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KNOWLEDGE AND PRACTICE OF WAIT-TIME IN MATHEMATICS CLASSROOM INSTRUCTIONS

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ABSTRACT

The study was designed to ascertain if mathematics teachers in secondary schools know and practise wait-time during classroom instructions. It also sought to determine wait-time periods in current practice by mathematics teachers in Nigeria. Four research questions were used to guide the study. The study adopted survey research design. The sample used for the study comprised 210 qualified mathematics teachers. Two instruments, namely; Wait-time Practice Questionnaire (WPQ) and Checklist for Classroom Wait-time Observations (CCWO) were constructed by the investigators and used for data collection. Research questions 1, 2, and 4 were answered using percentage (%), while research question 3 was answered using mean. The results established that wait-time is being practised in Nigerian secondary schools by mathematics teachers during classroom instructions. The results equally revealed that mathematics teachers currently practise an average of 1.33 seconds wait-time in class. Based on these findings, it was recommended that mathematics teachers should not only practise wait-time, but; they should be seen to practise adequate wait-time of at least 3 seconds each lesson, and the practice of wait-time should be emphasised in Nigerian schools for meaningful learning of mathematics to take place.

KEYWORDS: Classroom instructions, Knowledge and practice, Mathematics teachers, Question and responses, Wait-time

INTRODUCTION

The need to improve on the instructional delivery and learning of Mathematics in Nigerian Schools has continued to receive expert attention among researchers in mathematics education. The continued mathematics phobia and learners' anxiety during mathematics instructions is a clear demonstration of the perceived problem. Appropriate classroom verbal interaction processes involving the teacher, students and available instructional materials are lacking in most mathematics classroom instructions. Yet, it is what actually takes place in the classroom that, in practical terms, clearly defines the quality of instructions and learning taking place. Majority of mathematics teachers, even the qualified and professional ones, in our school system are still ignorant of this classroom requirement. So, the teacher's instructional delivery in most cases lacks the ingredients to stimulate both the teacher and students, to critically think and ask good and insightful questions.

Classroom interaction between the teacher and students is largely verbal; and questioning either by the teacher or students, constitutes a major part of verbal interaction in mathematics classrooms. Experts (example, Tobin, 1987) in education have pointed out that classroom questioning has been mostly teacher-centred. Also, since most of these teachers lack the skills of questioning, the way they react to students'

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responses/answers has hindered effective communication of mathematics during instructional delivery.

The result is that, classroom questioning in the subject is characterised by lower-order cognitive questions, which do not challenge students' divergent thinking. Besides, it is common to observe a teacher asks several questions very rapidly within a short period of time; and would expect his students to supply the correct answers equally very rapidly (Udo, 1998). This shows lack of knowledge or non-practice of the concept of wait-time, which is a very important area in the questioning behaviour of the teacher.

Wait-time is the period of silence a teacher is ready to allow a student to think and respond to a question before he asks another student(s) or answer the question himself (Rowe, 1987). It is a good instructional strategy to improve questioning and quality of responses in any mathematics class. Information processing involves multiple cognitive tasks that take time. Learners need to have uninterrupted periods of time to process information, reflect on what has been said by the teacher, observed, or done; and consider what their personal opinions or responses will be.

The concept of "wait-time" as an instructional variable was invented in 1972 by Mary Budd Rowe. She found that the periods of silence (wait-time) that followed teachers' questions and students' completed answers or responses did not very often last more than 1.5 seconds in typical classroom instructions. However, she discovered that when these wait-times lasted at least 3 seconds, many behavioural and attitudinal changes will take place in both the teacher and students.

For instance, when learners are given 3 or more seconds of undisturbed wait-time, certain positive outcomes are achieved, namely; (1) the length and correctness of their answers increase, (2) the number of their "I don't know" and no answer responses decrease, (3) larger number of students volunteer to answer questions and (4) learners' academic achievement tend to improve. Similarly, when teachers wait patiently in silence for 3 or more seconds at appropriate points during instructions, positive changes in their own (teachers) behaviours may occur. Their questioning strategies may tend to be more varied and flexible; they may decrease the quantity and increase the quality and variety of their questions or they may ask additional questions that will require more complex information processing and higher-level thinking on the part of the learners.

To achieve the above benefits, teachers of Mathematics are urged to wait in silence for at least 3 seconds after questions, and after learners completed their answers (Didau, 2017; Boulton, 2013; Stahl, 1990 and Tobin, 1987). However, the concern here is not that wait-time of less than 3 seconds is bad, while 3 seconds is good, or more than 3 seconds of silence is better. The concern is to provide the period of time that would most effectively assist nearly every learner to complete the cognitive tasks needed in a mathematics concept. The job of the teacher is his ability to manage and guide what occurs prior to and immediately following each wait-time allowed so that the processing of information that needs to occur is completed by the learners.

An instructional strategy to improve questioning and quality responses in the practice of wait-time is what Dylan (2014) calls Pose-Pause-Pounce-Bounce (PPPB) questioning. It is a simple yet sophisticated Assessment For Learning (AFL) questioning technique that helps Mathematics teachers move from good-to-outstanding during lesson delivery. PPPB questioning practised during periods of silence (wait-times) works thus:

1. Pose. Pose a question you have planned to the whole class. Teacher considers what his question is designed to achieve. For example, sometimes teachers ask questions to assess what students have learned, sometimes they use questions to provoke thought in the hope students will start to understand a new concept. Pause and wait for as long as possible before any student is asked to respond.
2. Pause. Once the teacher asks the question, students should be given time to think and respond. Ensure every student in class has opportunity to ponder.
3. Pounce. Pounce on student to answer. Plan in your mind who you are going to ask the question before speaking to the class. The better a teacher knows his students, the better he is placed to select a student to answer the question.
4. Bounce. If the selected student does manage the answer, then bounce the student's response onto another student and allow time to tease out concepts or opinions. That is, ask another student immediately after the pounce response, their opinion of the first student's answer. This is irrespective of whether the answer is correct or not. This will create opportunity for whole class discussion with the teacher facilitating.

The importance of the practice of wait-time in classroom instructional delivery cannot be overstressed. Yet, it has been reported that most mathematics teachers in Nigeria are the most impatient with their students in class. Also, they practise the least wait-time of 1.27 seconds as compared to physics teachers (1.35 seconds) and chemistry teachers (1.56 seconds) wait-time, 5 seconds wait-time (Rowe, 1980) and 3 seconds or more wait-time (Fletcher-Wood, 2013).

The practice of decreased or inadequate wait-time of 1.27 seconds by most mathematics teachers in Nigerian schools could be responsible for observed students' anxiety, fear and lack of confidence not only in learning Mathematics, but their inability to think Mathematics and communicate Mathematics in class and in their daily life. This may have led to learners' lack of interest, negative attitude and low achievement in the subject traceable to poor learning.

However, the practice of wait-time would obviate the observed problem of anxiety and fear from students thereby instil interest and confidence in them during Mathematics instructions. This is because adequate wait-time allows students to think, process information, and reflect on what has been said by the teacher before attempting a response/answer to a question. This would lead to higher achievement in mathematics. The quality of instructions in mathematics class would improve. This is because the practice of adequate wait-time by mathematics teachers enables them to ask questions they have planned in advance. Class discussions and active class participation could be achieved. Knowledge of the instructional importance of the practice of wait-time by Inspectors of Education and Heads of Schools would make them realise the educational implications of too much emphasis on teachers "covering" the curriculum each school session.

Furthermore, the dynamics of pedagogical change requires mathematics teachers to constantly explore, integrate and reinforce other instructional techniques that could provide opportunity for effective and efficient classroom verbal interaction. That is why an instructional technique that advocates a dynamic verbal interaction between the teacher and students, a student and other students and learner-centred, is considered in this study as remedy in addressing this observed and important gap in mathematics instructions and learning. Thus, the study of the concept of wait-time and its practice as an instructional technique.

The problem of study here is bounded by the following questions: (1) Do mathematics teachers have knowledge of the practice of wait-time in classroom instructions? (2) Do mathematics teachers in Nigeria practice wait-time during classroom instructions? (3) What wait-time is practised by mathematics teachers during classroom instructions? (4) What observable effect does the practice of wait-time have during mathematics instructional delivery?

PURPOSE OF THE STUDY

The purpose of the study was to; determine if mathematics teachers are aware of the concept of wait-time in classroom instructions. Determine if mathematics teachers in Nigeria do practice wait-time during classroom instructions. Ascertain what wait-time mathematics teachers practice during classroom instructions. Ascertain observable effects the practice of wait-time could have on students and teachers during mathematics instructions.

RESEARCH QUESTIONS

The following research questions guided the study.

Four research questions were posed to guide this study. These included:

1. Do mathematics teachers have knowledge of the concept of wait-time in classroom instructions?
2. Do mathematics teachers practice wait-time during instructional delivery?
3. What measure of wait-time is practised by mathematics teachers during classroom instructions?
4. What observable effect does the practice of wait-time have on students and teachers during Mathematics instructions?

RESEARCH METHODOLOGY

The study covered the three (3) Education Zones in Cross River State of Nigeria. These included: Calabar, Ikom and Ogoja Education Zones. The study adopted survey research design because the investigators sought to determine wait-time periods in current practice by mathematics teachers.

The population of the study consisted of 375 mathematics teachers in 236 public secondary schools in the area of study (Planning, Research and Statistics Department, State Secondary Education Board, February 07, 2016).A total

sample of 210 mathematics teachers was used for the study. Mathematics teachers who teach SS 2 intact classes of 105 public secondary schools in three Education Zones constituted the sample of study. Simple random sampling method was used to select 105 schools from 236 public secondary schools in the area of study.

Two instruments were constructed by the investigators and used for data collection. The first instrument: Wait-time Practice Questionnaire (WPQ) was meant for mathematics teachers to express their views on the practice of wait-time in Mathematics classes. The instrument contained four statements with two response option – Agree, Disagree.

The second instrument: Checklist for Classroom Wait-time Observations (CCWO) with a clock was for Observers (research assistants) to observe and record wait-time periods questioning by teachers in Mathematics instructions. CCWO contained 6 wait-time periods. Four (4) weeks of twelve (12) periods of instructions and observations were carried out.

In each lesson period, the observer recorded the time as soon as the teacher asked each question, recorded the time again after the period of silence (wait-time) allowed by the teacher for a student to think, process information and respond to the question. At the end of four weeks of twelve lesson periods. 1. The total observed wait-times practised by each of the 210 teachers were added and recorded for each of the twelve lesson periods; 2. The means of these wait-times were computed and recorded according to the range of wait-time in CCWO.

The instruments (WPQ) and (CCWO) were first validated by three experts in Mathematics Education. The experts matched the statements in the instrument (WPQ) with the purpose and research questions. It was established that each statement measured the purpose as captured in the research questions. The wait-time periods in the instrument (CCWO) were compared with approved wait-time periods which are practised by experts in Mathematics Education. It was established that the wait-time periods in CCWO adequately covered approved wait-time continuum. Each of WPQ and CCWO was trial tested by administering same instrument(s) twice to respondents at a time interval of two weeks.

The three experts in Mathematics Education were each provided with two sets of responses gathered. The statements were matched for stability of responses based on the two-time administration of WPQ and CCWO on the same respondents. This was done in order to establish the internal consistency (reliability) of each of the instruments. The two sets of responses were found to be stable. Hence, the instruments were reliable and good for this investigation.

One hundred and five (105) research assistants (Observers) used to observe teachers during Mathematics instructions and record wait-time periods were trained. They were trained on observation techniques and how to use the instrument (CCWO) for this purpose; without causing distraction in class. The training workshop was for one day and this took place at each Education Zone at different dates.

Extraneous variables such as subject variable, student variable and Hawthorne effect were controlled by the investigators. This was done to avoid the introduction of bias into the research.

Two different instruments were used to collect data for the study. The investigators visited the 105 selected secondary schools in Calabar, Ikom and Ogoja Education Zones. The first instrument (WPQ) was administered by the investigators. All the copies were retrieved from the respondents after filling. Two hundred and ten (210) research assistants (regular class teachers) and 105 Vice Principals (Observers) were used for the second instrument (CCWO). The permission of the Principal in each school was granted for this research. The research assistants (class teachers) taught their mathematics lessons under normal setting; while the other research assistants (Vice Principals) observed the teachers while teaching. The Vice Principals were seen by students and teachers as carrying out their routine office duty of inspecting classes. Data collected by the Observers using CCWO and from the administration of WPQ were used for data analysis.

DATA ANALYSIS/RESULTS

The data collected from the two instruments – WPQ and CCWO were used to answer the research questions posed for the study. Research questions 1, 2 and 3 were answered

using percentages (%). Research question 4 was answered using mean.

The data required to provide answers to the research questions raised for this study were responses from subjects to items in WPQ; and, observed wait-time periods within the range in CCWO by Observers. Research questions 1, 2 and 3 were answered using percentage (%) while research question 4 was answered using mean. Summary of results is presented in Tables 1 and 2.

RESEARCH QUESTION 1

Do Mathematics teachers have knowledge of the concept of wait-time in classroom instructions?

The responses to Items 1 and 2 in WPQ obtained from the subjects revealed the results presented in Table 1.

Table 1: Percentage Analysis on knowledge and practice of Wait-time by Mathematics Teachers

S/N	Statement	N	Agree	%	Disagree	%
1.	I had knowledge of the practice of wait-time during mathematics instructions at my Pre-service training (Undergraduate programme).	210	146	69.50	64	30.50
2.	The concept of wait-time and its practice during mathematics instructions is not known to me as a class teacher.		13	6.20	197	93.80
3.	I do practise wait-time during my mathematics lessons.		173	82.38	37	17.62
4.	I do practise wait-time, but still do not know approved wait-time to practise during my mathematics lessons.		167	79.52	43	20.48

As shown in Table 1, 146 out of 210 respondents representing 69.50% agree knowledge of the concept of wait-time during mathematics instructions at their Pre-service training, that is, Undergraduate programme. Whereas, 64 respondents representing 30.50% disagreed. This implies that the subjects had knowledge of the concept of wait-time and its practice during Mathematics lessons before their employment as Mathematics teachers in the secondary school. Again, Table 1 shows that 13 out of 64 subjects who were not aware of the concept of wait-time in classroom instructions at their Pre-service training programme agreed that they still do not know about the concept even as teachers. However, knowledge of the practice of the concept by 51 subjects now as class teachers could have been acquired during In-service training, example, retraining workshops. Hence, 93.80% as against 69.50% subjects in the school system have shown to have knowledge of the practice of wait-time in mathematics instructions.

It could therefore be concluded that majority of the Mathematics teachers in secondary schools have knowledge of the concept of wait-time and its practice in class.

RESEARCH QUESTION 2

Do Mathematics teachers practise wait-time during instructional delivery?

From Table 1, the responses from subjects revealed that 173 out of 210 respondents representing 82.38%; as against 37 (17.62%), agreed that they do practise wait-time during instructional delivery in Mathematics. But, 79.52% of the subjects who practise wait-time do not know approved wait-time to observe during Mathematics lessons. However, one could conclude that wait-time is being practised in Mathematics classes in the area of study.

RESEARCH QUESTION 3

What measure of wait-time is practised by Mathematics teachers during classroom instructions?

This research question was answered by calculating the mean of observed wait-time practised by subjects. Trained Observers by the investigators observed the teachers while teaching and recorded the wait-time periods practised. Summary of results is presented in Table 2.

Table 2: Mean Analysis on Observed Wait-time Period Practised by Mathematics Teachers

Range of wait-time periods	N	Total Wait-time Periods Observed	$\bar{X}$
00 – 1.59 seconds	27	5.91 seconds	0.22
1.00 – 1.59 seconds	166	232.05 seconds	1.40
2.00 – 2.59 seconds	13	27.91 seconds	2.15
3.00 – 3.59 seconds	4	12.30 seconds	3.08
4.00 & above seconds	Nil	-	-
00 – 3.59 seconds	210	278.17 seconds	1.33

Table 2 shows that 27 subjects practiced wait-time of 0.22 seconds, which is less than one second; 13 subjects practiced wait-time of 2.15seconds, which is above two seconds but less than three seconds, while 4 subjects practised wait-time above three seconds but less than 4 seconds (3.08 seconds). Whereas majority of the subjects (that is, 166) practised wait-time of 1.40 seconds, which is above one second but less than two seconds, no subjects practised wait-time up to 4.00 seconds and above.

However, the 210 subjects who participated in the study practised wait-time of 1.33 seconds, which is above one second but less than two seconds. One may conclude that mathematics teachers in the secondary schools practise wait-time of 1.33 seconds.

RESEARCH QUESTION 4

What observable effect does the practice of wait-time have on students and teachers during Mathematics instructions?

Research question 4 was answered using the free comments made by the subjects on the practice of wait-time in class; as required at the end of the questionnaire (WPQ). Their comments addressed fundamental issues in classroom Mathematics lessons. Thus, these were categorised into four, namely; learners' active class participation, students' anxiety and fear in learning mathematics, Time for students to think and provide responses/answers and teacher's inability to "cover" planned scheme of work. The results are as shown in Table 3.

Table 3: Percentage Analysis on Teachers' Free Comments on Effects of the Practice of Wait-time

Comments	N	Agree (%)	Disagree (%)
Learners participated actively in class	210	169(80.47%)	41(19.53%)
Practice of wait-time reduces student's anxiety and fear in learning Mathematics.	210	188(89.52%)	22(10.48%)
Mathematics students are allowed time to think and respond to teacher's question.	210	191(90.95%)	19(9.05%)
Teachers can "cover" planned scheme of work	210	167(79.52%)	43(8.57%)

Table 3 reveals the following results: 80.47% of the subjects agreed that the practice of wait-time provides opportunity for learners to participate actively in class. 19.53% disagreed. One therefore concludes that when Mathematics teachers practise wait-time, they ensure learners' active class participation.

Also, 89.52% of the respondents agreed that wait-time practised by teachers reduces students' anxiety and fear in learning the subject. 10.48% disagreed. Again, 90.95% of the respondents agreed that the practice of wait-time allows students a period of silence to think, process information and respond to teacher's questions.

Finally, 79.52% of the respondents agreed that when teachers practise wait-time in Mathematics lessons, they end up not "covering" the planned scheme of work each term. 8.57% disagreed.

SUMMARY OF FINDINGS

Based on the results of the analysis of data, the following major findings were made:

1. Mathematics teachers in the secondary schools have knowledge of the concept of wait-time and its practice during instructions.
2. Wait-time is being practised by mathematics teachers in class.
3. Majority of the mathematics teachers do not know approved wait-time of at least 3 seconds to observe during mathematics instructions.
4. Mathematics teachers in Nigerian schools practise an average of 1.33 seconds wait-time.
5. Wait-time practice in Mathematics instructions ensures learners' active class participation.
6. The practice of wait-time in Mathematics lessons allows students time to think, process information and respond to teacher's questions.
7. Wait-time practice reduces students' anxiety and fear in learning Mathematics.
8. Wait-time practice in Mathematics lessons prevents teachers from "covering" the planned scheme of work each school term.

DISCUSSIONS

The findings of this study revealed in Table 1 indicated that (1) Mathematics teachers in secondary schools in Cross River State of Nigeria had knowledge of the concept of wait-time and its practice during mathematics instructions at their Pre-service training programme. That is, teachers were exposed to this very important instructional concept before their employment in the secondary school. (2) Mathematics teachers do practise wait-time, but majority of them do not know approved wait-time to observe during mathematics lessons. These findings contradicted the finding of Udo (1998) who had argued that it was the lack of knowledge or non-practice of wait-time that most teachers asked several questions very rapidly within a short period of time and expected students to supply correct responses very rapidly.

The findings (Table 2) of this study equally revealed that on the average, mathematics teachers practised wait-time of 1.33 seconds. This finding was consistent with the earlier finding (Udo, 1998), that mathematics teachers in Nigeria practise the least wait-time of 1.27 seconds as compared to physics teachers (1.35 seconds) and chemistry teachers (1.5 seconds). Furthermore, this finding was inconsistent with the findings of Rowe (1980), Gyuse (1982) and Fletcher-Wood (2013) who recommended wait-time periods of 5 seconds, 3.5 seconds and 3 seconds and above. Didau (2017) also very recently recommended increased wait-time of at least 3 seconds. These experts argued that teachers should provide adequate period of silence (wait-time) that would most effectively assist nearly every learner in class to complete the cognitive tasks needed in a mathematics concept before supplying the response/answer.

Furthermore, the findings of this study as revealed in Table 3 indicated the following observable effects of the practice of adequate period of silence (wait-time) on students and teachers during class instructions in mathematics:

- Provides opportunity for learners to participate actively in class.
- reduces students' anxiety and fear in learning mathematics.
- allows students a period of silence to think and process information by completing the cognitive tasks needed in mathematics concepts.
- teachers would not be able to "cover" the planned scheme of work each term of the school year.

These findings agreed with those of Dylan (2014) who provided an instructional strategy called Pose-Pause-Pounce-Bounce (PPPB) questioning to be adopted in the practice of wait-time. This has the benefits of improving questioning and quality of responses.

CONCLUSION

The practice of adequate wait-time as an instructional strategy in mathematics instructions has been identified to have far reaching implications in mathematics learning. This would also foster effective teaching by mathematics teachers as they would be patient when presenting concepts in mathematics to students with different learning abilities

RECOMMENDATIONS

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

1. Mathematics teachers in secondary schools should not only practise wait-time, but, they should be seen to practise adequate wait-time of at least 3 seconds each lesson.
2. Federal and State Governments in Nigeria should expose teachers to Workshops on training in the practicality of wait-time in mathematics class instructions.
3. Wait-time practice should be emphasised in the Nigerian School System for meaningful learning to take place.
4. Faculties of Education and Colleges of Education should emphasis on the importance of wait-time practice, and by observing same during teaching practice supervision.

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