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Research Paper

Development and Standardisation of Mathematics (Geometry) Classroom Interaction Sheet (MgCIS) 2023

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ABSTRACT

This paper was designed to develop and standardise Mathematics (geometry) Classroom Interaction Sheet (MgCIS) to observe teaching and learning activities at the senior secondary school level in Nigeria. Instrumentation design was adopted. Face and content validities of MgCIS were established. The final MgCIS has eight categories and 66 behaviours. The validation and standardisation procedures of the MgCIS involved several procedures. Data analysis was done using Cohen's Kappa intra-class estimate for inter-rater reliability to obtain the correlation coefficient of observers' level of agreements (r=0.87 to 0.99) using IRR package in R software version 4.2.2 for each teacher pair observed, while the construct reliability yielded r=0.99. The MgCIS was found to be consistent and highly reliable. It was recommended that policy makers and school administrators should encourage proper teaching of Mathematics, while head teachers and researchers interested in Mathematics (geometry) performance, should adopt the MgCIS to evaluate teaching.

Keywords: *Secondary School Mathematics, Geometry, Development and Standardisation*

Observation is a research tool that can be used to collect quantitative data (when numerical value is attached to the observed phenomenon) or qualitative data (when only the absence or presence of the phenomenon is of interest) during a scientific inquiry. Observation tools capture and record 'the absence or presence of verbal and non-verbal behaviours of an individual' (Okpala & Onocha, 2012, p. 123) (or groups of persons). The settings could be natural e.g. in a classroom or simulated environment. Valid inferences on the individual or groups of persons observed can be made. Classroom observation instruments (COIs) are organised, objective systems for observing, coding, arranging, and analysing the behaviours emitted by teachers and students during teaching and learning (Martin, 1977). Classroom behaviours are clerked using tallies, checks, or other marks. Typically, the codes put in predefined categories, yield information on the behaviours that occurred and how often they occurred during the period of observation ((Martin, 1977, p. 43). These records can be analysed by researchers in a variety of ways and for different purposes. The earliest category observation instruments were developed mainly for the study of classroom behaviours in the thirties and forties (Wrightstone, 1934; Anderson & Brewer,

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1945, 1946; Withall, 1949). Thereafter, several observation instruments have been developed for various purposes and classroom instruction. Of these, only a few have received systematic attention and enjoyed widespread popularity and use. Prominent among these are: Teaching Dimensions Observation Protocol (TDOP) (Osthoff, et al., 2009), Classroom Observation Protocol for Undergraduate STEM (COPUS) (Smith, et al., 2013); Approaches to Teaching Inventory (ATI) (Trigwell & Prosser, 2004); and Teaching Practices Inventory (TPI) (Wieman & Gilbert, 2014).

Category observation instruments have been used by educators to measure students' participation, effective teaching behaviour, classroom climate, and multiple dimensions of classroom interaction (Medley & Mitzel, 1963). These instruments have demonstrated their utility in teacher effectiveness research and the tremendously important area of teacher education (Flanders, 1970; Borg, et al., 1968). Increasing numbers of educators have attempted to develop their category systems to fit what they perceive as the unique features of their classrooms, research projects, or social-vocational settings. Unfortunately, many of these works have proceeded without meeting rigorous criteria of valid and reliable instruments. Observation instruments that fall into this category are the Reformed Teaching Observation Protocol (RTOP) by Piburn, et al., (2000), which is used to capture elements of both instructor and student behaviours; and the UTeach Observation Protocol (UTOP), developed at the University of Texas – Austin (2011) – described as a protocol to assess the overall quality of instruction. The observation instruments focused more on the instructor and not on content taught in the observed class, having forced-choice response options which lack 'not applicable' options that may result in implausible ratings in some cases. These features of RTOP led to the critique by Wainwright, et al, (2003) that it has no agreed-upon set of practices that represent the Mathematics and science standards and the expected outcomes are open to wide interpretations while the UTOP lacked preference or bias for any particular way of teaching (Walkington, et al., 2011). These observation instruments used a Likert-scale format and only considered the frequency of occurrence of each item but did not take into account the time of occurrence which is a combination of events and time category observation.

Mathematics is the science of structure, order, and relation that has evolved from elemental practices of counting, measuring, and describing shapes of objects. It deals with logical reasoning and quantitative calculation, and its development involves an increasing degree of idealisation and abstraction of its subject matter (Berggren et al., 2020, p. 1). According to the National Policy on Education (FRN, 2014), as a science-related subject, Mathematics deals with space and quantity and could, therefore, be described as the science of numbers, quantity, shape and space as well as a way of thinking and organising a local proof. It is a subject that could help learners develop all necessary mathematical skills and ensure they are problem solvers in their daily lives. The Mathematics curriculum at the secondary school level, as prepared by NERDC consists of six major sections which are: Number and Numeration, Algebra, Calculus, Measurement, Statistics and Probability, and Trigonometry. Students' achievement in Mathematics is measured by the extent to which they can master these fundamental concepts. The language of Mathematics is international and transcends national or cultural boundaries. Students learn to explore and explain their ideas using universal symbols, common diagrams, spoken and written languages. For instance, students can use the concept of area and perimeter to build a flower bed. Developed nations of the world such as the USA, UK, Japan, and Germany and other emerging nations such as China and India have attained scientific and technological feats, consequent upon the development and effectiveness of their Mathematics education.

Challenges Facing Mathematics Teaching and the Rationale for the Scale Development

Despite its importance, Mathematics education in Nigeria has not transformed into excellence over the years as evidenced by the performance of students in public examinations conducted by the West Africa Examinations Council (WAEC) and the National Examinations Council (NECO). The majority of Nigerian secondary school students generally perform poorly in the subject and this raises concerns among major stakeholders about the quality and quantity of knowledge which students acquire in Mathematics. These concerns arise from the importance of the subject as it is used as a basic entry requirement into tertiary institutions to study courses like medicine, architecture, engineering and other science-based courses. Students find major areas such as geometry, construction, mensuration, longitude and latitude, bearing, and trigonometry difficult in senior secondary school Mathematics. Therefore, it is important for Nigeria, like other nations of the world, to develop her Mathematics education programme at the secondary school level. Table 1 presents the statistics of students' performance in WASSCE from 2009 to 2018.

Table 1: Statistics of Performance in WASSCE Mathematics, 2009-2018

Years	**(A1-C6) % Higher Passes**	**(D7-E8) % Passes**	**(F9) % Failure**
2009	47.04	25.56	23.41
2010	41.95	27.85	27.20
2011	40.35	31.46	27.93
2012	46.64	28.70	24.54
2013	44.24	26.53	29.03
2014	40.20	30.53	29.17
2015	57.02	26.91	16.06
2016	70.23	19.37	12.84
2017	59.22	25.59	10.41
2018	76.84	24.35	18.40

Source: WAEC, 2020

Table 1 presents the general performance of secondary school students in the West Africa School Certificate Examination (Mathematics) for 10 years (2009 – 2018) as released by the WAEC. The table shows that, between 2009 and 2014, the number of students who had minimum credit pass at C6, on average, was 44.0 per cent. The import of this is that a large number of students did not meet the minimum pass criteria. Although there was an improvement in 2015 and 2016, the expectation has not been achieved yet. The ultimate aim is to achieve a 100 per cent pass rate at distinction level. This would justify the government and parents' financial commitment to students' education in Nigeria.

Secondary School Mathematics curriculum under circle geometry has these contents: radius, diameter, segments, angles and sectors including theorems and propositions. The emphasis given to these topics in the Mathematics curriculum underlines the importance of geometry to human beings. To improve the teaching and learning of the subject, researchers have suggested the use of various teaching-learning software packages such as Number Gym Plus Mathematics Software and Dynamic Geometry Software (DGS). However, teachers and students find these software packages difficult to use because their foreign developers use complex computer programming languages which make them quite incomprehensible to would-be users and they are very expensive. Also, worthy of note is the Circle Geometry Software Package (CiGoSPac) developed through the use of Microsoft PowerPoint for teaching-learning geometry and self-learning for students. It was established by Kurumeh, et al, (2016) that when students are taught geometry using the Rusbult problem-solving model they performed well. However, the major challenges with the use of these packages among others are: they are not user-friendly; teachers do not understand how to teach the basic concept of these topics for learners' comprehension; and they do not have mastery of these concepts. Additionally, it could be noted that the contents of external examinations such as WAEC or NECO are derived from various Mathematics topics some of which teachers find difficult to teach, and could have negative effects on the performance of students in the subject. Also, Fabiyi (2017) corroborating WAEC and NECO found that students perceived all the aspects of geometry difficult to learn.

Despite the above-listed topics that seemed difficult to some students and the various suggestions that have been made on how to improve teaching and learning, no considerable changes in the performance of students in external examinations have been witnessed. Geometry derives its name from the combination of the Greek words Geo (earth) and Metron (measure) - for the measurement of the earth. Flat geometry (or two (2D) dimensions shapes e.g square, triangles, etc and three (3D) objects such as cuboids, spheres, cones, have the third dimension of height or depth. Geometry plays a significant role in primary and secondary school Mathematics curricula in Nigeria and other countries. Geometry responds to the practical problems found in surveying: it provides a rich source of visualisation for understanding arithmetical, algebraic, and statistical concepts (Battista, 1999) and a complete appreciation of the world (Golderman, 2012). It is used to develop students' spatial awareness, intuition, and visualisations; and to solve practical problems (Sunsuma, et al, 2012). Circle geometry is important because its fundamental principles, theorems and laws are applied in architecture, survey, aeronautics and space travel. As such, Adegoke (2003) argued that understanding these basic principles of circle theorems, laws and proportions can help in developing students' logical reasoning ability. Despite these important benefits, researchers have adduced some of the many factors that are responsible for students' difficulty in learning geometry to inadequate proof by students, inadequate background knowledge, poor reasoning skills in geometry, geometric language comprehension, inadequate visualising abilities, non-availability of instructional materials, gender differences, teachers' poor teaching methods and inadequate knowledge of the subject matter (Uduosoro, 2011; Telima, 2011; Aysen, 2012). Students' attribute difficulty in learning geometry to unavailability of instructional materials, insufficient time allocation, teachers' method of instruction, complexity, students' gender and misconception of concepts (Telima, 2011).

Adegoke (2003) and Adeleke (2007) found that students in Nigeria persistently perform below average in geometry and other themes in Mathematics, due to their poor application to develop reasoning ability, and constructions which manifest in inability to understand and explain the meaning of concepts, construct and label shapes, state and prove circle theorems. These facts and more were affirmed by West African Examination Council (WAEC) Chief Examiners' Reports (2016, 2017, 2018) that these aspects among others, were poorly attempted by majority of the candidates, many of whom treated them haphazardly, or avoided them. The report suggested areas where Mathematics teachers are expected to lay more emphasis during Mathematics instruction and lead students to appreciate the application of mathematical concepts in everyday living. In addition, the adoption of effective pedagogy such as the mastery learning approach (Adeniji, et al., 2018); and the Circle Geometry Software Package (CiGoSPac) (Ogunyomi, 2021) were found to positively influence students' learning outcomes in Circle Geometry. The implication of these is that if teachers adopt innovative teaching methods in the teaching of some Mathematics concepts, students are likely to perform better in Mathematics.

Observation instruments provide information to schools, organisations and persons being observed to make decisions to correct weaknesses observed in their teaching activities. Consequently, increasing numbers of educators have attempted to develop their observation category systems to fit what they perceive as the unique features of their classrooms, research projects, or social-vocational settings. It is against this background that the researchers developed and standardised a Mathematics (Geometry) Classroom Interaction Sheet (MgCIS) that would be used to observe teaching and learning activities at the senior secondary school level in Nigeria, and perhaps elsewhere.

Research Questions

This instrument development provides answers to the following research questions.

1. What are the behaviours displayed by teachers in a Mathematics (Geometry) class?
2. What is the frequency of occurrence of the behaviours and overall pattern of Mathematics teachers' geometry classroom interaction in the sampled schools in Ibadan Metropolis?
3. How consistent is the Mathematics (Geometry) Classroom Interaction Sheet (MgCIS) based on observers' ratings per teacher in sampled schools?

METHODOLOGY

Study Design: The study adopted instrumentation design.

Population and Sample: Senior Secondary School 2 Mathematics students and 80 teachers in intact classes formed the sample.

Development of the Mathematics (geometry) Classroom Interaction Sheet (MgCIS): The procedures followed while developing the MgCIS were specification of the objectives, setting of the event, identification of the construct, defining the category of the construct, construction of codes, development of behaviours/traits, validation procedure, trail stage of the instrument, standardisation process and administration of the instrument.

Method of Analysis: The construct reliability of the MgCIS was estimated using Cohen's Kappa intra-class estimate for inter-rater reliability to obtain the correlation coefficient of observers' level of agreements using the IRR package implemented in R software version 4.2.2 for pair of teachers observed per school. This ranged from 0.87 to 0.99 while the construct reliability yielded r = 0.99.

Research question 1: What are the behaviours displayed by teachers in a Mathematics (geometry) class?

The development of the MgCIS involves these ten steps:

Step 1: Specification of the Objective: The objective was to develop an instrument that could be used to capture the classroom interaction patterns of Mathematics teachers while teaching geometry in senior secondary school classes. This was to ensure that teachers exhibit the necessary traits that would positively influence secondary school students' comprehension and ultimate achievement in Mathematics.

Step 2: Setting of the Event: The MgCIS should be used in a Mathematics classroom. Observers are expected to critically note both teacher and students behaviours simultaneously and record the occurrence of the enacted behaviours by ticking the appropriate cell at the time of the occurrence. The type of observation is the 'Event and Time Category System' where behaviours are recorded as they occurred and at a particular time (minutes) of occurrence.

Step 3: Development of the MgCIS, Identification of the Construct and Categories: The MgCIS is the construct. The researchers developed the categories of the construct based on what is expected to occur in a geometry class before the draft was taken to the class. The MgCIS has eight categories which are teacher facilitating learning, teacher pedagogy, individual student activity, group activity, whole class activity, teacher not facilitating learning, monologue and confusion.

Step 4: Explaining the Categories of the Construct: The categories of Mathematics (geometry) Classroom Interaction Sheet (MgCIS) are explained as follows:

i. *TFL*: where the teacher is facilitating learning;
ii. *TP:* where the teacher adopts different approaches to facilitation of lesson content and delivery;
iii. *ISA:* where each student is engaged in learning activities;
iv. *GA:* where students are divided into subgroups for group activities;
v. *WCA:* where every student is engaged in some activities together;
vi. *TNFL:* where the teacher engages in activities not related to the content of the lesson;
vii. *M:* where the teacher engages in an activity continuously for a long time; and
viii. *C:* where teaching and learning are disrupted due to a teacher's statement or disciplinary action.

Step 5: Development of Behaviours or Traits of the Construct and the Codes: The Mathematics (geometry) Classroom Interaction Sheet (MgCIS) comprised an initial 58 behaviours but the final version had 66 behaviours or traits across the categories. The sub-categories are as presented:

A. ***Teacher Facilitating Learning (TFL)*** has eighteen sub-categories: the teacher introduces the lesson, recaps previous lesson, sketches dimensions, lectures, teaches with materials, gives examples, draws lines, measures, identifies and labels, manipulates, asks questions, responds to questions, reinforces correct response, constructs angles, solves problems on the board, probes ideas, clarifies, is enthusiastic during teaching (1-18)
B. ***Teacher Pedagogy (TP)*** has four sub-categories: the teacher displays teaching materials, demonstrates, gestures, and illustrates with teaching materials (19-22).
C. ***Individual Students Activity (ISA)*** has eleven sub-categories: student sketches dimension, draws lines, measures, identifies and labels, initiates ideas, manipulates, constructs angles, asks questions, responds to questions, illustrates with learning materials, solves problems on the board (23-33).
D. ***Group Activity (GA)*** has twelve sub-categories: brainstorming, sketching dimensions, drawing lines, measuring, identifying and labelling, initiating ideas, discussing ideas,

asking questions, responding to questions, manipulating, constructing angles, solving problems in their books (34-45).

E. ***Whole Class Activity (WCA)*** has eleven sub-categories: students sketch dimension, draw lines, measure, identify and label, ask questions, respond to questions, manipulate, construct angles, recite, give chorus answer, solve problems in their books (46-56).
F. ***Teacher Not Facilitating Learning (TNFL)*** has four sub-categories: manages disruptive behaviours, deviates from lesson content, makes phone calls, and attends to other matters (57-60).
G. ***Monologue (M)*** has two sub-categories: the teacher talks non-stop, and gives notes (61-62).
H. ***Confusion (C)*** has four sub-categories: noise arising from class discussion, class disorder due to teacher's statement, unorganised movement of students and disciplinary action (63-66).

The definition of these codes can be found in the 'Development and Standardisation of Mathematics Classroom (Geometry) Interaction Sheet (MgCIS) and User's Manual 2023' on the Institute of Education Website (https://www.ie.ui.edu.ng).

Step 6: Duration of Events and Coding Procedure: The duration of events is within a 40-minute class. The behaviours or traits of each sub-category of MgCIS have been specified above. The observer is expected to look out for the most predominant activity that occurred and record/code promptly every one minute.

Step 7: Validation Procedures: Face and content validities of the developed first and second MgCIS drafts were ensured by giving the instrument to the Research Fellow in charge of the course for vetting. Corrections and the suggestions were effected on the third draft. Additionally, copies of the MgCIS were given to four practising Mathematics teachers at the senior secondary school level in Ibadan Metropolis for scrutiny and appropriateness of the terms used for defining key concepts. These teachers were asked to check for behaviours or traits that do not frequently occur in a typical Mathematics (geometry) classroom and itemise the behaviours which usually do occur but were not captured in the MgCIS. Though the teachers noted that the categories and behaviours of the MgCIS were chronologically arranged and well structured, some of them suggested that some behaviours should be modified, e.g. 'construct angle' should be restructured as 'construction of angle' under TFL, ISA, GA and WCA. This was modified as suggested under TFL, ISA, GA and WCA since that was the language used in the curriculum. However, to make the term easily measurable, experts suggested that it should be stated as a 'construct angle' in the instrument. The Mathematics teachers' suggestions were effected on the fourth draft of the instrument after which copies were given to experts in Educational Evaluation in the area of scale development and psychometrics for constructive criticisms. Their suggestions were effected in the instrument. They were to check if the behaviours were not ambiguous as well as whether the behaviours measured the teaching activities in a Mathematics (geometry) classroom. The experts acknowledged that the behaviours were ideal and not ambiguous for their purpose. Under TFL, they suggested that 'teach with pre-made materials' and 'teach with handwritten materials' should be changed to 'teach with materials', and 'solve problems' should be 'solve problems on the board'. Other suggestions were that sketch dimension, draw lines, measure and manipulate should be included. Also, to be effected under ISA, GA and WCA were sketching dimensions, drawing lines, measuring and manipulating and changing ‘solve problems’ to ‘solve problems in their books’. The experts’ criticisms and suggestions were affected in the fifth draft of MgCIS which formed the final categories and behaviours of the modified MgCIS version outlined in Step 5.

Step 8: Establishing the Construct Validity and Trail-Out on Similar but Different Samples: The construct (that is convergent) validity of the MgCIS was established by two observers who captured the classroom interaction of four Mathematics teachers (that is eight observations) in four schools in Akinyele Local Government Area of Oyo State. The essence of the observations was to ensure that the categories and behaviours of the MgCIS are valid with what is obtained in a typical Mathematics (geometry) classroom setting. The observers noted that the MgCIS measures the construct of the Mathematic classroom interaction which it was designed for.

Step 9: Standardisation Procedures: While the standardisation procedures of instruments such as achievement tests, attitudes scales, aptitudes, intelligence tests may be established through certain norms (e.g. age, sex, class, location, school type etc), that of an observation instrument (category system) may not take the same process because of the nature of the instrument which does not measure cognition or ability but interaction patterns of specific traits as observed. After the validation process, the standardisation procedures of the MgCIS followed three processes: the administration of MgCIS in schools, the selection of consistent MgCIS observations and the estimation of internal consistency to determine the level of agreement in observers’ ratings.

- **Administration:** The final copy of the instrument was administered by two observers on 40 Mathematics teachers during teaching and learning interaction. This made a total of 80 observations in 40 sampled senior secondary schools in Ibadan Metropolis, Oyo State, Nigeria.
- **Selection of Observers Ratings**: The Generalisability theory was used to select 30 pairs of observations (a total of 60 observations) that were consistent based on the number of behaviours and total frequency of occurrence observed from 40 Mathematics teachers (80 observations) from the sampled senior secondary schools. Ten Mathematics teachers (that is 20 observations) were excluded due to disparities in observers’ ratings.
- **Estimation of Internal Consistency Using Intra-class Coefficient Reliability:** To estimate the internal consistency of MgCIS, the intra-class correlation coefficient for inter-rater reliability was used to measure the consistency in the two observers’ level of agreement while using the MgCIS. The two-way Random Effects Model was used while estimating the reliability coefficient because two observers used the instrument concurrently in a class to observe the classroom interactions of Mathematics teachers in different schools and to generalise the observers’ findings on similar samples. The consistency relationship was obtained because the researchers were interested in the systematic difference between the observers’ level of agreement across samples. The mean of observers’ ratings or scores was used as the basis for measurement. Koo and Li’s (2016) perspective was used to make inferences on the intra-class coefficient values obtained. Four ranges of values were adopted: less than 0.50 as poor reliability, between 0.50 and 0.75 as moderate reliability, between 0.75 and 0.90 as good reliability, and greater than 0.90 as excellent reliability. The construct reliability of the MgCIS was estimated with the intra-rater reliability (irr) package in R software version 4.2.2. This yielded **r = 0.99**. Based on the criteria for intra-class coefficients, the overall construct reliability of MgCIS was rated excellent because the coefficient is greater

than the 0.90 benchmarks. This implies that the MgCIS is consistent and highly reliable in measuring and analysing teaching and learning in Mathematics (geometry) classrooms.

Results of Mathematics (MgCIS) Classroom Interaction

Research question 2: What is the frequency of occurrence of the behaviours and overall pattern of Mathematics teachers' geometry classroom interaction in the sampled schools in Ibadan Metropolis?

To estimate the number of occurrences of behaviours in teaching and learning Mathematics (geometry) for each teacher per sampled schools, frequency and percentages were used while the overall pattern of teaching and learning of Mathematics (geometry) in the classroom setting was determined using a graph. These are presented in Tables 2a to 2c and illustrated in Figure 1.

Table 2a: Analysis of Mathematic Classroom Frequency of Occurrence by Observers per School

Category	**School 1**		**School 2**		**School 3**		**School 4**		**School 5**		**School 6**		**School 7**		**School 8**		**School 9**		**School 10**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Teacher Facilitating Learning (TFL)	18	21	20	17	20	18	12	21	11	10	17	21	23	21	19	17	20	23	19	22
Teacher Pedagogy (TP)	5	6	1	4	7	2	3	1	2	1	0	0	0	0	4	6	6	3	4	5
Individual Students Activity (ISA)	12	7	7	7	5	5	6	6	1	4	16	18	11	9	6	11	3	6	6	7
Whole Class Activity (WCA)	3	1	10	3	3	9	5	3	15	13	5	0	2	7	11	6	11	8	11	6
Group Activity (GA)	0	5	0	7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Teacher Not Facilitating Learning (TNFL)	2	0	2	2	3	5	7	2	4	7	2	1	3	3	0	0	0	0	0	0
Monologue (M)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Confusion (C)	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0
Total	**40**	**40**	**40**	**40**	**40**	**40**	**33**	**33**	**35**	**37**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**

Table 2b: Analysis of Mathematic Classroom Frequency of Occurrence by Observers per School

Category	School 11		School 12		School 13		School 14		School 15		School 16		School 17		School 18		School 19		School 20	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Teacher Facilitating Learning (TFL)	25	21	32	31	28	26	25	27	16	13	25	21	32	31	28	26	25	27	16	13
Teacher Pedagogy (TP)	0	7	0	0	0	0	0	0	2	1	0	7	0	0	0	0	0	0	2	1
Individual Students Activity (ISA)	11	5	7	7	5	6	10	8	1	4	11	5	7	7	5	6	10	8	1	4
Whole Class Activity (WCA)	4	3	0	0	7	8	3	3	15	13	4	3	0	0	7	8	3	3	15	13
Group Activity (GA)	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Teacher Not Facilitating Learning (TNFL)	0	3	1	2	0	0	0	0	4	7	0	3	1	2	0	0	0	0	4	7
Monologue (M)	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	2	0	0
Confusion (C)	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	2	2
Total	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**

Table 2c: Analysis of Mathematic Classroom Frequency of Occurrence by Observers per School

Category	School 21		School 22		School 23		School 24		School 25		School 26		School 27		School 28		School 29		School 30	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Teacher Facilitating Learning (TFL)	22	20	19	18	29	30	23	24	20	18	20	21	25	21	23	20	28	26	27	22
Teacher Pedagogy (TP)	0	0	4	2	0	0	0	0	5	4	0	0	0	0	4	6	0	0	4	5
Individual Students Activity (ISA)	11	9	5	5	7	7	10	6	5	5	13	14	9	7	6	8	4	6	6	9
Whole Class Activity (WCA)	3	7	8	9	0	0	2	7	3	7	5	4	2	7	7	6	4	4	2	4
Group Activity (GA)	0	0	2	1	1	1	0	0	2	1	0	0	0	0	0	0	2	1	0	0
Teacher Not Facilitating Learning (TNFL)	3	3	4	5	3	2	4	2	5	5	2	1	2	3	0	0	0	0	0	0
Monologue (M)	1	1	0	0	0	0	1	1	0	0	0	0	2	2	0	0	2	4	0	0
Confusion (C)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**	**40**

Tables 2a, 2b and 2c present the analysis of observation in teaching geometry in a Mathematics classroom and the frequency of occurrence as captured by observers in each classroom taught per sampled school in Ibadan Metropolis. The tables show that there were 60 observations (from observers A and B) in 30 schools showing that 30 Mathematics teachers were pair-observed across the sampled schools. The tables revealed that 'teacher facilitating learning' was the most predominant behaviour that occurred across all the sampled schools. The aggregates of the observers' ratings are presented in Figure 1.

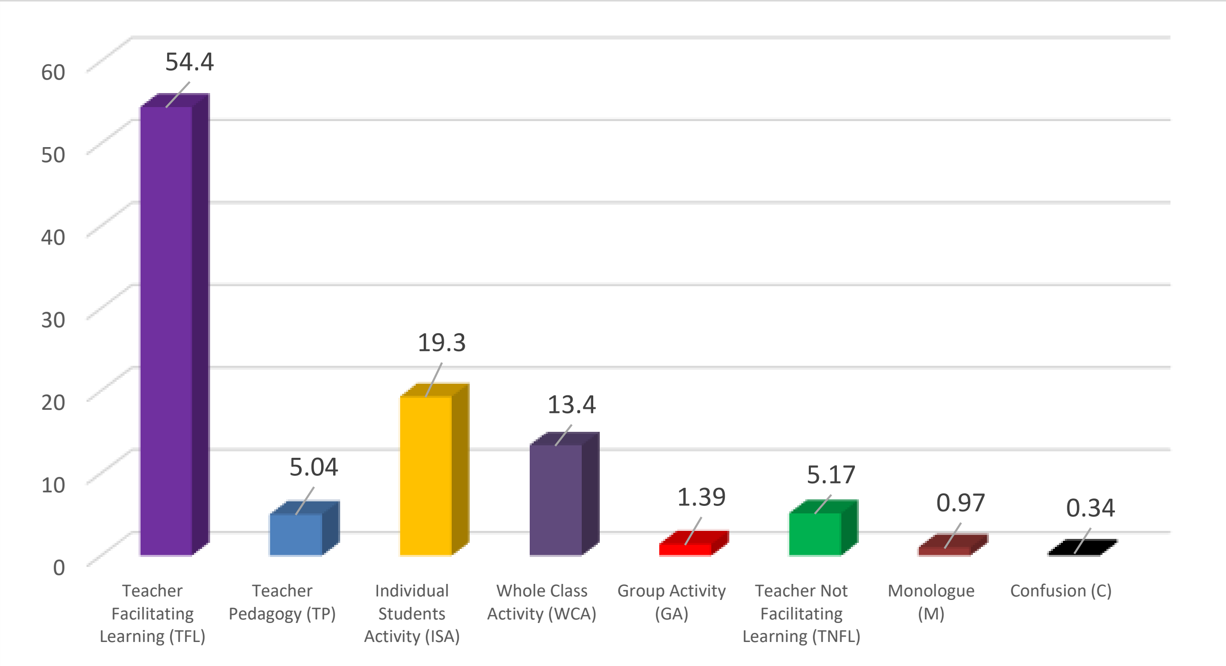

Figure 1: Overall Pattern of Mathematics Classroom Interactions across Sampled Schools in Ibadan Metropolis

Figure 1, shows the aggregate analysis of geometry in Mathematics classroom interaction activities concerning events, time of occurrence and percentages across all the teachers in sampled schools. Figure 1 revealed that more of the lesson time: 54.4 per cent (21mins 58secs) was spent on teacher facilitating learning, followed by 19.3 per cent (8 mins 5 secs) on individual students activity, and 13.4 per cent (5 mins 32 secs) on whole class activity for the teaching and learning activities in the classroom. Time spent on other behaviours was minimal during teaching and learning, e. g. teacher not facilitating learning was 5.17 per cent (2 mins 05 secs); teacher pedagogy, 5.04 per cent (2 mins); group activity, 1.39 percent (55 secs); monologue 0.97 per cent (38 secs); and confusion 0.34 per cent (13 secs). This finding reveals that teacher facilitating learning (TFL) activities such as the teacher introducing the lesson, recapping previous lesson, solving problems on the board, sketching dimensions, giving examples, asking questions, responding to questions and being enthusiastic during teaching dominated the classroom interaction pattern of the teaching and learning of Mathematics among the sampled teachers in selected schools in Ibadan Metropolis. It is necessary that while facilitating learning, Mathematics teachers should increase emphasis on individual student activities such as asking questions, responding to questions, solving problems on the board and illustrating with learning materials, as well as group activities like brainstorming, discussing ideas, manipulating, and responding to questions. Less emphasis should be devoted to whole-class activities such as measuring, drawing, sketching dimensions, solving problems in their books. This is to extensively increase individual students' participation which could stimulate their learning and improve their performance.

Research question 3: How consistent is the Mathematics (geometry) Classroom Interaction Sheet (MgCIS) based on observers' ratings per teacher in sampled schools?

The intra-class reliability (IRR) package in R software version 4.2.2 was used to estimate the reliabilities of the observers' level of agreement in the use of the Mathematics (geometry) Classroom Interaction Sheet (MgCIS) per teacher in sampled schools (Table 3 for observer A and observer B).

Table 3: Reliability Coefficients Estimate of Mathematic Classroom Interactions Per Teacher in Each School

School 1	**School 2**	**School 3**	**School 4**	**School 5**	**School 6**	**School 7**	**School 8**	**School 9**	**School 10**
A B	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**
r = 0.95 ER	r = 0.89 GR	r = 0.93 ER	r = 0.87 GR	r = 0.97 ER	r = 0.98 ER	r = 0.98 ER	r = 0.95 ER	r = 0.98 ER	r = 0.98 ER
School 11	**School 12**	**School 13**	**School 14**	**School 15**	**School 16**	**School 17**	**School 18**	**School 19**	**School 20**
A B	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**
r = 0.93 ER	r = 0.99 ER	r = 0.99 ER	r = 0.99 ER	r = 0.97 ER	r = 0.95 ER	r = 0.97 ER	r = 0.99 ER	r = 0.94 ER	r = 0.99 ER
School 21	**School 22**	**School 23**	**School 24**	**School 25**	**School 26**	**School 27**	**School 28**	**School 29**	**School 30**
A B	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**	**A B**
r = 0.98 ER	r = 0.99 ER	r = 0.99 ER	r = 0.97 ER	r = 0.98 ER	r = 0.99 ER	r = 0.97 ER	r = 0.99 ER	r = 0.99 ER	r = 0.98 ER

NOTE: ER = Excellent Reliability; GR = Good Reliability

Table 3 presents the intra-class reliability coefficient of the observers' level of agreement in the use of the mathematics (geometry) Classroom Interaction Sheet (MgCIS). School 2 (r = 0.89) and School 4 (r = 0.87) had the lowest reliability coefficient, which revealed good reliability. The intra-class reliability coefficient of the observers' level of agreement in the use of MgCIS in the remaining 288 schools ranged from 0.93 to 0.99 and shows excellent reliabilities. However, the composite reliability of the MgCIS was r = 0.99. This implies that the MgCIS is consistent and highly reliable in measuring and analysing teaching and learning geometry in Mathematics classrooms.

DISCUSSION OF FINDINGS

In terms of the frequency of the most typical and important categories and behaviours displayed by Mathematics teachers in standard classroom interaction, the result of the overall pattern of Mathematics teachers' (geometry) classroom interaction in the sampled schools indicated that the predominant behaviour observed across the schools was teacher facilitating learning (54.4 per cent), individual student activity (19.4 per cent) and whole class activity (13.4 per cent). Other category behaviours such as teacher not facilitating learning, teacher pedagogy, group activity, monologue, and confusion utilised less of the lesson time. These findings are consistent with classroom interaction sheets adopted in the studies of Odinko and Williams (2006) where major behaviours displayed in pre-primary classrooms were teacher whole-class activity (prompting learning), pupil-group activity, individual activity, the teacher not facilitating learning activity and confusion. However, the findings of this study were different in some ways from the categories and behaviours displayed in the studies by

Osthoff et al., (2009), and Hora, et al., (2013) where teaching methods, pedagogical moves, students-teacher interaction, cognitive demand, students engagement, instructional technology were displayed. In terms of the categories and behaviours displayed, the findings of this study, are not consistent with the corrected version of COPUS by Smith, et al., (2014) whose categories of 25 codes were limited to only two ("What the students are doing" and "What the instructor is doing").

Although findings in this study imply that teachers often dominate the teaching and learning activities in a typical classroom setting, it is important to emphasise that Mathematics teachers are expected to incorporate more group activity into their teaching to encourage collaboration and critical thinking skills in students as well as improve assimilation and learning by less performing students. While the studies of Pervin et al., (2021) and Ogundare (2019) may have slightly different behaviours that constitute their classroom interactions, the findings of this study are, nonetheless, consistent with that of Pervin, et. al. who found that teacher-student interaction took most of the lesson periods and Ogundare's (2019) discovery that in all four segments of 10 minutes threshold established during observation, teacher talk was predominant compared to student-talk during teaching and learning in the classroom. However, the findings negate that of Odinko and Williams (2006) who found that the prevailing interaction pattern during the teaching of numeracy in Nigerian pre-primary classrooms was teacher whole class activity (prompting learning) while fewer proportions of time were spent on pupils-group activity and individual activity.

The construct reliability of the Mathematics (geometry) Classroom Interaction Sheet (MgCIS), signifies an extremely high level of consistency in measuring and analysing teaching and learning interactions in Mathematics classrooms. Also, in terms of the consistency based on observers rating per teacher in this study, findings revealed that the level of agreement of intra-class reliability coefficients for the observers, ranges between $r = 0.87$ and $r = 0.99$, while the construct reliability yielded $r = 0.99$. The result indicates an excellent reliability in the use of the MgCIS in educational settings Thus, findings underscore the robustness and dependability of the MgCIS as a tool for assessing classroom dynamics and instructional practices. Therefore, the finding of this study is consistent with that of Hora, et. al., (2013) that inter-rater reliability using Kappa scores ranges from $r = 0.80$ to $r = 0.90$; and it aligns with that of Markelz, et al., (2020) who used Cohen's Kappa and intra-class correlation to measure the level of agreement of four raters and found that each measure yielded adequate reliability of above 0.80 and a high degree of an intra-class average of 0.78. Additionally, the finding of this study has greater reliability indices than that of Cardot (2021) who found agreement between raters using Cohen's Kappa to be 0.58 for strategy endorsement and quality ratings agreement between raters to be 0.68 for quality ratings on Five-in-20 minutes classroom observation tool. After modification of Cardot's (2021) Five-in-20 classroom observation tool by Buechlein (2023), he found an improvement in the reliability coefficient of the level of agreement in strategy endorsement to be 0.71 unlike quality rating which is 0.56. Given the reliability estimates obtained for the level of agreement between observers' ratings and construct reliability as well as the innovative techniques used in this study, it can be concluded that the MgCIS was found to be novel, more reliable, and consistent than those of the previous studies.

CONCLUSION

The Mathematics observation instrument MgCIS was developed in this study. The instrument is to serve as an observation tool to capture Mathematics teachers' interaction in a geometry classroom. MgCIS has 66 traits and codes, and an excellent observers' rater reliability consistency of 0.99. Results indicate that the instrument can be used to capture essential traits exhibited in a Mathematics (geometry) class.

Recommendations

This study recommends that:

1. Teachers should devote more of lesson time to facilitate individual and group activities and less of teacher activity since this is where individual participation is enhanced.
2. School administrators should adopt the use of MgCIS to evaluate the teaching of geometry to improve performance in Mathematics (geometry) teaching and learning.
3. Policymakers should encourage the use of appropriate strategies to teach Mathematics.

REFERENCES

Adegoke, B. A. (2003). Teacher influence as a determinant of dependent-prone students' learning outcomes in Senior Secondary School Geometry in Ibadan South East Nigeria. Ph.D. Thesis. Institute of Education. University of Ibadan. Prelim. i-xviii, pp. 1-253.

Adeleke J. O. 2007. Identification and effect of cognitive entry characteristics on students' learning outcomes in bearing in Mathematics. Ph.D. Thesis. Institute of Education. University of Ibadan. Pp 1-178.

Adeniji, S. M., Ameen, S. K., Dambatta, B. U., & Orilonise, R. (2018). Effect of Mastery Learning Approach on Senior School Students' Academic Performance and Retention in Circle Geometry. *International Journal of Instruction,* 11(4), 951-962. https://doi.org/10.12973/iji.2018.11460a

Anderson, H. H., & Brewer, H. M. (1945). Studies of teachers' classroom personalities. I. Dominant and socially integrative behaviour of kindergarten teachers. *Applied Psychological Monographs.* No. 6.

Anderson, H. H., & Brewer, H. M. (1946). Studies of teachers' classroom personalities. II. Effects of teachers' dominative and integrative contacts on children's classroom behaviour. *Applied Psychological Monographs,* No. 8.

Aysen, O. (2012). Misconceptions in geometry and suggested solutions for seventh-grade students. *International Journal of New Trends in Arts, Sports and Science Education,* 1(4), 1-13.

Battista, M. 1999. Geometry results from the third international mathematics and science study. *Teaching Children Mathematics,* 5(6), 367-373.

Berggren, J. L., Grag, J. J., Knorr, W. L. R., Fraser, C. G. & Folkerts, M. (2020). Mathematics encyclopaedia. Britannica. https://www.britannica.com/science/mathematics.

Borg, W. R., Kallenbach, W. W., Kelly, M. L. & Langer, P. (1968). The minicourse: A rationale and uses in the in-service education of teachers. Paper read at American Educational Association annual meeting, Chicago, February.

Buechlein, D. (2023). Assessing the reliability of the five-in-20 classroom observation tool. Masters Thesis. https://thekeep.eiu.edu/thesis/4978.

Cardot, A. (2021). Five in 20: An exploratory study to develop and pilot an observation tool used to assess the five features critical to effective classroom management. Masters Theses. https://thekeep.eiu.edu/thesis/4875

Fabiyi, T. R. (2017). Geometry concepts in mathematics are perceived as difficult to learn by senior secondary school students in Ekiti State, Nigeria. *IOSR Journal of Research & Method in Education,* 7(1), 88 – 90.

Federal Republic of Nigeria (2013). *National policy on education, (6th ed.).* Lagos: Federal Government Press.

Flanders, N. A. (1970). *Analysing teaching behaviour*. Reading, Mass.: Addison-Wesley.

Goldman, C. (2012). How maths work. In Sunzuma, G., Masocha, M. and Zezekwa, N. Secondary school students' attitudes towards their learning of geometry: A survey of Bindura urban secondary schools. *Greener Journal of Educational Research*, 3(8), 402- 410.

Hora, M. T. Oleson, A. & Ferrare, J. I. (2013). Teaching dimensions observation protocol (TDOP) user's manual. Wisconsin Center for Education Research University of Wisconsin-Madison. http://ccher.wceruw.org

Kurumeh, M. S., Obarakpo J. S., Odoh C. O., & Ikyereve, R. O. (2016). Enhancing senior secondary school students' achievement in geometry through the utilization of result problem-solving model in Keffi metropolis, Nasarawa State, Nigeria. *Merit Research Journal of Education and Review.* 4(6) 065-070.

Markelz, A. M., Riden, B. S., Zoder-Martell, K. A., Miller, J. E. & Bolinger, S. J. (2020). Reliability assessment of an observation tool to measure praise characteristics. *Journal of Positive Behavior.* 23(1), 17-29. https://doi.org/10.1177/

Martin, J. (1977). The Development and Use of Classroom Observation Instruments. *Canadian Journal of Education*, Vol. 2, No. 3, pp. 43-54.

Odinko, M. N. & Williams, J. (2006). Language of Instruction and Interaction Patterns in Pre-Primary Classrooms in Nigeria. *Journal of Classroom Interaction.* 41(1), pg. 22 – 32

Ogunyomi, K. O. (2021). Development and use of software package for teaching and learning circle geometry in senior secondary schools in Ibadan-land, Nigeria. Unpublished Ph.D. Thesis, Institute of Education, University of Ibadan, Ibadan, Nigeria.

Okpala, P. N. & Onocha, C. O. (2012). *Tools for educational research*. Stirling-Horden Publishers Ltd. Orogun, Oyo State, Nigeria.

Osthoff, E., Clune, W., Ferrare, J., Kretchmar, K., & White, P. (2009). Implementing immersion: Design, professional development, classroom enactment and learning effects of an extended science inquiry unit in an urban district. Madison: University of Wisconsin–Madison, Wisconsin Center for Educational Research.

Pervin, M., Ferdowsh, N. & Munni, I. J. (2021). Teacher-student interactions and academic performance of students. *Dhaka Univ. J. Biol. Sci*. 30(1): 87-93.

Piburn, M., Sawada, D., Falconer, K., Turley, J. Benford, R. & Bloom, I. (2000). Reformed Teaching Observation Protocol (RTOP). ACCEPT IN-003.

Smith, M., Jones, F., Gilbert, S. & Wieman, C. (2013). The classroom observation protocol for undergraduate STEM (COPUS): A new instrument to characterize university STEM classroom practices. *CBE-Life Sciences Education*, Vol. 12.4.

Telima, A. (2011). Problems of teaching and learning of geometry in secondary schools in River State, Nigeria. *International Journal of Emerging Science,* 1(2), 143-152.

Trigwell, K., Prosser, M. (2004). Development and use of the approaches to teaching inventory. Educational *Psychology Review,* 16 (4), 409-424.

Uduosoro, U. J. (2011). Perceived and actual learning difficulties of students in secondary school mathematics. *International Multidisciplinary Journal, Ethiopia, 5 (5), 357-366.*

Wainwright, C. L., Flick, L. B., & Morrell, P. D. (2003). Development of instruments for assessment of instructional practices in standards-based teaching. *Journal of Mathematics and Science: Collaborative Explorations*, *6*(1), 21–46.

Walkington, C., Arora, P., Ihorn, S., Gordon, J., Walker, M., Abraham, L., & Marder, M. (2011). Development of the UTeach Observation Protocol: A classroom observation instrument to evaluate mathematics and science teachers from the UTeach Preparation Program (UTeach Technical Report 2011-01). UTeach Natural Sciences, University of Texas at Austin.

West African Examination Council (WAEC) (2016). Chief Examiners' Report

West African Examination Council (WAEC) (2017). Chief Examiners' Report.

West African Examination Council (WAEC) (2018). Chief Examiners' Reports.

West African Examination Council (WAEC) (2020). Chief Examiners' Reports.

Wieman, C. & Gilbert, S. (2014). The teaching practices inventory: A new tool for characterizing College and University teaching in Mathematics and Science. *CBE-Life Sciences Education*, 13 (3): 552–569.

Withall, J. (1949). Development of a technique for the measurement of socio-emotional climate in the classroom. *Journal of Experimental Education*, 17, 347-361.

Wrightstone, J. W. (1934). Measuring teacher conduct of class discussion. *Elementary Journal*, 34, 454-460.

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Conflict of Interest

The authors declared no conflict of interest.

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APPENDIX

MATHEMATICS (Geometry) CLASSROOM INTERACTION SHEET (MgCIS)

©Eugenia A. Okwilagwe; Sunday N. Okocha & Miriam U. James (2023)

School: ____

Teacher's Name: ____

Topic: ____

Class: ______________________________

Period: _____________________________

Date: ____

Time Start: ____________________ **Time Stopped**: ________________

Number of Students: _________________

	Behaviour Category	Code	→	Tally/Time Occurrence	→	Total	%
A.	**Teacher Facilitating Learning (TFL)**						
1	Introduces the lesson	Il					
2	Recap previous lesson	Rpl					
3	Sketch dimension	Sd					
4	Lectures	L					
5	Teach with materials	Tm					
6	Gives examples	Ge					
7	Draw lines	Dl					
8	Measure	Me					
9	Identify and label	Idl					
10	Manipulate	Ma					
11	Ask questions	Aq					
12	Respond to questions	Rq					
13	Reinforces correct response	Rcr					
14	Construct angle	Ca					
15	Solve problems on the board	SPB					
16	Probing ideas	Pi					
17	Clarifies	C					
18	Enthusiastic during teaching	Edt					
B.	**Teacher Pedagogy (TP)**						
19	Displays teaching materials	Dtm					
20	Demonstrates	D					
21	Gestures	G					
22	Illustrates with teaching materials	Itm					
C.	**Individual Students Activity (ISA)**						
23	Sketch dimension	Sd					
24	Draw lines	Dl					
25	Measure	M					
26	Identify and label	Idl					
27	Initiate ideas	Ii					
28	Manipulate	Ma					
29	Construct angle	Ca					
30	Ask question	Aq					
31	Respond to question	Rq					
32	Illustrates with learning materials	Ilm					
33	Solve problems on the board	SPB					
D.	**Group Activity (GA)**						
34	Brainstorming	Bs					

35	Sketch dimension	**Sd**
36	Draw lines	**Dl**
37	Measure	**Me**
38	Identify and label	**Idl**
39	Initiates ideas	**Ii**
40	Discuss ideas	**Di**
41	Ask question	**Aq**
42	Responds to question	**Rq**
43	Manipulate	**Ma**
44	Construct angle	**Ca**
45	Solve problems in their books	**SPb**
E.	**Whole Class Activity (WCA)**	
46	Sketch dimension	**Sd**
47	Draw lines	**Dl**
48	Measure	**Me**
49	Identify and label	**Idl**
50	Ask question	**Aq**
51	Respond to question	**Rq**
52	Manipulate	**Ma**
53	Construct angle	**Ca**
54	Recites	**R**
55	Give chorus answer	**Gca**
56	Solve problems in their books	**SPb**
F.	**Teacher Not Facilitating Learning (TNFL)**	
57	Manages disruptive behaviours	**Mdb**
58	Deviate from lesson content	**Dlc**
59	Makes phone calls	**Mpc**
60	Attends to other matters	**Aom**
G.	**Monologue (M)**	
61	Teacher talking non-stop	**Ttn**
62	Gives note	**Gn**
H.	**Confusion (C)**	
63	Noise arising from class discussion	**Nacd**
64	Class disorder due to teacher's statement	**Cdts**
65	Unorganised movement of students	**Ums**
66	Disciplinary action	**Da**

Code only one dominant behaviour every 1 minute

Note: make more necessary comments on the content taught or any other behaviour that is observed

____
____
____
____
____
____
____
____

***Name of Observer*____**