EFFECTS OF PRE-THEORETIC INTUITION QUIZ INSTRUCTIONAL STRATEGY ON STUDENTS' ACHIEVEMENT IN MATHEMATICS IN SENIOR SECONDARY SCHOOLS IN OGBIA LOCAL GOVERNMENT AREA OF BAYELSA STATE

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Abstract

The study investigated the effects of pre-theoretic intuition quiz instructional strategy on senior secondary school students' achievement in mathematics. The moderating effects of gender and age were also examined on the dependent variable. A pretest-posttest, control group, quasi-experimental design was adopted. One hundred and seventy eight (178) SS2 students in Ogbia Local Government Area of Bayelsa State, Nigeria, were purposively selected for the study. Four schools were randomly assigned to experimental and control groups and the study lasted for eight weeks. Three instruments were used for the study. They were two Instructional Guides and Mathematics Achievement Test (MAT) with a reliability of 0.74 using Kuder-Richardson Formula 21(KR-21). Three research questions were answered and three null hypotheses were tested at 0.05 level of significance. Mean and standard deviation were used to analyze the research questions and Analysis of Covariance (ANCOVA) for the hypotheses. Treatment had significant effect on students' achievement in mathematics F (1,175) = 3.910; p < 0.05; and partial eta squared = 0.356). A non-significant effect of gender and age was observed. The findings showed that pre-theoretic intuition quiz instructional strategy improved students' achievement in mathematics more than the modified lecture instructional strategy. It was recommended among others that, teachers should adopt pre-theoretic intuition quiz instructional strategy to improve students' achievement in mathematics in senior secondary schools.
Keywords: Pre-theoretic intuition quiz instructional strategy, Gender, Age.

Introduction

Mathematics is an activity for everybody in human societies. Thus, it is a subject or field of study that everybody need and use consciously and unconsciously in daily life. Obasi, Ezekiel and Mba (2016) aver that, mathematics is an integral part of everyone's life and affects virtually every field of human endeavour. To Zalmon, Gogo and Peters (2014), it is an indispensible tool

for nation development. It is a model of thinking (Adenegan, 2014). Mathematics is the foundation subject of science and technology. No nation can achieve the task of development without science and technology (Khan, Haider & Bukhari, 2016). Mathematics is a core and compulsory school subject in the curricula from primary to junior secondary and to the senior secondary school levels of the Nigeria educational system (Abubakar & Bawa, 2006; Aguele & Usman, 2007; Kurumeh & Imoko, 2008).

Despite the importance of mathematics, students' achievement in mathematics in Nigeria over the years has been poor. Considering the West Africa Examination Council (WAEC) results released from Students' achievement in the Senior School Certificate Examination in mathematics in four years (2006-2010) was below 50% and it was in 2005, students' achievement was slightly above average (Salman, Mohammed, Ogunlade & Ayinla, 2012). In the WAEC results released on the 10th of August 2015, the failure rate of students in mathematics and English Language is 61.32% (Adesulu, 2015). From (2012-2016) credit passes and above in mathematics was 49.00 %, 36.00 %, 31.30 %, 34.18 % and 38.68 % respectively (Zalmon &Wonu, 2017).

However, the poor achievement of students in mathematics in Nigeria is not without a cause. There are many factors that contribute to poor students' achievement in mathematics ranging from the major to the minor. Such factors include students' emotional problems, study habits, self-esteem/self-efficacy, teachers' incompetency, lack of motivation and poor instructional methods (Salman *et al*, 2012). The major cause of poor students' achievement in mathematics in secondary schools is the poor instructional method or strategy use by teachers in classrooms which is the lecture instructional strategy (Kaur, 2011).

The lecture instructional strategy is a telling strategy that is teacher-centred, involving much input from the teacher with little or none from the learner. It does not support active learning which enhances students' understanding of subject matter (Achuonye & Ajoku in Frederick-Jonah & Ibaba, 2015). There seems to be consensus of opinions among science educators concerning the important role played by instructional strategy adopted as a classroom variable in affecting students' achievement in mathematics (Ogundiwin & Awolere, 2012; Frederick-Jonah & Ibaba, 2015; Chinweoke, 2016). It is therefore necessary to consider the effects of pre-theoretic intuition quiz instructional strategy or sometimes called concept inventory on students' achievement in mathematics. Pre-theoretic intuition quiz is a pedagogical instructional strategy that is based on constructivism whereby learners actively construct their own knowledge and meaning from their experiences (Fosnot in Ogundiwin & Awolere, 2012). Constructivism promote active learning or learning by doing.

In the teaching and learning process, questions lead to more questions and answers to understanding. Many students virtually have no questions to ask. They might sit passively in the class looking at the teacher or chalk board with their minds and brains inactive as well. This confirms the observation that, teachers asked as many as fifty thousand questions a year while students asked ten questions (Watson & Young in Shahrill, 2013). Studies such as Barak and Dori; Ben-Chaim, Ron and Zoller; Ennis; Facion; and Harpaz and Adam in Aizikovitsh-Udi (2011) revealed that, the changing and challenging world require students to advance beyond the building of their knowledge to developing higher-order skills. Such as critical thinking, problem-solving and others which can be developed through question-asking and question-answering. These are vital skills in mathematics learning. As put forward by Devlin (2012), mathematical

thinking is a crucial but elusive ability which need to be developed in students. These abilities include logical and analytic thinking as well as quantitative reasoning.

There is need for mathematics educators to developing instructional strategies that may enhance these mathematical abilities. Thus, engaging students in the pre-theoretic intuition quiz instructional strategy which involves asking first-tier lower level quiz to attract students' attention and activate their background knowledge and skills in mathematics. Second-tier higher level quiz questions to activate students' thinking. Shahrill (2013) reported that higher order questions promote analysis, encourages critical thinking and considered as powerful tool for learning. The study further states that, effective questioning skills have been linked with students' achievement in mathematics. Question-asking and question-answering will elicit feedback aimed at getting students to both identify and assess their own views on a concept precisely mathematics to correcting their misconceptions of the concept in order to allow new information to be learnt (Ogundiwin & Awolere, 2012).

The impact of gender, the state of being male or female, on education has been investigated by many gender-based researchers. Gender inequalities in mathematics achievement have been a course for great concern to educationists/scientists (Ajai & Imoko, 2015). Abubakar and Bada (2012) found low correlation coefficient (r= 0.004) of gender which is not significant on students' academic achievement in college mathematics. Also, Habibollah, Rohani, Aizan, Jamaluddin and Kumar (2009) found no significant difference between gender and achievement of undergraduate students. In the same vein, Frederick-Jonah and Ibaba, (2015) found no significant difference between gender and achievement of secondary school students in mathematics. In the United States, Jabor, Kungu, Machtmes, Buntat and Nordin (2011) found that, female students had statistically significant higher mathematics achievement scores than their male counterparts with an effect size of Cohen's d (d = 0.24) which revealed a small effect size.

Gender inequalities in students' mathematics achievement might be eliminated by the teachers by using an appropriate instructional strategy. Examining the possibilities of using pre-theoretic intuition quiz instructional strategy to eliminate gender inequalities or differences in mathematics achievement of students specifically in sequence and set theory is one interest of the study.

There have been many studies conducted to determine the effect of several demographic variables on students' achievement. One of such variables is age. Educational researchers in their investigation of the influence of age on academic achievement discovered a variety of findings.   Abubakar and Bada (2012) observed age and gender differences on academic achievement of students in college mathematics and found that, age positively correlated to achievement with a coefficient (r= 0.142) which is a better predictor than gender with (r=0.004). Jabor *etal* (2011) found that, below 19 years of age students had a statistically significant higher mathematics achievement scores than 19 years and above age students in mathematics with an effect size of Cohen's d (d = 0.41). Habibollah *et al* (2009) observed that creativity and age show as lower predictors of academic achievement of students with creativity (t = 2.011, p = 0.046) and age (t = 4.269, p = 0.000). Also, Frederick-Jonah and Ibaba, (2015) found non-significant effect of age on the academic achievement of secondary school students in mathematics. This mixed influence of age on students' achievement in mathematics need to be examined using pre-theoretic intuition quiz instructional strategy.

Statement of the Problem

Mathematical skills are crucial for a wide array of analytical, technological, scientific, security and economic applications. Mathematics is a core and compulsory school subject in the curricula from primary to junior secondary and to the senior secondary school levels of the Nigeria educational system. Psychologically, mathematics helps in developing an analytic mind and assists in better organization of ideas and accurate expression of thoughts. It plays a predominant role in our everyday life and it has become an indispensable factor for the progress of our present day world. The available literature shows that students' poor achievement in mathematics is due to a number of factors, especially those related to the strategies used for teaching mathematics (Kaur, 2011)). Many studies on pre-theoretic intuition quiz instructional strategy relatively ae carried out in other fields of study rather than in mathematics. Therefore, this study determined the effects of pre-theoretic intuition quiz instructional strategy on students' achievement in mathematics (sequences; AP & GP) and set theory. The study also determined the moderating effects of gender and age on the dependent variable.

Research Questions

The following three research questions guided the study
1. What difference exists in students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies?
2. What difference exists between male and female students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies?
3. What difference exists between students' within ages 13-15 and 16-18 years achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies?

Hypotheses

The following three null hypotheses were tested at 0.05 significant level.
HO_1 There is no statistically significant difference in students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies
HO_2. There is no statistically significant difference between male and female students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies
HO_3. There is no statistically significant difference between 13-15 and 16-18 years students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies

Research Design

The study adopted a pretest-posttest, control group, quasi-experimental design. A 2 x 2 x 2 factorial matrix was adopted with instructional strategies (pre-theoretic intuition quiz and modified lecture instructional strategies) as treatment, gender (male and female), age (13-15 and 16-18) years as moderator variables.

Selection of Participants

Four schools in Ogbia Local Government Area of Bayelsa State were purposively selected and assigned to treatment and control groups. The selection of the schools was based on the following criteria:

1. The schools must be public schools,
2. The teachers must be specialist in mathematics education and have been teaching mathematics for at least five (5) years and
3. The teachers must be willing to be involved in the experiment.
   One intact class of Senior Secondary two (SS11) students was randomly selected and two (2) schools were randomly assigned to treatment and control groups. A total of 178 students (males=112, females=66) were involved in the study.

Research Instruments

Three instruments were used in this study; namely:
1. Instructional Guide on Pre-theoretic Intuition Quiz Instructional Strategy (IGPIQIS)
2. Instructional Guide on Modified Lecture Instructional Strategy (IGMLIS)
3. Mathematics Achievement Test (MAT)

IGPIQIS and IGMLIS were used as teaching guides for the experimental and control groups respectively. The Mathematics Achievement Test (MAT) had a reliability of 0.74 using Kuder-Richardson Formula 21 (KR-21). All the instruments were duly validated by expert review

Research Procedure

The first two weeks were used for training the participating teachers in each of the schools by the researchers on the use of IGMLIS and IGPIQIS. The third week was used for the administration of pre-test by the teachers and researchers on MAT. The next four weeks (weeks 4-7) were used for the administration of treatment to experimental group; Pre-theoretic Intuition Quiz Instructional Strategy (PIQIS) and control group; Modified Lecture Instructional Strategy (MLIS) and week eight was used for the administration of posttest on MAT by the teachers and researchers.

Method of Data Analysis

The data collected were analyzed using Analysis of Covariance (ANCOVA). This was adopted to test the hypotheses using pre-test scores as covariates. The research questions were analyzed using mean and standard deviation.

Results

Research Question one:

What difference exists in students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies?

Table 1: Summary of mean and standard deviation of pretest and posttest scores on the effect of instructional strategies on students' achievement in mathematics

Instructional Strategies	N	Pretest scores		Posttest scores		Mean gain scores
		$\overline{X}$	SD	$\overline{X}$	SD	
Pre-theoretic intuition quiz	110	8.0	3.23	14.80	3.23	6.80
Modified Lecture	68	7.26	3.20	11.24	2.70	3.98
Total	178	7.72	3.23	13.44	3.49	5.72

The data presented in table 1 show that the post-test mean score of students' taught with pre-theoretic intuition quiz instructional strategy 14.80 is greater than the post-test mean score of students' taught with modified lecture instructional strategy 11.24. The data further

indicates that the mean gain score of students' taught with pre-theoretic intuition quiz instructional strategy 6.80 is greater than the mean gain score of students taught with modified lecture instructional strategy 3.98. This implies that students' taught with pre-theoretic intuition quiz instructional strategy achieved better than their counterparts taught with modified lecture instructional strategy.

Research Question two:

What difference exists between male and female students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies?

Table 2: Summary of mean and standard deviation of pretest and posttest scores on the effect of instructional strategies on male and female students' achievement in mathematics

Instructional Strategies	Gender	N	Pretest scores		Posttest scores		Mean gain scores
			$\overline{X}$	SD	$\overline{X}$	SD	
Pre-theoretic intuition quiz	Male	64	8.09	3.26	14.78	3.21	6.69
	Female	46	7.87	3.22	14.83	3.29	6.96
	Total	110	8.00	3.23	14.80	3.23	6.80
Modified Lecture	Male	48	7.27	3.07	11.06	2.65	3.79
	Female	20	7.25	3.58	11.65	2.85	4.40
	Total	68	7.26	3.20	11.24	2.70	3.98
Total	Male	112	7.47	3.19	13.18	3.49	5.44
	Female	66	7.68	3.32	13.86	3.47	6.18
	Total	178	7.27	3.23	13.44	3.49	5.72

The data presented in Table 2 reveals that the post-test mean score of female students taught with pre-theoretic intuition quiz instructional strategy 14.83 was greater than their male counterparts with 14.78. Also the post-test mean score of female students taught with modified lecture instructional strategy 11.65 was greater than those of male counterparts with 11.06. On the whole, the post-test mean score of female students taught with pre-theoretic intuition quiz and modified lecture instructional strategies 13.86 was greater than that of their male colleagues with 13.18. The table further indicates that, the mean gain score of female students taught with both strategies 6.18 was greater than those of their male counterparts with 5.44. This simply implies that, the achievement of female students was slightly greater than their male counterparts when taught with both instructional strategies.

Research Question three

What difference exists between students' within ages 13-15 and 16-18 years achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies

Table 3:   Summary of mean and standard deviation of pretest and posttest scores on the effect of instructional strategies on students within ages 13-15 and 16-18 years achievements in mathematics

Instructional Strategies	Age	N	Pretest scores		Posttest scores		Mean gain
			$\overline{X}$	SD	$\overline{X}$	SD	
Pre-theoretic intuition quiz	13- 15	84	7.67	3.27	14.67	3.16	7.00
	16-18	26	9.08	2.93	15.23	3.47	6.15
	Total	110	8.00	3.23	14.80	3.23	6.80
Modified Lecture	13- 15	48	7.79	3.36	11.67	2.70	3.88
	16- 18	20	6.00	2.38	10.20	2.46	4.20
	Total	68	7.26	3.20	11.24	2.70	3.88
Total	13 - 15	132	7.71	3.29	13.58	3.32	5.87
	16 - 18	46	7.74	3.09	13.04	3.95	5.30
	Total	178	7.72	3.23	13.44	3.49	5.72

The data presented in Table 3 indicates that the post-test mean score of 16-18 years students taught with pre-theoretic intuition quiz instructional strategy 15.23 was greater than their 13-15 years counterparts with 14.67. However, the reverse is the case; the post-test mean score of 16-18 years students taught with modified lecture instructional strategy 10.20 was less than those of 13-15 years counterparts with 11.67. On the whole, the post-test mean score of 16-18 years students taught with pre-theoretic intuition quiz and modified lecture instructional strategies 13.04 was less than that of their 13-15 years colleagues with 13.58. The table further indicates that, the mean gain score of 16-18 year students taught with both strategies 5.30 was less than those of their 13-15 years counterparts with 5.87. This simply implies that, the achievement of 13-15 years students was slightly greater than their 16-18 years counterparts when taught with both instructional strategies.

Hypothesis One

There is no statistically significant difference in students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies.

Table 4: One way analysis of covariance (ANCOVA) of post-test scores of students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies

Source of variation	Sum of squares	Df	Mean square	F	Sig.	Partial Eta squared	Decision at P< 0.05
Covariate pre-test scores	1081.095	1	1081.095	272.646	.000	0.754	
Main effects	383.353	1	383.353	97.039	.000	0.356	*
Model	1464.448	2	732.224	185.340	.000	0.679	
Residual	691.373	175	3.951				
Total	2155.820	177	12.180				

*=Significant at 0.05 level; critical F1, 175 = 3.910; N= 178

The data in table 4 shows that the main effect is significant at p < 0.05 alpha level because, the calculated F-value of 97.039 is greater than the critical F-value of 3.910 at 0.05 alpha level with 1 and 175 degrees of freedom and a partial eta squared value of 0.356, which is

an indication of 35.6 percent effect size. Therefore, the null hypothesis, which states that there is no statistically significant difference in students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies, is rejected. The alternative hypothesis which states that there is a statistically significant difference in students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies is upheld.

Hypothesis Two

There is no statistically significant difference between male and female students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies.

Table 5: 2 x 2 factorial analysis of covariance (ANCOVA) of post-test scores of male and female students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies

Source of variation	Sum of squares	df	Mean square	F	Sig.	Partial Eta squared	Decision at P< 0.05
Covariate pretest scores	1081.095	1	1081.095	272.987	.000	0.567	
Main effects (combined)	388.353	2	194.072	49.005	.000	0.687	
Instructional strategies	383.353	1	383.353	96.800	.000	0.315	
Gender	4.792	1	4.972	1.210	.273	0.009	
2Way-interactions							
instructional strategies*Gender	1.458	1	1.458	0.368	.545	0.002	NS
Model	1470.697	4	367.674	92.841	.000	0.682	
Residual	685.123	173	3.960				
Total	2155.820	177	12.180				

*= Significant at 0.05 level; critical F1, 173 = 3.910

The data in Table 5 reveals that the interactions effect is not significant at p < 0.05 alpha level because, the calculated F-value of 0.368 is less than the critical F-value of 3.910 at 0.05 with 1 and 173 degrees of freedom and a partial eta squared value of 0.002, which indicates a non-significant 0.2 percent effect size. Therefore, the null hypothesis, which states that there is no statistically significant difference between male and female students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies, cannot be rejected.

Hypothesis Three

There is no statistically significant difference between 13-15 and 16-18 years students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies.

Table 6: Two way analysis of covariance (ANCOVA) of post-test scores of 13-15 and 16-18 years students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies

Source of variation	Sum of squares	df	Mean square	F	Sig.	Partial Eta squared	Decision at P< 0.05
Covariate pre-test scores	1081.095	1	1081.095	272.266	.000	0.567	
Main effects (combined)	387.206	2	193.603	48.757	.000	0.663	
Instructional strategies	383.353	1	383.353	96.545	.000	0.287	
Age	3.853	1	3.853	.970	.326	0.005	
2Way-interactions							
instructional strategies*Age	.583	1	.583	0.147	.702	0.001	NS
Model	1468.883	4	367.221	92.483	.000	0.681	
Residual	686.937	173					
Total	2155.820	177					

*=Significant at 0.05 level; critical F1,173= 3.910; N=178

The data in Table 6 shows that the interactions effects is not significant at p < 0.05 alpha level because, the calculated F-value of 0.147 is less than the critical F-value of 3.910 at 0.05 with 1 and 173 degrees of freedom and a partial eta squared value of 0.001, which indicates a non-significant 0.1 percent effect size. Therefore, the null hypothesis, which states that there is no statistically significant difference between 13-15 and 16-18 years students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies, is retained.

Summary of Findings
1. There is a statistically significant difference in students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies.
2. There is no statistically significant difference between male and female students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies
3. There is no statistically significant difference between 13-15 and 16-18 years students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies.

Discussion

The findings from the study revealed that there was a statistically significant difference in students' achievement in mathematics when taught with pre-theoretic intuition quiz and modified lecture instructional strategies. Students exposed to pre-theoretic intuition quiz instructional strategy had a higher mean achievement score in mathematics than those taught using modified lecture instructional strategy. The finding of this study is consistent with (Ogundiwin & Awolere, 2012) on the effectiveness of the use of pre-theoretic intuition quiz instructional strategy that, pre-theoretic intuition quiz instructional strategy improves students' achievement significantly more than the modified lecture instructional strategy. The advantage PIQIS had over MLIS could be as a result of the opportunity students of the PIQIS group had by way of the teacher getting students interested in the topic before the beginning of the lesson through a quiz, exposing students to identify and assess their own views after they have responded to the questions individually, compare answers in pairs or small groups and discuss the ones on which they disagree. Also, the

finding of this study gives credence to the assertion of Aizikovitsh-Udi (2013) that those interested in mathematics education have recognized the value of asking good questions for centuries. By extension, good questioning strategies in mathematics are a sine qua non for students' achievement in mathematics. Also, Shahrill (2013) reported that asking questions lead to gains in students' achievement. These include stimulation of interest in the subject, motivates students' participation, stimulate critical and creative thinking of the students, contribute to class discussions and building up self confidence and achievement.

The findings of the study also showed no statistically significant gender difference in the achievement of male and female students in the experimental and control groups. This finding agrees with those of Frederick-Jonah and Ibaba (2015), Zalmon and Peters (2014), Badru (2016), Amadi and Ogunkunle (2016) and Nnoli and Offiah (2017). However, Aransi (2018) found that, a weak linear relationship existed between age and performance while there was significant difference in the academic performance of the High School students in Economics on the basis of gender but in favour of female students.

Also, the findings of the study further showed that there was no statistically significant difference in the achievement of students in mathematics by age. This finding agrees with the report of Frederick-Jonah and Ibaba (2015) that there is no significant difference between age and achievement in their study. The finding is also consistent with the findings of Josiah and Adejoke (2014) that the differences in achievement across gender, age and mathematics anxiety groupings were all non-significant. However, Abubakar and Bada (2012) found that, age positively correlated to achievement and a better predictor than gender. In the same vein, Jabor *et al* (2011) found that, below 19 years of age students had a statistically higher mathematics achievement scores than 19 years and above age students.

Conclusion

Pre-theoretic intuition quiz instructional strategy (PIQIS) is more effective in improving students' achievement in mathematics more than the modified lecture instructional strategy (MLIS). Pre-theoretic intuition quiz instructional strategy is suitable for both male and female students, students with different age brackets and can be used to eliminate gender and age differences in education.

Recommendations

Based on the findings of the study, the following recommendations are made.

Mathematics teachers and educators should adopt pre-theoretic intuition quiz instructional strategy in the classroom to enhance students' achievement in mathematics.
Pre-theoretic intuition quiz instructional strategy should be adopted for use in mathematics classes so as to eliminate gender and age inequity in academic achievement in mathematics.

The Federal and State government and other educational bodies should organize workshops and in-service training programmes as well as seminars on regular basis for senior secondary mathematics teachers on the use of innovative strategies, like the use of pre-theoretic intuition quiz instructional strategy while implementing the mathematics curriculum.

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