PRACTICAL APPROACH TO TEACHING AND ASSESSMENT IN MATHEMATICS

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Abstract

Mathematics is a subject characterised with abstraction. Many learners in the world dread Mathematics. Theoretical approach to teaching and assessment are often adopted with lecture method in most cases resulting to poor learning outcomes. Poor teaching methods have been reported but practical approach of teaching and assessment have rarely been considered and has not been adopted in classroom activities. This study proves that some concepts can be taught practically and assessed practically to reduce cognitive loading as to usher in learning with fun and without anxiety. PMTTQ questionnaire containing ten mathematics concepts that can be taught practically (section B) and the same ten items that can be tested practically (section C) are administered among Mathematics stakeholders which include Mathematics teachers and Mathematics educators. A sample size of 42 is randomly selected from the mathematics stakeholders (excluding students) who are participants of M.A.N conference. Above 65% are of the opinion that all these concepts are better taught through practical approach; above 52% opine that these same concepts are better assessed in a practical way. There is significant difference between concepts that can be taught practically and those that can be assessed practically. There is a gap between their opinion on the concepts that can be taught and tested through practical approach. The stakeholders need to be shown and convinced on the possibility of practical assessment of these concepts.

Key words: practical teaching and assessment, theoretical teaching and assessment, science subjects, teaching approach

Introduction

Mathematics is one of the core subjects in primary and secondary schools in Nigeria. This is due to its importance to the successful existence of other careers and vocations. The status of mathematics in schools is not just peculiar to Nigeria. Gbenga-Adeaga and Awe (2017) claim that it is a universal subject and that the knowledge of it is not only necessary for successful schooling but also unavoidable for human survival on daily

basis. Olunloyo (2010) also made allusion to the universality of mathematics as a discipline which relevance and utilitarian value goes beyond the need of mathematicians to other professions. Adegboye (2003) comments on its aesthetic value as used by artists. The knowledge of mathematics is a precursor to success in science and technology, which are determinants of national development. Gbenga-Adeaga and Awe (2017) again cited Eraikuemen and Oteze (2001) that it aids appreciation of nature and enhances critical thinking and logical reasoning. Mathematics influences the basic sciences, applied sciences, engineering, technology and day-to-day activities (Markarfin, 2001). Justifiably, the Federal Government of Nigeria declared it in the *National Policy on Education* (Federal Republic of Nigeria, 2004) as a core subject (Afolabi, 2015).

Mathematics is taught and assessed in schools just the way Economics or Social Studies or English will be taught and assessed. It has not been considered that it should be taught and assessed like other sciences like Physics, Chemistry or Biology. In a study by Abimbade and Afolabi (2012), more than thirteen teaching methods are found to be commonly used by mathematics teachers in South West of Nigeria. Foremost among them is the lecture method. In the studies by Abimbade and Afolabi (2012), Afolabi (2010a); Igbokwe (2000) it was concluded that mathematics is being taught through the lecture method. Afolabi (2010a), Abimbade and Afolabi (2012) establish the reasons for the use of lecture method by teachers. Paramount among them are unavailability of instructional materials and teachers' lack of knowledge of proven methods and strategies that research has established as efficient in enhancing high learning outcomes.

Afolabi and Adesope (2010) clarified the concepts; teaching approach, teaching method and teaching strategy. Teaching approach is the direction of teacher's commitment and concentration of efforts. The approach could be subject-centred, teacher-centred or child-centred. The lecture or expository teaching method can be classified under subject-centred approach. Any teaching method and strategy can be classified under at least one of these approaches. They also defined teaching method in Afolabi (2010b) as a specific instructional process that differs from any other by diversities of specialised activities. Teaching strategy is an instructional process which follows a specific routine. That means, in the application of a teaching strategy, there is a specific algorithmic pattern on the steps to follow in order to achieve the learning goals.

Assessment in education can be defined as the process of establishing the status of the performance of an individual or group in a given task usually with reference to the expected outcomes (Adeleke, 2010). This may take quantitative and non-quantitative forms. The National Policy on Education (FGN, 2004) emphasised the necessity for continuous assessment under the Universal Basic Education and the 6-3-3-4 educational structure. Students' assessment is a means of measuring the learning outcomes. Assessment of students can take various forms, which include classwork, assignment,

test, examination. The test instrument may be objective tests (in various forms) essay or practical, oral or written.

Researchers such as Maduabum and Odili (2006), Okereke (2006) in Adebiyi (2017) have reported constant failure rate in mathematics generally. Specifically, the failure in external examination in this subject conducted by WAEC and NECO is alarming. The chief examiners of WAEC (2015 and 2017) have reported inadequate skills in approaching the mathematics examination questions. Areas of weaknesses of students include circle geometry 3-dimensional problems, algebraic problems, and word problems. It is also reported that students try to avoid problems in 3-dimensional geometry. The teaching of mathematics in schools is theoretical and the assessment approach in schools and by these examination bodies is also theoretical. The abstract nature of mathematics makes it cognitively loaded and this alludes to the difficulties in teaching and learning. Its nature also explains the reason for negative attitude of students towards mathematics and consequently poor achievement. However, researchers have not been attributing students' failure in mathematics to mode of assessment and the test instrument used. Although, this is worth looking into, this study may not be able to deal fully with it.

Mathematics is regarded and classified as a science subject in a formal institution. Most of the sciences have periods for practical teachings. They are as well assessed both practically and theoretically. In most cases, achievement level of students who offer science subjects is often higher in science subjects than in Mathematics. Mathematics teaching and assessment in schools is only theoretical and lecture method is often used in teaching. In a study carried out by Afolabi (2014a) on improving mathematics learning outcomes, he reports that about five periods (i.e. 3.3 or 3.75 hours) per week is being used in teaching each of Physics, Chemistry, Biology, Mathematics, Food and Nutrition and English. Firstly, in the assessment of these subjects the number of hours spent by WAEC on Physics, Chemistry, Mathematics, Food and Nutrition and English Language is 5.5, 5, 4, 5.25, 4.25 and by NECO is 5.75, 5, 3.5, 6, 3.5 respectively. In all the subjects above, Mathematics attracts the least hours of examination in both WAEC and NECO. Secondly, from table 1, it is obvious that mathematics assessment is ranked at the same level with History, Principles of accounting, Commerce and Economics whereas more hours are committed to teaching of Mathematics than any of these subjects. Thirdly, two types of assessment instrument- essay and objectives- are conducted in Mathematics and in these subjects.

Table 1: A Comparative Analysis of Time (Hours) Assigned by WAEC and NECO to Conduct Senior School Certificate Examination (SSCE) in Some Subjects

S/N	SUBJECTS	OBECTIVE TEST		ESSAY		PRACTICALS		TOTAL HOURS	
		WAEC	*NECO*	**WAEC**	*NECO*	**WAEC**	*NECO*	**WAEC**	NECO
1	English Language	**1**	*1*	**2.5**	*1.75*	**.75**	*.75*	**4.25**	*3.5*
2	Mathematics	**1.5**	*1.5*	**2.5**	*2*	**-**	*-*	**4**	*3.5*
3	Physics	**1.25**	*1.25*	**1.5**	*1.75*	**2.75**	*2.75*	**5.5**	*5.75*
4	Chemistry	**1**	*1.5*	**2**	*1.5*	**2**	*2*	**5**	*5*
5	Biology	**1**	*1*	**1.5**	*1.5*	**2**	*2*	**4.5**	*4.5*
6	Further Mathematics	**1.5**	*2*	**2.5**	*2.5*	**-**	*-*	**4**	*4.5*
7	Computer Education	**-**	*1*	**-**	*2*	**-**	*3*	**-**	*5*
8	Economics	**.83**	*1*	**3**	*2*	**-**	*-*	**3.83**	*3*
9	Geography	**.83**	*1*	**1.83**	*2*	**2**	*1.5*	**4.66**	*4.5*
10	Principles of Account	**1**	*1.33*	**2.5**	*2.5*	**-**	*-*	**3.5**	*3.83*
11	Agric. Science	**1**	*1*	**2**	*1.5*	**1.5**	*1.5*	**4.5**	*4*
12	Food & Nutrition	**1**	*1.5*	**1.5**	*1.5*	**3**	*3*	**5.25**	*6*
13	History	**1**	*1*	**2.5**	*2*	**-**	*-*	**3.5**	*3*
14	French	**1.5**	*-*	**1.25**	*2.33*	**.67**	*1.5*	**3.42**	*3.83*
15	Technical Drawing	**1**	*1*	**1.75**	*1.5*	**2.75**	*3*	**5.5**	*5.5*

Source: Excerpt from Afolabi, 2014 a

The two bodies have 2 hours of practical for each of the science subjects except Agricultural Science with 1½ hours. The rating of each form of assessment is made in such a way that any students who fails in the practical can hardly pass the subject. Here is the variety of opportunities given to students under these subjects whereas they could not be accorded similar opportunity in Mathematics.

Along the line of this thought, is the idea of Mathematics laboratory. Odili (2006) in Iyekekpolor, Adamu and Ayuba (2011) describes Mathematics laboratory as a resource centre for the learning of mathematics, consisting of a specially equipped room in the building where Mathematics classes meet on a regular basis or a corner of regular classroom with tables and equipment, or a collection of teaching aids for pupils' manipulation. Many researchers like Ogunkunle (2000), Igbokwe (2000), Farayola (2011), have argued in favour of mathematics laboratory. In spite of its acclaimed importance, most schools and teachers do not make effective use of it. This may be due to teachers' unwillingness to give the needed time and attention. This paper however goes beyond the claims of Mathematics stakeholders about their views on practical

teaching and testing of some Mathematical concepts as against theoretical approach. To start with, there is need for curriculum reform backed up by government policy, and the writing of appropriate textbooks that adopt the practical teaching and testing approach of some mathematical concepts. The textbook is the most important source of instruction and students' learning tool (Afolabi, 2014b). A well laid out textbook with properly organised content, attractive and motivating presentation, appropriate vocabulary (communication) and suitable illustration are some of the qualities of a good textbook suggested by Aggarwal (2001) and Afolabi (2014b). This has to be a follow up to policy decision on practical approach to teaching and assessment.

As a result of benefits which practical approach can afford the student, this study examines some concepts in Mathematics which can be taught in a practical way and also assessed in a practical way.

Statement of the Problem

Many researches on Mathematics education have consistently reported poor performance of students in Mathematics because of difficulties associated with the teaching-learning process of Mathematics. Much has been researched on psychological and pedagogical concerns in improving Mathematics learning outcomes. The results have always been the same because teaching and assessment is done using the same approach. Hence, this research considers a new dimension of teaching and assessing Mathematics through the practical approach. It should be noted here that this is more than the usual acclaimed Mathematics laboratory approach.

Research Questions

1. How competent are the Mathematics stakeholders in determining Mathematical concepts to be taught and assessed practically?
2. Can Mathematics be taught and assessed with a practical approach?
3. Which Mathematical concepts can be i) taught and ii) assessed with a practical approach?

Hypothesis

Ho: There is no significant difference between Mathematical concepts to be taught practically and those to be assessed practically

Research Design

The study is a descriptive survey of the *ex-post* factor because there is no manipulation of the independent variable.

Population and Sample

The population comprise all stakeholders in Mathematics. These include Mathematics teachers, students, educators, Mathematicians, and Educationists. The sample comprises randomly selected participants at the Mathematical Association of Nigeria Conference, 2014 held at the University of Ilorin, Nigeria. The sample consists Mathematics teachers, Mathematics educators, educationist, and Mathematicians from tertiary institutions. The total sample size is 42.

Research Instrument

The Practical Mathematics Teaching and Testing Questionnaire (PMTTQ) is developed by the researcher. PMTTQ has 3 sections. Section A consists of 10 items, which are bio data of the respondents. Section B has 10 items, which are mathematics concepts. The researcher asks the respondents to indicate on a dichotomous scale if each of the Mathematical concepts can be taught normally or by practical approach. The same 10 items for section B are repeated for section C but they are to indicate which can be assessed normally or by practical approach. The researcher in his own opinion and experience carefully selects 10 items that can be taught and assessed through a practical approach. The concepts are plane geometry such as angle of elevation and depression, locus, the pi (π), elementary survey construction, solid geometry-net, construction, properties in 3-D shapes, sphere. Criteria for selection of these concepts include the fact that students often find it difficult and that they do not exclusively belong to abstract mathematics.

Data Collection

The researcher administers PMTTQ on the randomly selected 42 mathematics stakeholders at the MAN conference.

Result and Discussion

There are 32 males, 9 females and 1 unidentified respondents. The respondents are from 18 states across the country.

Research Question 1: How competent are the Mathematics stakeholders in determining concepts to be taught and assessed practically?

To determine the competence of the respondent in capability to decide on which mathematics concepts could be taught by practical approach, 3 indices are used. These are; the level of qualification, subject specialisation and their teaching experience.

Table 2 : Respondent Qualifications in Mathematics and their Mathematics Teaching Experiences

		N	%
Qualifications	NCE	3	7.1
	B.Sc./B.A	9	21.4
	B.Sc. Ed/B.A. Ed	14	33.3
	Higher Degree	11	26.3
	None in mathematics	2	4.8
	Missing	3	7.18
Specialisation	Mathematics	42	100.0
	Any other (None maths)	0	0.0
Teaching Experiences	0-3 years	2	4.8
	4-7 years	3	7.1
	8-11 years	7	16.7
	12-15 years	6	14.3
	16+ years	19	45.2
	None in Mathematics	5	11.9

Table 2 shows the levels of qualifications in Mathematics' subject specialisation and Mathematics' teaching experiences of the stakeholders. The result reveals that majority of the respondents have high level of qualifications. About 60% have at least a bachelor degree in Mathematics and or Education. Similarly, one can say that the respondents have long years of experience. About 60% have more than 10 years of teaching experience. This experience suffices a professional to formulate policies on his job. Better still, more than 45% have experience of more than 16 years of Mathematics teaching. 5 (11.9%) have no teaching experience. These may be educationists (officials and policy makers in the parastatal) or fresh graduates. All the 42 (100%) specialise in Mathematics. It implies that they are qualified to take part in this type of study; their view could be dependable.

Research Question 2: Can Mathematics be taught and assessed with a practical approach?

The researcher holds this as an assertion that Mathematics could be taught practically. The responses of the well-qualified and experienced Mathematics stakeholders' submission in research question 3 will unveil the true position of the assertion.

Research Question 3: Which Mathematical concepts can be i) taught and ii) assessed with a practical approach?

Table 3: Summary of Concepts that can be taught with Practical Approach

S/N	Mathematics Concepts	Practical Teaching Approach		Conventional (Normal) Teaching Approach		Mean	Standard Dev.
		N	%	N	%		
1	Plane Geometry - Construction	39	92.9	2	4.8	1.05	.218
2	Solid Geometry- Net	37	88.1	4	9.5	1.10	.300
3	Solid Geometry - Construction	39	92.9	3	7.2	1.05	.218
4	Solid Geometry - Properties	30	71.4	12	28.6	1.25	.439
5	Solid Geometry- other relationship b/w cone and cylinder	36	85.7	6	14.3	1.12	.331
6	Solid Geometry - Sphere/Globe	37	88.1	5	11.9	1.10	.300
7	Elementary Survey	30	71.4	12	28.6	1.27	.449
8	Angle of Elevation & depression	29	69.0	13	31.0	1.29	.461
9	Pi (π) value	28	66.7	14	33.3	1.32	.471
10	Locus	32	76.2	10	23.8	1.22	.419

Table 3 shows the result of the opinion held by Mathematics' stakeholders. The question posed to the stakeholders is 'which method would you choose as a better way of teaching these Mathematical concepts?' Going by the proportion of those who indicate that these mathematics concepts can be taught better by practical approach, it can be asserted that each of these Mathematical concepts can be taught with practical approach. Each of the concepts attract above 65% in favour of practical approach as a better way of teaching them. This is an indication that these concepts can be taught practically.

Table 4 is the presentation of the response of the stakeholders to the question 'which method would you choose as a better way of testing and examining these mathematics concepts?'

Table 4: Summary of Mathematics Concepts that can be Assessed by Practical Approach.

S/N	Mathematics Concepts	Practical Assessment Approach		Conventional (Normal) Assessment Approach		Mean	SD
		N	%	N	%		
1	Plane Geometry - Construction	34	81.0	8	19.0	1.11	.311
2	Solid Geometry- Net	29	69.0	13	20.9	1.12	.417
3	Solid Geometry - Construction	34	81.0	8	19.0	1.11	.311
4	Solid Geometry - Properties	25	59.5	17	40.5	1.34	.481
5	Solid Geometry - other relationship b/w cone and cylinder	28	66.7	14	33.3	1.26	.446
6	Solid Geometry - Sphere/Globe	27	64.3	15	35.7	1.29	.460
7	Elementary Survey	22	52.4	20	47.6	1.42	.500
8	Angle of Elevation & depression	22	52.4	20	47.6	1.42	.500
9	Pi (π) value	22	52.4	20	47.6	1.42	.500
10	Locus	22	52.4	20	47.6	1.41	.498

Each of the concepts attract above 52% possibility of being assessed through the practical approach while a good number of them are quite far above this. This indicates that these concepts can be assessed better using the practical approach. Where the respondents failed to indicate their approach, the respondent's missing value was added to the normal classroom teaching and testing approach. Yet, the number of those who favour the practical approach still supercedes that of those who favour the normal classroom teaching method. This implies that those in favour of the practical teaching and assessment approach are genuine. A comparative analysis of tables 3 and 4 shows that the stakeholders hold the view that practical teaching approach can be feasible than the practical assessment approach. The statistical significance of this difference shall be tested by the hypothesis.

Hypothesis

Ho: There is no significant difference between Mathematical concepts that can be taught practically and those that can be assessed practically.

Table5: t-test Comparison of Significance of the Mathematics Concepts that can be Taught Practically and Assessed Practically

	N	Mean	Std. Dev.	Std. Error of mean	T	df	Sig.
Practical Teaching	10	33.70	4.322	1.367	3.539	18	.002
Practical Assessment	10	26.50	4.767	1.507			

Table 5 shows a t- test comparison of the means of Mathematical concepts that can be taught practically and assessed practically. The hypothesis tested states that there is no significant difference between Mathematical concepts that can be taught practically and those that can be assessed practically. The mean score for the concepts to be taught with practical approach is 33.70 while the mean score for the concepts to be assessed practically is 26.50. The view on practical teaching approach is higher than practical assessment approach. This difference in view is statistically significant at 0.05 alpha level ($t = 3.539$, $p = .002 < .05$). The null hypothesis of no significant mean difference in concepts to be taught practically and to be assessed practically is rejected. Thus, it is concluded that there is statistical significant difference between concepts for practical teaching and practical assessment. That means, there is a stronger number in favour of practical teaching than practical assessment of Mathematical concepts.

The idea of a practical assessment in Mathematics is a new dimension and the central focus of this research. As a new paradigm in teaching and assessment, it may not be as popular until it is started in an experimental way. The Mathematics stakeholders need to be convinced first that all these concepts can be assessed practically. Thereafter, they can convince the government and the world on this new approach to these concepts' assessment.

The advantages that can be derived from practical teaching and testing of Mathematics may include the followings;

1. Practical approach can elicit a positive attitude of learners.

2. It reduces cognitive loading and enhances affective and psychomotor development. A practical approach will also usher in novelty and hand on activities within and outside the classroom. A social and democratic mathematics classroom environment can be initiated through group work which this theory accommodates unlike the theoretical approach which does not accommodate much of interaction during problem solving.

3. It exposes the students to varieties of assessment form, so that if they fall short in one, they can gain in the other.

4. It will improve overall performance in Mathematics and the anxiety will be reduced.

5. Practical teaching and assessment approach will place Mathematics on the same pedestal with teaching and assessment of other science subjects.

A practical approach could be a better alternative to algebraic approach of teaching or testing of these concepts.

Recommendations

This study transcends the often acclaimed laboratory teaching approach recommended by Mathematics researchers in the sense that the inadequate infrastructure is an inhibition to the implementation of the idea. Yet still, some essential dimensions to be included are thus commended;

1. Policy dimension: This is foremost in the step forward. The idea of Mathematics laboratory has not been taken as a policy, however, this study is not an attempt to solicit for that. More than that, it should be mandated that these Mathematics concepts should be taught and assessed separately using the practical approach as a matter of policy. A separate practical mathematics paper should be included in the form of tests and examinations to be taken both in school and certificate examination.

2. Alignment of the curriculum with the policy: The mathematics curriculum should separate these and similar concepts from those that should be taught theoretically. These contents should be grouped separately within the curriculum and should be taught and assessed practically.

3. Alignment of the Textbook with the curriculum: The textbook is the most important source of instruction as it serves as the student's learning tool (Afolabi, 2014b). Authors should come up with acceptable practical textbooks as a guide to the practical just as there are in other science subjects.

4. Alignment with Instructional Resources: The new paradigm should bring in new orientation on instructional materials that are relevant. Improvisation and procurements should be sourced out. Moderate infrastructure that can accommodate free movement of students at work other than a regular classroom should be provided.

5. Inclusion of the practical teaching and assessment technique in the teacher education programme: This new orientation should be forwarded to the teacher education institutions such as colleges and universities and should be used in the training of their students.

6. Workshops for in-service teachers: The new approach should be introduced to the teachers who are already in the system. They have to develop the understanding that education is life-long learning. Through workshops and conferences, they can be kept abreast of the modern trend in teaching and assessment in Mathematics.

Conclusion

The Mathematics stakeholders are in support of practical approach to teaching and assessment of Mathematics. The stakeholders are more disposed to practical teaching than practical assessment. They hold a higher opinion on practical teaching, which is statistically significantly different from concepts to be assessed practically. Therefore, it is not enough to proclaim the benefits of Mathematics laboratory activities. The relevant and appropriate Mathematics concepts that would be taught through practical teaching and testing should be grouped together and backed up by government policy. The initiative should not be left to the hands of teachers alone who may/may not do it. It should lastly be noted that the introduction of practical/activity teaching of some Mathematical concepts to be assessed practically like other sciences will enhance students' motivation and a positive attitude. This will demystify Mathematics anxiety and reduce failure rate.

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