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Mathematics symbol instruction and senior secondary students' achievement in word problems: A quasi-experimental study

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ABSTRACT

An assessment of the possible effect of mathematics symbol instruction on achievement in word problems was the main thrust of the study. Two null hypotheses were tested in the study. The non-equivalent group pre-test-post-test quasi-experimental research design was adopted. The multistage sampling technique was used to select a sample of 387 participants from 6,740 senior secondary class one students in the 81 government-owned coeducational secondary schools in Calabar education zone of Cross River State. The treatment class was exposed to mathematics symbol instructional strategy for solving word problems while the control class was exposed to regular word problem teaching, otherwise called the conventional method. "Students mathematics achievement test" was the instrument used for data collection after validation by experts. The reliability coefficient of 0.90 was determined using the Kuder-Richarson 20 formula. Primary data were obtained after informed consent from the participants. The null hypotheses were all tested at the .05 alpha level using the analysis of covariance. Findings revealed a significant effect of the mathematics symbol instructional strategy on students' word problem achievement in secondary schools. Male students perform significantly better in word problems than their female counterparts when taught using the mathematics symbol instruction. These findings discussed fundamental theoretical, practical, and research implications. It was recommended, among other things, that mathematics teachers concentrate on demystifying the abstraction in mathematics by deliberately adopting mathematics symbol instructional strategy in interpreting mathematical statements and sentences into their symbolic notations before engaging in their computation.

Keywords: achievement, gender, mathematics, symbols, word problems

INTRODUCTION

Mathematics is one of the most important subjects taught in schools today because of its vital role in shaping how individuals deal with the various aspect of private, social, and civil life (Ekwueme, 2013). Mathematics is a language of science and acts as a universal language that helps people to communicate and describe different situations in everyday life (Edoho & Esuong, 2016). The importance of mathematics cannot be overemphasized since everyone uses mathematics daily, especially in this scientific and technological world. The emphasis in Nigeria today is on technological development, and mathematics is needed for this technological development (Esuong, 2016). This justifies the compulsion of mathematics (a core subject in the secondary school curriculum) to provide the rudiment for all scientific and technological careers. Despite the overall importance and critical value of mathematics to society, students' achievement in the subject in high stakes examinations such as the West African senior school certificate examinations (WASSCE) and the National Examination Council examinations has been dismal (WASSCE chief examiner report, 2000-2018).

The information in **Table 1** shows that the percentage achievement of students who failed or scored low in mathematics in the past 18 years is exceptionally high, 72.6%, compared to students who scored credit and above, which is just 27.31%. The WASSCE chief examiners reports listed some of the weaknesses of candidates as difficulty in

(a) Translating word problems into mathematical statements,

(b) Solving problems on probability,

(c) Solving equations simultaneously involving indices, and

(d) Solving problems involving mensuration.

Table 1. WAEC mathematics results from 2000-2018

Year	Total number of candidates	Number of students with credit & above (A1-C6)	Percentage of students with credit & above (A1-C6)	Number of students with grades below a credit (D7-F9)	Percentage of students with grades below a credit (D7-F9)
2000	530,074	173,816	32.80	356,258	67.20
2001	843,991	350,746	41.60	493,245	58.40
2002	949,139	142,589	15.00	806,550	85.00
2003	518,516	237,377	45.80	281,139	54.20
2004	1,051,246	565,570	53.80	485,676	46.20
2005	1,091,763	388,122	35.55	703,641	64.45
2006	1,184,223	472,979	39.94	711,244	69.06
2007	1,275,330	198,441	15.56	1,076,889	84.44
2008	1,369,142	314,903	23.00	1,054,239	77.00
2009	1,373,009	425,633	31.00	947,376	69.00
2010	1,351,577	453,447	33.55	898,110	66.45
2011	1,540,250	587,630	38.93	952,620	61.97
2012	1,675,224	819,390	49.00	852,834	51.00
2013	1,543,683	555,726	36.00	987,957	64.00
2014	1,692,435	529,732	31.30	1,162,703	68.70
2015	1,593,442	544,638	34.18	1,048,804	65.82
2016	1,544,234	597,310	38.68	946,924	61.32
2017	1,678,440	501,556	30.12	1,176,884	69.88
2018	1,650,321	664,112	31.01	986,209	68.99
Mean (%)			27.31		72.60

Note. Source: Test Development Division, West African Examination Council Lagos

Table 2. Question analysis of WAEC word problems questions

Year	Question no	Average score	Percentage (%)
2010	2, 4, 5, & 8	32.20	21.90
2011	2, 5, 7, & 9	24.50	11.10
2012	3, 5, 8, & 9	37.50	32.80
2013	2, 4, 7, & 9	20.90	10.08
2014	2, 4, 5, & 8	25.70	12.56
2015	3, 4, 5, & 9	32.80	22.20
2016	2, 4, 5, & 9	30.40	20.10
2017	2, 3, 7, & 8	31.80	20.95
2018	3, 5, 7, & 9	30.20	20.50
Mean score		24.18	19.13

Note. Source: Test Development Division, West African Examination Council Lagos

However, difficulty translating word problems into mathematical statements has been a recurring weakness in all the years of reports (WAEC report, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, and 2018).

A key component responsible for the reoccurring low students' achievement in mathematics word problems in WASSCE examination is the understanding of mathematics symbols, which is key to finding a solution to mathematics word problems. The reports presented by mathematics chief examiners for 2010-2018 reveal that mathematical problems, which require the translation of words into mathematics statements often occur yearly, as shown in **Table 2**. The average scores, as presented in **Table 2**, show students' poor achievement levels in tackling mathematics word problems.

Mathematics symbols are letters, numerals, or other marks representing a number, an operation, or a mathematical idea. Mathematics is a specialized language with terminologies (vocabulary) and symbols that make it a concise and precise subject (Mutunga & Breakwell, 1992). These symbols begin with the 10 basic mathematics alphabets (0, 1, 2, …, 9), which are likened to the 24 English alphabets (a, b, c, …, z). Unlike the English language, the mathematics language is highly symbolized, and it mainly uses ideograms (symbols for communicating ideas) as opposed to phonograms (symbols for words) as used in the English language (Pimm, 1997). Most mathematics communications embrace symbols and notations for brevity and to avoid verbosity (Edoho & Esuong, 2019).

According to Ofonime (2016), mathematics uses symbols to represent concepts, functions, values, operations, structures, and ideas. Mathematical expressions in their symbolic forms help students solve numerous complicated problems. Most of the progress in mathematics, especially in word problems, depends heavily on the learner's ability to employ mathematics symbolism (Njoroge, 2003). It is reasonable to mention here that most scientific inventions and discoveries results are stated with mathematics symbols. However, there are many symbols in mathematics, such as basic mathematics symbols, geometry symbols, algebra symbols, probability, and statistics symbols, set theory symbols, logic symbols, calculus and real analysis symbols, numeric symbols, Greek alphabets, and Roman numerals.

Mathematics symbols cut short lengthy statements and help express ideas in their exact form. Symbols are free from verbosity and help to point out and clarify the exact expression of facts. For example, instead of saying that 'the square of the sum of two terms is equal to the sum of the square of the first term, square of the second term and double the product of the terms, we simply write $(a+b)^2=a^2+b^2+2ab$ in symbolic form. Where a and b are variables representing the first term and second term, respectively.

Word problem-solving is integral to teaching and learning mathematics at the secondary school level; its understanding affects students' knowledge and abilities in mathematics, especially when dealing with translational problems (Burns, 2007). Considering the overall importance of word problem knowledge in mathematics generally, students in secondary school are exposed to word problems at the early stage of their mathematics classes.

Students often cram statements and procedures and try to solve problems mechanically, ending them frustrated. Thus, making word translation to symbols undeniably one of the most complex and critical solution processes in solving word problems (Esuong et al., 2019). This is because understanding the components of mathematics language that enable students to carry out word translation tends to interfere with the everyday usage of words and symbols, which students are more familiar with in their immediate environment, but outside the context of mathematics. This makes it very cumbersome for students to understand word translation to symbols, especially at the early stage of their mathematics language development. This agrees with Mayer (1987, as cited by Yared, 2003) that one common problem in translating sentences into symbolic language is that individuals remember materials consistent only with their prior schemas. That is students trying to interpret word problems end up interpreting worded statements based on only familiar symbols exposed to them previously, thereby misrepresenting the information contained in the given problem.

Furthermore, Yared (2003) asserted that the ability to interpret words into symbols and understand and appreciate mathematics precision, brevity, and logically mathematised expression is most directly linked with success in mathematics problem-solving. In other words, symbolism, precision, and brevity have been age-long attributes of mathematics that learners must first inculcate if they must correctly utilize mathematics symbols in solving word problems.

A study conducted by Bardillion (2004) on symbolic translation for students exposed to English-spoken words found that students' efficiency in the symbolic translation of English words was directly related to the problem-solving ability of secondary school students in mathematics. Consequently, students who often understand science and mathematics mnemonics such as BODMAS, MR NIGER D, and SOHCAHTOA tend to do better in the use and application of mathematics symbols. This follows logically with Yeo's (2009) assertion that students perceive science subjects such as physics and chemistry as difficult because of their over-dependency on symbolic notations, usually pre-established constants used for scientific computation. As a result, most science subjects are filled with symbols that must be properly understood to enable one to carry out any operation on them.

Similarly, Cruz and Lapinid (2014) reported in a study titled students' difficulties in translating worded problems into mathematical symbols, which examined the students' difficulties and level of achievement in translating worded problems into mathematical symbols. A 20-item problem-solving test involving the four fundamental operations was given during the third quarter of 2012-2013 to two hundred and four (204) secondary school students. Scores in this test measured their achievement level in translating worded problems, while interpretation of their mistakes identified their difficulties in translating worded problems. Results indicated that 40% of the respondents were below the satisfactory level in translating worded problems. Carelessness, lack of comprehension, interchanging values, and unfamiliar words were common difficulties the respondents encountered in translating worded problems. Given these points, raised from the study, difficulties presented to students in word problem-solving can be solved by devising different student strategies and activities.

A similar study by Aniano (2010), titled "students' word problem strategies," the difficulty in translating phrases to symbols was one factor that determined the students' word problem-solving skills. This study specifically addressed the achievement level of secondary school students in translating worded problems into mathematical symbols, and the strategies teachers can adopt to subdue the difficulties students encountered. The study further revealed that the teacher's role in enhancing students' comprehension in translating phrases into symbols and teachers' instructional strategies in word problems affected students understanding of symbolic interpretation and general achievement in word problem-solving. Thus, teachers must emphasise word-to-word interpretation to enable the students to understand the symbols attached to each word in a particular problem.

On the other hand, another strategy was adopted by Vula and Berdynaj (2011) in a study entitled "Mathematics word problem solving through collaborative action research". The study examined word problem-solving through collaborative action research. A 30-item word problem-solving assessment involving primary school pupils was developed and administered. Scores in the assessment measured collaborative action research's effectiveness in helping pupils interpret simple worded problems. Results indicated that when pupils collaborate in a classroom situation, there will be a 70% likelihood of finding the correct interpretation of any word problem in symbolic form. This implies that a collaborative classroom enables students to understand faster and more easily how to use and interpret symbols in mathematics word problems.

In addition, Powell et al. (2012) analyzed the word problem achievement and strategies of students encountering mathematics difficulties (MDs). The study also assessed the efficacy of a word-problem intervention and compared the word-problem achievement of students with MDs who received the intervention (n=51) to students with MDs who received general education classroom word-problem instruction (n=60). The intervention occurred for 16 weeks, three times per week, 30 minutes per session and focused on helping students understand the schemas and symbols of word problems. Results demonstrated that students with MDs who received the word-problem intervention outperformed students with MDs who received general education classroom word-problem instruction. The study also analysed the word-problem strategies of 30 randomly selected students from the study to understand how students set up and solve word problems. Students who received intervention demonstrated more sophisticated word-problem strategies, especially in symbolic interpretation, than students who only received general education classroom word-problem instruction. Findings suggested that students with MDs, especially in word problem interpretation, who are exposed to an intense mathematics language class emphasising the symbol's identification, interpretation and usage will perform better than students who received general classroom word problem instruction.

All the facts, as presented and seen, show that mathematics language instruction in symbols plays a key role in understanding and interpreting word problems in sciences and mathematics. Thus, emphasis must be placed on students' ability to understand

Table 3. Sample distribution of the participants of this study

S/N	LGA	Number of schools	The number of schools that met the criteria
1	Odukpani	11	1
2	Calabar South	15	3
3	Calabar Municipal	12	2
Total number of schools selected			6

symbols found in mathematics and other science subjects. Moreover, a conscious effort must be adopted by teachers using the mathematics language instruction in interpreting word by word, phrase by phrase and sentence by sentence in symbolic form to enable students to have an understanding, which will, in turn, improve their achievement in mathematics.

Although translating worded problems into simple mathematics equations seems to be one of the most challenging tasks for students, particularly at the secondary school level. It is considered a significant hindrance in learning mathematics and other science subjects as most students lose interest in mathematics because of their inability to understand its symbolism.

Some environmental, sociocultural, and psychological factors moderate the effect of mathematics symbol instruction on students' academic achievement, such as gender, age, location, task difficulty and self-esteem. For this reason, the present study focused on the moderating effect of gender. Gender is a social construct; it concerns the differential qualities culturally attributed to women and men. The use of the word "gender" not only denotes an emphasis on the social (as opposed to biological) attributes of women and men but also indicates recognition of the relationship between masculinity and femininity (Hyde et al., 1990). In this study, gender is considered in relation to those differences that might be observed or perceived between boys and girls concerning achievement in word problems when taught using the mathematics symbol instruction. For instance, previous research has shown that girls tend to perform better in overall school achievement than boys, but they perform less than boys in mathematics (Esuong & Edoho, 2018). This observation could be interpreted as an issue about girls and mathematics. It has also been reported that boys are better than girls in mathematics and other science subjects (Aremu, 1999), while Georgius and McConell (2008) found that girls outperformed boys in some other subjects. Esuong et al. (2019) examined the influence of gender on achievement and found that male and female students tend to perform differently in various subject areas of education. Mathematics, science, and reading are traditional subjects prone to obvious achievement gender gaps (Owan, 2020). Male students tend to be more motivated to achieve better in mathematics and science subjects, while female students perform better in reading (Ayara et al., 2019). Owan et al. (2019) reported that sex is a factor in school mathematics achievement. On the general trend, in Nigeria, they assert that male learners tend to achieve higher in mathematics than their female counterparts. It is against the facts presented above, and as can be seen, that the current study determined the effect of mathematics symbols instructional strategy on students' performance in word problems among senior secondary school students. Also, it assesses gender differences in the effect of mathematics symbol instruction on their achievement in word problems.

Statement of Hypotheses

The null hypothesis formulated and tested for this study is, as follows:

HO1: Students in the experimental group do not differ significantly in their post-test achievement in word problems from those in the control group.

HA1: Students in the experimental group differ significantly in their post-test achievement in word problems from those in the control group.

HO2: No significant gender difference exists in students' post-test achievement in word problems between the experimental and control groups.

HA2: A significant gender difference exists in students' post-test achievement in word problems between the experimental and control groups.

METHODS

The research design adopted for the study is the non-equivalent group pre-test-post-test quasi-experimental design. The population of this study comprised 6,740 senior secondary class one (SS1) students in the 81 government-owned coeducational secondary schools spread across the seven local government areas (LGAs) in Calabar education zone of Cross River State. The multistage random sampling techniques was used to select a sample of 387 students as discussed below.

In the first stage, a simple random sampling technique, particularly the hat and draw system, was used to select three LGAs in Calabar education zone LGAs for the study. In the second stage, a simple random sampling technique was used to select the secondary schools that will participate in the study. In the third stage, simple random sampling was used to choose the schools that would form the experimental and control group in the study from the three selected LGAs in stage 1. At the final stage, all the students in SS1 in each of the randomly selected schools in the LGAs were used for the study. This sampling procedure was deemed appropriate for this study because it allowed the researcher to have a representative sample of the LGAs that make up Calabar education zone for adequate prediction and generalization. **Table 3** shows the sample distribution of the participants of this study. **Table 4** depicts the number of SS1 students in each of the purposively selected schools for the study.

The experimental or treatment class was exposed to mathematics symbols instruction for solving word problems. In contrast, the control class was exposed to a normal word problem instruction, otherwise called the conventional method.

Table 4. Number of SS1 students in each of the purposively selected schools for the study

S/N	LGA	Schools	Number of students	Total selected
1	Odukpani	A	52	52
2	Calabar South	B	82	
		C	67	
		D	63	
Sub-total				212
3	Calabar Municipality	E	50	
		F	73	
Sub-total				123
Total				387

The instrument used for data collection was students mathematics achievement test (SMAT), consisting of three sections. Section one collected students' demographic information, and section two comprised five items designed and organized to measure students' ability to express basic mathematics symbols and their interpretation. Section three of SMAT was a teacher-made test, which consists of 50 multiple-choice items drawn from the SS1 mathematics curriculum/syllabus and covers the following core areas of senior secondary school mathematics: algebra, arithmetic, geometry, and everyday statistics.

The instrument received face and content validity from two experts in mathematics education and one expert in research, measurement, and evaluation, all in the Faculty of Education, University of Calabar, Calabar, who vetted the items for clarity and relevance. The instrument was trial tested using 20 SS1 students outside the sample used for the research. The data obtained from the trial testing was used to determine the reliability coefficient for SMAT. The internal consistency reliability coefficient of 0.90 was determined using the Kuder Richarson 20 (KR-20) formula.

To administer SMAT, a letter of consent was submitted to the schools to enable the researchers gain access to the study participants for experimentation. Permission was obtained from the principals of the selected public, coeducational secondary schools in Calabar education zone. Before the administration, all the copies of the instrument (SMAT) were assigned serial numbers. This was done to ease sorting, classification, coding and to avoid the problem of misallocation.

Treatment

The treatment offered to the experimental group in this study is the mathematics symbol Instruction for solving mathematics word problems. It comprises a step-by-step approach to the identification, interpretation and usage of the mathematics symbols as contained in mathematics word problems. This symbol instruction exposes students to the meaning of the different content of symbols in mathematics, their correct and appropriate interpretation, and fair usage as it applies to the context of mathematics word problems.

Application of Mathematics Symbol Instruction

1. **Step 1**: The teacher outlines to the students the different mathematics symbols present in mathematics concepts, especially word problems.
2. **Step 2**: The teacher writes out the examples and meaning or interpretation of each of the basic mathematics symbols' constituents.
3. **Step 3**: The teacher explains their usage in different areas of mathematics, their placement when interpreted in each word problem and how each symbol functions in everyday English word usage.
4. **Step 4**: The teacher writes out a word problem example and identifies the different mathematics symbol constituents contained in the example already written out, after which the teacher interprets them separately and arranges or places them according to the stated problem.
5. **Step 5**: The teacher shows the students how to combine the already interpreted symbols constituent contained in any given problem before their computation based on the different usages.

The experiment for this study was carried out for four weeks, which is one month, as follows:

1. **Week 1**: Familiarization with schools and pre-experimental training of research assistants: The training guide developed by the researchers was discussed during the one-day pre-experimental training conducted for the participating teachers, where the research assistants were made to be fully aware of the steps involved in teaching word problems using the mathematics symbols instruction.
2. **Week 2:** Administration of pre-test to both the control and the experimental group.
3. **Week 3**: Administration of treatment by research assistants to the experimental group: They were teaching mathematics word problems using the symbol instruction method to the treatment group in their respective schools. The treatment was conducted during the normal school periods following the school timetable. The treatment lasted for one week.
4. **Week 4**: Administration of post-test: The researchers and the research assistants administered the post-test to the students in the two groups in each selected school.

The pre- and post-test were developed from the same content. Before administering the instrument to the selected respondents, the researchers sought informed consent from the targeted participants. The experimental or treatment class was exposed to mathematics symbols and instructional strategies for solving word problems. In contrast, the control class was exposed to a regular word problem class, otherwise called the conventional method. Primary data were obtained in this study

Table 5. ANCOVA results of the post-test difference in mathematics (word problem) achievement between students taught mathematics word problems using mathematics symbol instruction and those taught with the conventional method

Group			Mean		Standard deviation	n
Control			1.90		.936	205
Experimental			3.54		.902	182
Total			2.67		1.232	387
Source	Type III SS	df	MS	F	Sig.	Partial η^2
Corrected model	260.401[a]	2	130.201	153.201	.000	.445
Intercept	507.851	1	507.851	599.561	.000	.610
Pretest symbol	.817	1	.817	.964	.327	.003
Group	259.827	1	259.827	306.748	.000	.444
Error	325.268	384	.847			
Total	3,343.000	387				
Corrected total	585.664	386				

a R-squared=.445 (adjusted R-squared=.442)

through the quasi-experiment followed by the administration of copies of the SMAT. Data collected from the pre- and post-test for the instrument were kept separately for the two groups and used to test the null hypotheses that guided the study. Data collected were analyzed, while the null hypotheses were all tested at the .05 alpha level using the two-way analysis of covariance (ANCOVA).

RESULTS

Hypothesis 1

The first hypothesis of this study states there is no significant difference in mathematics achievement between students' word problems taught using mathematics symbols instruction and those taught with the conventional method in the Calabar education zone of Cross River State. The independent variable of this hypothesis is mathematics instruction in symbols, while the dependent variable is students' post-test achievement in mathematics word problems, with the pre-test scores as the covariate. ANCOVA was performed to test the null hypothesis at the .05 level of significance.

The descriptive result section of **Table 5** reveals a higher mean achievement score in the experimental group (3.54) as against the control group (1.90). The table generally revealed that there is a significant difference in the post-test mathematics achievement scores between students in the experimental and control group ($F_{(1, 384)}$=306.748, p<.05, partial η^2=.444). However, the result indicates further that there is no significant difference in the pre-test achievement of students in word problems between the experimental and control group ($F_{(1, 384)}$=0.964, p>.05, partial η^2=.003). Based on this result, the null hypothesis was rejected, while the alternate hypothesis was upheld. This implies a significant difference in mathematics achievement between students taught mathematics word problems using mathematics symbols instruction and those taught with the conventional method.

Hypothesis 2

The result of the second hypothesis indicates that male students are significantly different from their female counterparts in their post-test achievement in mathematics word problems when taught using mathematics symbols instruction $t_{(385)}$=2.11, MD=.11, p<.05. The result of the analysis led to the rejection of the null hypothesis.

Discussion of Findings

The result of the first hypothesis of this study established a significant effect of mathematics symbol instruction on students' achievement in word problems. This result is not surprising since there was a significant difference in the post-test achievement of students in the experimental group and control group. Before the treatment, no significant difference was recorded in the pre-test. This implies that the treatment offered to the experimental group played a crucial role in improving their knowledge of mathematics symbols, which contributed 44.4% (partial η^2=.444) to their achievement in word problems. This finding is not surprising because, for effective solving of word problems, there is a need to use mathematical symbols. These symbols play a part in enabling the student to translate grammatical statements into mathematical expressions.

This study supports the finding of Bardillion (2004) that students' efficiency in the symbolic translation of English words was directly related to the problem-solving ability of secondary school students in mathematics. Consequently, students who often understand science and mathematics mnemonics such as BODMAS, MR NIGER D, and SOHCAHTOA tend to do better in the use and application of mathematics symbols. This follows logically with Yeo (2009), students perceive that science subjects such as physics and chemistry as problematic because of their over-dependence on symbolic notations, usually pre-established constants used for scientific computations. As a result, most science subjects are filled with symbols that must be adequately understood to enable one to carry out any operation on them. Similarly, Cruz and Lapinid (2014) reported in a study that 40% of the respondents were below the satisfactory level in translating worded problems. Carelessness, lack of comprehension, interchanging values, and unfamiliar words were common difficulties the respondents encountered in translating worded problems. Given these points, raised from the study, difficulties presented to students in word problem-solving can be solved by devising different student strategies and activities.

The result from the second hypothesis of this study also revealed that gender plays a significant role in moderating the effect of mathematics symbol instruction on students' achievement in word problems. This result is so because male students differed significantly from their female counterparts. The significant difference in gender achievement is due to perceived male students' proficiency in mathematics in addition to the treatment offered to them. This implies that male students have a better knowledge of mathematics language, specifically in solving word problems, than females when taught using mathematics symbol instruction. An explanation for this result may be the general perception that male students are better in science-oriented subjects than females, who are often believed to be better in languages. This agrees with Esuong and Edoho's (2018) results that girls tend to perform better in overall school achievement than boys but perform less than boys in mathematics. Furthermore, it has been reported that boys are better than girls in mathematics and other science subjects (Aremu, 1999), while Georgius and McConell (2008) found that girls outperformed boys in some other subjects.

The result of this study also strengthens the finding of Owan et al. (2019) that sex is a factor in school mathematics achievement and that male learners achieve higher in mathematics than their female counterparts. Similarly, Joffe and Foxman (1986) showed that in the English language, females perform comparatively better than males, while in mathematics, males perform better than females, especially in computational skills and abilities. On the contrary, Hanna and Kuendiger (1999) reported a pattern of results in mathematics, which indicated that girls were more successful than boys in Belgium, Finland, Hungary, and Thailand but least in France, Israel, Nigeria, and the Netherlands. The variation in the result of this study and that of Hanna and Kuendiger (1999) may be attributed to the geographical differences between the studies. Respondents across geographical regions can possess different characteristics, which may affect their cognitive ability.

CONCLUSION

Based on the findings of this study, it was concluded that mathematics symbol instruction plays a significant role in promoting students' achievement in word problems in senior secondary schools. Students exposed to the mathematics symbols instruction tend to achieve better than those not exposed to the treatment or instruction in word problems. This finding implies that exposing senior secondary school students to quality teaching of mathematics symbols will enable them to decode word problems, translate same into appropriate mathematical expressions, and apply the proper procedures and operators in solving them. A student's gender affects the student's achievement in word problems when taught using the mathematics symbols instruction. This study has some theoretical, practical and research implications. The study has been able to extend the theory of language acquisition device by Chomsky, which initially prescribes, among other things, that all children are born with an innate ability to learn symbols, which may be in mathematics, English or any other language as presented to the child in his later part of life. This implies that the learning of symbols is a prerequisite for growth and development in children. This study adds to the theory that students in secondary schools are likely to develop good mathematical symbols skills if they are exposed using appropriate instructional strategies. As shown in this study, the students in the experimental group exposed to the mathematics symbols instruction achieved better in mathematics word problems than the students in the control group as a result of the treatment (training received). Practically, the study has also revealed the need for mathematics teachers to pay close attention to developing their skills to master the mathematics symbols instructional approach and use the same to teach word problems in secondary schools to boost students' mathematics achievement in norm-referenced, criterion-referenced, or high stakes examinations beyond word problems. This research has opened new paths for prospective related studies to be anchored. Based on the study's conclusion, it is recommended that mathematics teachers concentrate on demystifying the abstraction in mathematics by interpreting mathematical statements and sentences into their symbolic notations before engaging in their computation. Students should first be taught the symbols of mathematics properly, enabling them to make adequate and appropriate interpretations of word problems.

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Ethical statement: The authors stated that a thorough validity and regulatory data-gathering approach assisted in minimizing any potential bias in the study. Because completing a survey posed no significant risk to participants, ethical approval was waived under the Nigerian Code for Health Research Ethics (NCHRE), which exempts survey research or studies with little or no associated risk of participation (for more information, see https://bit.ly/3pK9ORh). The authors further stated that this research was like the daily teaching and learning children experience in their schools. Nevertheless, participating in the study was entirely optional and respondents had the liberty to exit the exercise at any point. As a result, participants were not exposed to any danger or possible injury. Furthermore, no hazardous substances were used in the study's experimental circumstances, which may have caused bodily, psychological, or social harm to the students. Aside from that, the tests were all carried out under the direct observation of the school's administration. The respondents provided written informed permission after signing a form verifying that they were aware of the study and agreed to participate. Respondents were informed that the information acquired would be de-identified and anonymized, following safe harbour requirements for anonymity. Participants were notified that their responses would be anonymized before being collated for privacy. All respondents' biodata (such as age, gender, family type, and parent socioeconomic position) were given a range of equal intervals so that no one could be recognized from the aggregated data. Students' names were not collected in this study for confidentiality. To avoid unwanted access to the collected data, the coded data was kept on a computer accessible only to the researchers, with a security system (strong password, antivirus software, and a firewall). All participants were informed that their answers would be aggregated and published in a journal.

Declaration of interest: No conflict of interest is declared by authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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