EFFECT OF TEACHERS' TASKS PRACTICES ON STUDENTS' ACHIEVEMENT IN MATHEMATICS

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Abstract

What students do in the classroom during lessons is/are largely determined by the tasks that are set up and implemented by the teacher, and expectedly impact on the students' learning achievement. The researcher explores how task selection and implementation practices of the teacher affect students' achievement. The study employed quasi experimental research – two-group pre-test and post test design was used. Both experimental and control groups were SS 1 (science groups) in their respective schools in Lagos State. Pretest and posttest consist of collection of question items from past relevant examinations and Mathematics Olympiad questions. The regular mathematics teacher taught in the control group; while in the experimental group, the students were taught by their teacher but with technical support from the researcher on tasks selection and implementation. Data was analysed on two levels, using descriptive and inferential statistics. Results show that (1) learners in the control group performed statistically significantly better in the pre-test; (2) there was no statistically significant difference in performance of learners in the two groups at posttest. Descriptive statistics however shows that performance of learners in the experimental group was better than that of those in the control group. These results were discussed, implications for instructional practice, for teacher training and development were provided.

Introduction

Inculcating mathematical reasoning in learners is a major goal of reform curriculum around the globe. Mathematical reasoning develops in learner ability to formulate, test and justify conjecture; and then communicate results to others (Brodie, 2002). She argues that these skills have to be developed in learners for them to be proficient in mathematics. It is no gainsaying that their development are afforded or constrained by classroom experiences. Classroom experiences are to a large extent, determined by, and dependent on, the tasks that were implemented during instruction. "The kinds of tasks that students are asked to perform set the foundation for the system of instruction that is created. Different kinds of tasks lead to different systems of instruction" (Hiebert et al, 1997 p.7). Thus, the importance of tasks in mathematics classrooms cannot be overemphasized. The tasks with which students engage in the classroom are central to, and largely determine the experiences to which students are exposed in the classroom (Sullivan and Clarke, 1991).

Some mathematics education researchers have focused on the design and use of questions (Crespo, 2003; Sullivan and Clarke, 1991; Sullivan and Leder, 1990; Gall, 1984); and tasks set up and implementation in the classroom (Stein et al, 1996; Stein et al, 2000). In their different frameworks, the researchers identify features of tasks, procedures for students' engagement and levels of cognitive demands of tasks as important considerations in the use of tasks in mathematics classrooms. For instance, the framework presented in Stein et al (1996) provides categories for analysing tasks that are set up and implemented in classrooms using two dimensions: task features and cognitive demand. The researcher has earlier proposed an additional phase to the framework, that is task selection (See Sanni, 2005). This is because for Nigerian teachers, it is more relevant to study task selection and implementation practices in the classroom. In spite of the importance of tasks in mathematics classrooms and associated teachers' practices, where, when and how teachers come to learn and improve their task-related practices are not very clear. Crespo (2003) suggests that it should be part of teacher preparation programmes. But it could also be focused at in-service training and performance improvement workshops.

To achieve reform instructional objectives (or assessment standards), appropriate tasks have to be implemented, to enrich learners' mathematical knowledge and improve their mathematical reasoning. Kilpatrick et al (2001) suggest five interwoven strands of proficiency, which include conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition. These strands add reasoning, connections and communication practices to the conventional construal of mathematics learning as procedural and conceptual. Mathematics researchers converge on the nurture of these skills in class, to promote mathematical reasoning. The researcher's argument is that to nurture these skills is to select and implement tasks that afford development of the skill.

In this paper, the researcher attempt to establish empirically, the relationship between variety of tasks and achievement of learners in the area of surface area and volume of solid shapes. Thus, the major research question in focus is: will there be any statistically significant difference between the mean score of students that were exposed to variety of tasks during instructions and those that were not? The study attempts an analysis of the relationship between tasks and learners' achievement. The researcher provides support to the teacher in the experimental group. The support was heavily in form of selection of tasks during lesson planning and assistance (Assistance was in form of supervising group and individual work and providing written feedback on learners' work) during and after teaching.

Methodology

Design, context and sample

Because of the difficulty of random assignment of learners into experimental and control groups, the quasi experimental research designed was used in the study. The design termed nonequivalent groups pretest-posttest design (McMillan and Scumacher, 2001) was adopted in this study. Two intact classes designated as experimental and control groups were involved. However, conscious attempts were made at reducing the group variance, by involving SS1 students in the science classes, in two government schools within Badagry zone of Lagos State Education District V. Both classes were mixed with male and female students, with 63 students in one and 64 students in the other. Also their regular teachers are of the same academic and professional qualification and comparable length of experience. Another important thing in terms of context is the mathematical concepts of interest. During the period of the study, which was conducted during regular school hours, and according to the scheme (In Lagos State, schemes are centrally prepared by the Ministry, and handed to schools and teachers to implement during the term) of work, the concepts of surface area and volume of solid shapes were the focus.

Instrumentation

Two tests-the pretest and posttest-were administered at appropriate times of the study. On the one hand, the pretest consisted of 50 multiple choice items that were collected from past SSCE, JSCE and a few from JME past questions. The post test on the other hand consisted of 30 multiple choice items and 3 three essay-type questions. The format was adopted to allow a wide coverage of content on the one hand, with the multiple choice items; and to provide an opportunity of getting to see and follow learners' procedure in engagement with the tasks, on the other, with the essay type items (Sanni, 2002). Questions were also selected from past examinations papers above as well as from past mathematics Olympiad questions. Also, a few of the questions were teacher-researcher designed.

Validity and reliability of instruments

Validity refers to the degree to which a method, "a test or research tool actually measures what it was supposed to measure" (Opie, 2004). Reliability on the other hand, describes "the extent to which the results are similar over different forms of the same instrument or occasions of data collection" (McMillan and Scumacher, 2001:244). Thus, both validity and reliability are concerned with the "appropriateness, meaningfulness, and usefulness of the influences a researcher makes" (Fraenkel and Wallen, 1996: 152). Notwithstanding the fact that these items were selected from standardized examinations that have passed through various validity and reliability verification stages, the two instruments were validated and had their reliability tested. This was mainly because they were meant for different purpose (research) and different group of learners- SS1 students, who have just written the JSCE, at the end of JSS3, and two years away from the SSCE and JME. Specifically, on the one hand, face and content validity were afforded by the involvement of mathematics teachers in the two classes in selection and compilation of the items. They specifically advised on readability, understandability, and whether the contents were within the level of their respective learners. Also, the researcher independently conducted an opinion poll of learners outside the sample, but within the same level (SS 1) on the readability, understandability and level of difficulty of the items. Suggestions and advices at these two levels were all discussed and necessary amendments were made. On the other hand, reliability of the tests was also established. An r^2-value of 0.67 and 0.61 were observed for the pretest and posttest respectively. In both cases, the split half method of establishing reliability was used. However, the test-retest method was used for the essay part of the posttest. An r^2-value of 0.59 was observed for the essay part. For testing the reliability of the two tests, learners in SS1 (science class) in another school within the same locality with the sampled schools were involved.

Treatment and data collection

The regular teacher in the control class continued to teach the concepts of interest-surface area and volume of solid shapes-in his class, while the researcher provided some technical supports for the teacher in the experimental class. The support was specifically in two areas: preparation and implementation of lessons. On the one hand, in the area of preparation, selection of tasks and what to do with the selected tasks in class and how, were the main focus. The researcher and the teacher planned all lessons together, during which tasks were selected with justification for the inclusion of some tasks and not some others. On the other hand, during lesson implementation, the teacher was in control; but the researcher provided teaching assistance, especially during learners' engagement with tasks in groups or individually. Notable features of the treatment, which lasted two weeks (8 periods of 40 minutes each), were:

- there were lots of tasks implemented in class. Tasks with different features and varying levels of cognitive demands were consciously selected;
- tasks were engaged sometimes individually, sometimes in groups (Working in groups was very strange to learners. Many of them openly said they never thought they could sit and discuss with their friends during maths lessons);
- tasks were selected from a variety of textbooks and other sources;
- the researcher prepared activities that were selected for each lesson in worksheets (Where there exists a correct answer to tasks, learners do not have prior knowledge of what it was. This made them to concentrate more on working, than just having to check answers at the back of textbook and work towards getting it) format, after both the teacher and researcher have made selection;
- enough copies of worksheet for the learners were made by the researcher;
- two 'teachers'-the regular teacher, who is in control during lesson and the research, who provides teaching assistance in class and in control outside of the class-were involved in teaching; and
- learners get regular feedback on their work.

Data collection

The pretest was given to the learners before treatment in experimental and control groups. At the end of the treatment, the posttest was administered in the two groups. In both cases, supervision was done by the researcher and the respective teacher in each school. Scoring was done by a group of volunteered postgraduate diploma students. These PG students were all experienced mathematics teachers and are not likely to know the learners in the sample. This is because only their initials and roll numbers in class. were written on their scripts. In the presence of the teachers, we discussed the marking guide before marking could commence.

To ensure reliable scores, learners' response to items in section B (the theory part) of the posttest was duplicated, by photocopy. So each learner had two scores, emanating from two independent markers, for the section. These two scores were correlated and an r^2-value of 0.74 was observed. This translates to about 86% agreement between the two makers of each learner's scripts. For the section A of the paper and the pretest, this was not necessary, because of the objective (multiple choice) nature of the items.

Data analysis and results

Data analysis (Descriptive statistics)

Table 1 below shows a summary of the pretest and posttest scores in the two groups.

Table 1: Distribution of learners scores in pretest and posttest

	Pretest		Posttest	
Score	**Frequency**		**Frequency**	
	Exp. group	**Con. group**	**Exp. group**	**Con. Group**
30-39	10 (15.9%)	4 (6.3%)	1 (1.6%)	3 (4.7%)
40-49	15 (23.8%)	9 (14.1%)	11 (17.5%)	11 (17.2%)
50-59	16 (25.4%)	15 (23.4%)	15 (23.8%)	16 (25.0%)
60-69	14 (22.2%)	18 (28.1%)	20 (31.7%)	19 (29.7%)
70-79	8 (12.7%)	14 (21.9%)	13 (20.6%)	12 (18.8%)
80-89	0 (0%)	4 (6.3%)	3 (4.8%)	3 (4.7%)
No. of learners	63 (100%)	64 (100%)	63 (100%)	64 (100%)

As evident in Table 1 above, while learners in the control group performed better than learners in the experimental group in the pretest; learners in the experimental group physically performed better in posttest. While 25 students (representing 39.7%) and 13 students (representing 20.3%) in the experimental and control groups respectively, scored below 50% in pretest; 14 students (representing

22.2%) and 14 students (representing 21.9%) in the experimental and control groups respectively, scored below 50% in posttest. In a similar trend, 12.7% and 28.1% of learners in the experimental and control groups respectively, scored above 70% in pretest, while 25.4% and 23.4% of learners in the experimental and control groups respectively, scored above 70% in posttest. As shown in Table 2 below, descriptive statistics show that the group mean is greater and the standard deviation is smaller.

Table 2: Descriptive analyses of learners' scores in pretest and posttest

Index	Pretest		Posttest	
	Exp. Grp	Con. Grp.	Exp. grp	Con. Grp.
Mean	53.74	60.95	61.89	58.97
SD	12.54	12.5	11.17	12.28
Highest score	79	85	83	86
Least score	31	38	39	37
Range	48	47	44	49
Coefficient of variation	0.2333	0.0410	0.1895	0.2082

Using mean, standard deviation and indeed, coefficient of variation, learners in the control group showed a better achievement in the pretest. However, although the highest score in each of the tests was from the control group, group comparison, using descriptive statistics above, shows that learners in the experimental group performed better than their counterparts in the control group.

Data analysis (Inferential statistics)

Table 3 below shows the result of t-test analyses of both pretest and posttest scores of learners in the two groups.

Table 3: t-test analysis of pretest and posttest scores

Index	Pretest		Posttest	
	Experimental	Control	Experimental	Control
Mean	53.4	61.5	62	59.1
Variance (unequal)	157.29	156.30	124.91	150.86
Degree of freedom	125		125	
t-value	-3.24		1.43	
Pr > |t|	0.0015		0.1538	
Comparison	P value (0.0015) < 0.05		P value (0.1538) > 0.05	
Decision	Statistically significant		Not statistically significant	

From Table 3 above, t-test analyses show that a statistically significant difference exists between experimental group performance in pretest, in favour of the control group. On the contrary however, difference in group performance in posttest is not of any statistical significance. Recall from Tables 1 and 2 that observed group differences favour control group in pretest and experimental group in posttest.

Discussion of findings

Contrary to the observed pretest results, which shows a statistically significant difference in favour of the control group, the posttest results show that learners in the experimental group have an edge (Table 2), but not of any statistical significance (Table 3). Although the t-test statistics show that there is no statistically significant difference between the two groups, descriptive statistics show that there is a physical difference between the two groups, in favour of experimental group. This is because the experimental group mean is greater and the standard deviation is smaller. The observed better performance at pretest, in favour of the control group is not surprising because although, it is publicly owned, the school is better resourced (All boarding school, and with better resources) and with learners from medium and high socio-economic-class in the society. On the other hand, the observed difference in favour of experimental group at the posttest could be associated with the treatment.

However, without prejudice to other intervening variables that can possibly impact on learners' achievement, the fact that the control group had an edge in the pretest while the experimental group was better in the posttest suggests a link between the treatment and achievement. This position is also strengthened by the fact that while teachers' qualification and experience are comparable, learners in the control have an edge, in terms of resource level, learners' background, school rating, etc. With all these characteristics, one can safely relate the observed achievement of learners in the experimental group to the treatment.

Conclusion

The study reported in this paper was concerned with the effect of implementing variety of tasks-with different features and levels of cognitive demands-in mathematics lessons on learners' mathematical achievement. Specifically, it focused on the concepts of surface area and volume of solid shapes in SS 1. A randomized pretest-posttest control group (experimental research) design was used and data was collected with valid and reliable pretest and posttest instruments. Both descriptive and inferential statistics were used in data analysis. The results show that the technical support that was available to the teacher in the experimental group, impacted positively on the learners' achievement. Providing technical support and assistance for teachers will go a long way in improving their teaching effectiveness. Teaching in reform ways puts a lot of demands on teachers. These new demands and responsibilities need to be learnt if teachers are to be effective: otherwise, the effect is for them to implement only the part of reform with which they are comfortable. My classroom observations and interview with teachers on the larger study show that most mathematics teachers teach exactly the way they were taught many years ago. Thus such technical supports that embody innovative approaches to various teaching practices are not only likely to improve learners' achievement, but also likely to improve their level of mathematical reasoning and proficiency.

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