for the problem at hand.
4. Beliefs and the practices that give rise to them, students do not simply develop these unhelpful beliefs out of perversity. They learn their beliefs by abstracting from the typical practices of their classrooms.

According to Schoenfeld (2019), teaching for conceptual understanding necessitates that learners acquire declarative knowledge, procedural knowledge, and conceptual and metacognitive (cognitive and meta-process) knowledge—all of which can be acquired partially or in totality through direct teaching. During direct teaching, learners should be meaningfully involved in the lessons by analyzing, illustrating, explaining, and demonstrating their understanding of the mathematics skills they are learning. Based on the research carried out by Nuraini, Kusmayadi and Fitriana (2018) on Mathematics problem solving based on Schoenfeld in senior high school students, it was concluded that students performed well.

Furthermore, conventional method is just one of several teaching methods, taught in schools it's usually considered the primary one. The conventional is convenient for the institution and cost-efficient, especially with larger classroom sizes. This is why conventional is the standard for most college courses when there can be several hundred students in the classroom at once. Also, the conventional method is a talk-chalk method of teaching in which the teacher does most of the talk, while the students, listen and take down notes. The conventional method which is known as an expository approach is the oldest approach that is common in different schools for teaching almost every subject. Akande, Agu and Allahnana (2019) opined that when teaching is characterized by rote learning, meaningless memorization or verbalism, the facts learned are not long retained and can hardly change the learners' behavior.

Therefore, the instructional method employed by the teacher plays an important role in the acquisition of instructional content for meaningful learning. Teachers predominantly employed conventional method of teaching which does not encourage students' thereby leading to low performance. Low performance among students in geometry could be as a result of the kinds of teaching methods adopted by the mathematics teachers. It is on this premise that this research is set to investigate what result would be obtained in terms of performance using Schoenfeld problem-solving instructional strategy, which has proven to be an effective methodology in the teaching and learning of mathematics, which emphasizes that active learning, should always be explored for proper understanding of the subject. Iji, Obarakpo, & Samuel *(*2018).

Gender has been a key variable in numerous studies on science and mathematics performance. Individual behavioural traits and gender roles play an important determinant of interest, perception and performance. Therefore, using gender as a moderating variable in an experimental study can yield useful practical information. However, there are conflicting findings on how gender influences academic achievement. It seems the influence of gender varies according to school subject. Gender has remained a burning issue and has remained relevant in education because it has been linked to achievement and participation in certain professions. According to Hanawa (2017), and Yussif (2016) many research findings in Nigeria have shown that male students perform better than female students in mathematics generally even though they are put in the same classroom situation. On the contrary, Yau and Sylvester (2023). Lubienski and Ganley (2017) reported that females perform significantly better than their male counterparts. Gupta, Pasrija and Kavita (2015) also further supported the argument that females performed better than males when problem-solving learning is used. On the other hand, when competitive or individualized learning strategy is used males did better than females. Hayatu and Okoronka (2016), Kasap and Argenekon, (2017), showed that gender has an insignificant effect on mathematics and science performance.

Academic Performance; is the grade which the students score on the geometry performance test before and after being exposed to the Schoenfeld problem-solving instructional strategy and conventional method of teaching.

Problem-solving instructional strategy*; in this study* refers to the mental process that people go through to discover, analyze, and solve problems. It also consists of using generic or ad-hoc methods in an orderly manner, for finding solutions to problems.

Schoenfeld's Instructional Strategy; In this study Schoenfeld's Instructional Strategy is a goal-oriented teaching strategy that explores the knowledge base of the learner, guiding the learner to choose an appropriate strategy, helping the learner to monitor and self-regulate his thinking, where his belief systems and prior mathematical experiences are key in arriving at the solution.

Statement of the problem.

The knowledge of mathematics is an inevitable tool for the technological development of any nation. On the other hand, geometry as an aspect of mathematics allows students to connect mapping objects in the classroom to real-world contexts regarding direction and place. Despite the immense benefits to be derived from the teaching and learning of mathematics in Nigeria, there is low performance in the subject at the senior secondary school level, particularly in Gombe State. Of great concern is that 63.1% of mathematics teachers still rely on conventional methods of imparting mathematics knowledge (Rutkiene & Tandzegolskiene, 2022). This has led to the failure in producing the desired results in terms of interest and performance on the part of many students leading to increased failure of students in the Senior School Certificate Examinations (SSCE). The average performance of Gombe State mathematics students in external examinations such as the West African Senior Secondary Certificate Examination (WASSCE) is not encouraging, (EMIS, 2022).

If this trend is not reversed, Gombe state will continue to be in the league of educationally backward states with no hope of catching up with other advanced states of the federation. This is why the researcher wants to explore the schoenfeld problem-solving instructional strategy that has proven to improve learning. It is on this premise that this study seeks to investigate what results would be obtained when Schoenfeld's problem-solving strategy is used to teach students in terms of performance in mathematics in Gombe State. The researcher believes that a tested strategy like Schoenfeld's Problem-Solving is likely to help in reversing the ugly trend of mathematics poor performance among senior secondary school students in Gombe state.

Purpose of the study

The purpose of this paper is to investigate the effect of Schoenfeld problem problem-solving instructional strategy on students' performance in mathematics in senior secondary schools in Gombe state Nigeria.

Specifically, the study seeks to:

1. ascertain the pretest and posttest performance scores of the students in mathematics in the experimental and control groups.
2. Find out the pretest and posttest performance scores of male and female students in mathematics in the experimental group.

Research Questions

The following research questions are raised to guide the study:

1. What are the pre-test and post-test mean performance scores of senior secondary school students in the experimental and control groups?
2. What are the post-test mean performance scores of male and female students in the experimental group?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance in the study.

H_{01}: There is no significant difference between the posttest performance mean scores of senior secondary school students in mathematics in the experimental and control groups.

H_{02}: There is no significant difference between posttest performance mean score on the gender of senior secondary school students in mathematics in the experimental group

Method

The area of the study is Gombe state, located in the Northeast Geo-political zone of Nigeria. It shares common boundary lines with Borno, Bauchi, Yobe, and Taraba states. The state is made up of 11 local government areas and has three education zones namely; Gombe South, Gombe Central and Gombe North with 139 senior secondary schools. (EMIS, MoE, Gombe, 2021). The population of the study comprised 21,437 Senior secondary students II, offering mathematics in public senior secondary schools in Gombe state. The sample for the study was 202 students with 115 males and 87 females from four intact classes in four senior secondary schools. Two schools as the control schools with 100 students (GDSS Lamugu and GDSS Todi) and another two as experimental with 102 students (GDSS Shela and GDSS Ayaba) schools.

The study employed a pre-test, post-test, and nonequivalent quasi-experimental research design. This research design is appropriate for this study because it allows for the manipulation of an independent variable and the examination of causality between an intervention and outcome. Quasi-experimental research design examines whether there is a causal relationship between the dependent and independent variables. The design can be represented symbolically as follows:

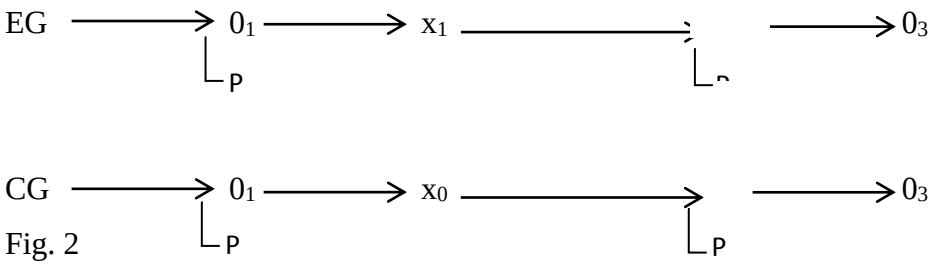

Fig. 2

Where:

EG - Experimental Group

CG - Conventional method (control) group

0_1 - Pretest administered on the groups

0_2 - Posttest on the groups

0_3 - Posttest on the groups

X_1 - Treatment is given to Group

X_0 - Conventional Method No treatment was given to the control group

P - Performance

The instrument used to collect data for the study was the Geometry Performance Test (GPT), which was adapted from the work of Timayi (2016) and modified by the researcher to suit the current study, it was subjected to content and face validation by two lecturers from the Department of Mathematics and Computer Sciences. All the validates are from Modibbo Adama University, Yola, their critiques and observations were incorporated into the test items and for developing the final draft used for the study. The instrument has a reliability coefficient of 0.76, which was computed using Kudder- Richardson formula K-R21.

Four different schools were selected for the study, two for experimental, and two for control. The experimental groups and control groups were randomly assigned. A pre-test of the Geometry Performance Test (GPT) was administered to the students in both groups (experimental and control) in their respective classes and scores were recorded. Then the students in the control group were taught geometrical topics like geometric ratios, triangles and polygons, circle geometry and loci. using the conventional method (CM), while the experimental groups were taught using Schoenfeld Problem- Solving Instructional (SPSIS) in which the students were guided in defining/ analyzing a given problem by exploring all the information in the problem, then devising a design/plan, implementing the design by using an appropriate heuristic and then verify the solution.

At the end of the treatment, the research assistants in each school administered a posttest using re-shuffled GPT to the groups which lasted for 1 hour 15 minutes (75 minutes). After the posttest, the researcher through the research assistants collected the scripts and marked and scored each participant using the marking scheme provided by the researcher. In GPT each item was scored 2½ marks making a total of 100 marks for the 40 items. The data obtained was further coded and analyzed using Statistical Package for Social Sciences (SPSS) version 25. Generally, the study was conducted within a period of six weeks. The first week was used to conduct the pretest, the treatment lasted for 4 weeks and the last week was used for the posttest. A descriptive statistic of mean and standard deviation was used to answer the research questions. Analysis of covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. Decision rule; If P-value $\leq$ 0.05 level of significance, the null hypothesis is rejected otherwise do not reject.

Results

Research Questions 1: What are the pre-test and post-test mean performance scores of senior secondary school students in the experimental and control groups?

Answer to research question 1 presented in Table 1

Table 1: Pretest-Posttest Mean Performance Scores of Senior Secondary School Students in the Experimental and Control Groups.

		Pre-Test		Post-Test		
Groups	N	$\bar{X}$(Pre)	SD	$\bar{X}$(Post)	SD	Mean Gain
Experimental	102	34.90	10.65	48.16	9.47	13.26
Control	100	33.44	9.38	35.20	8.57	1.76
MD		1.46		12.96		

MD = Mean Difference

Table 1 revealed the mean pretest and posttest performance scores in mathematics for students in the Experimental and control groups. For students the Experimental group, the results revealed the mean scores of 34.90 and 48.16 for the pretest and posttest respectively; which yielded a mean gain of 13.26. Also, for students in the control group, the Table revealed 33.44 and 35.20 for pre-test and post-test values respectively. This yielded 1.76 as a mean gain in performance score. This implies that those in the Experimental group had greater mean gain than those in the control group. However, further analysis (inferential) should be carried out to determine whether the differences are significant or not.

Research Question 2: What are the pre-test and post-test mean performance scores of male and female students in the experimental group

The answer to research question 4 is presented in Table 2

Table 2: Pre-test and post-test mean Performance scores of male and female students' performance based on treatment.

			Pre-test		post-test		
Group	**Gender**	**N**	$\overline{X(Pre)}$	**SD**	$\overline{X}$**(Post)**	**SD**	**Mean Performance Gain**
Experimental	Male	60	34.14	10.98	49.04	10.97	14.90
	Female	42	35.25	10.14	48.02	8.30	12.90
MD			1.11		1.02		

MD= Mean Difference

The descriptive analyses on the effects of gender on treatment in Table 4 show the mean and standard deviation for the male and female students' performance based on treatment. Male students had a mean score of 34.14 and 49.04 for pretest and posttest, which yielded a mean gain of 14.90. Female students had a mean score of 35.25 and 48.02 for pretest and posttest respectively, which yielded a mean gain of 12.90. This implies that male students had more mean gain than female students.

H_{01}: There is no significant difference between the posttest performance mean scores of senior secondary school students in mathematics in the experimental and control groups.

Table 3: Summary of Pretest and posttest Performance Score of Students in the Experimental and Control Groups

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12676.331[a]	2	6338.165	35.482	.000	.263
Intercept	94847.907	1	94847.907	530.971	.000	.727
Pre-test	4.174	1	4.174	.023	.879	.000
Group	12665.733	1	12665.733	70.904	.000*	.263
Error	35547.555	199	178.631			
Total	970612.500	202				
Corrected Total	48223.886	201				

Dependent Variable: Post Test Perf.., *P ≤ 0.05

a. R Squared = .263 (Adjusted R Squared = .255)

Table 3 presents one-way ANCOVA results on the significant difference between experimental and control groups on senior secondary school students' performance in mathematics. The table reveals the F (1, 201) = 70.904 at p=0.00. Thus, F (70.904) is significant since P calculated (0.00) < P hypothetical (0.05) the null hypothesis is therefore rejected. This implies that there is a significant difference between the posttest mean performance scores of the students in the experimental and control groups in favour of those in the experimental group. More so, the Eta-squared (.263) was reported. This indicates that about 26.3 % of performance noticed at the post-test between the two groups of students was attributed to the treatment.

H_{O2} There is no significant difference between posttest performance mean scores on the gender of senior secondary school students in mathematics in the experimental group.

Table 4: ANCOVA Summary of Performance Score of Treatment based on Gender.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	166.565[a]	2	83.282	.387	.680	.008
Intercept	65621.940	1	65621.940	304.689	.000	.755
PretestPerf	164.288	1	164.288	.763	.385	.008
Gender	1.024	1	1.024	.005	.945*	.000
Error	21321.977	99	215.374			
Total	601631.250	102				
Corrected Total	21488.542	101				

Dependent Variable: Post-test Perf., * P≤ 0.05

a. R Squared = .008 (Adjusted R Squared = -.012)

Table 4 presents one-way ANCOVA results on the effect of gender on senior secondary school students' performance in mathematics with treatment. The table reveals the F (1, 101) = 0.005 at p=0.945. Thus,

F (0.005) is not significant since P calculated (0.945) > P hypothetical (0.05) the null hypothesis is therefore accepted. This implies that there is no significant difference between posttest mean performances in mathematics of the male and female in the experimental group.

Summary of Findings

The findings of the study are as follows:

1. Students in the experimental group had a higher mean score (48.1) than those in the control group (35.2). There was also a significant difference in the performance mean scores of those students in the experimental group and those in the control group. (F_{202}, p-value 0.0001 < 0.05) in favour of those in the experimental group. This agrees with the findings from earlier studies by Nuraini, Kusmayadi and Fitriana (2018)
2. There is no significant effect of treatment on gender with regard to students' mean performance. (F 1, 101) = 0.005; p-value 0.945 > 0.05). This finding agrees with Hayatu and Okoronka (2016), Kasap and Ergenekon (2017).

Conclusion

This paper however reiterated the importance of teaching methods in improving performance in mathematics. Specifically, the study had shown that effective teaching methods such as Schoenfeld's Problem-Solving Instructional Strategy could be used to enhance students' academic performance in mathematics in Gombe state. The current study shows no sex difference in the academic performance of students in mathematics. It can be concluded that gender as an intervening variable did not account for student's academic performance in mathematics.

Recommendations

Based on the results of this study, the following recommendations were made:

1. Mathematics teachers should use SPSIS to enhance academic performance in mathematics.
2. Curriculum planners should incorporate SPSIS as an accepted instructional strategy since the method is not gender biased.
3. Principals of secondary schools should encourage their mathematics teachers through sponsorship to attend refresher courses and other forms of in-service training to enable them to acquire the needed skills that can help them use or apply different Schoenfeld strategies in classroom teaching and learning.
4. Students are to be encouraged by teachers to learn and use SPSIS in dealing with mathematics problems to increase interest in mathematics.
5. Mathematics teachers should use SPSIS to arouse students' interest in mathematics teaching.
6. Textbook writers to develop a balanced textbook in terms of content, methodology, practical activities and assessment exercises.

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