HANDS-ON/MIND-ON ACTIVITY-BASED STRATEGY: THE EFFECT ON PRE-SERVICE TEACHERS SUBJECT MATTER KNOWLEDGE IN A PRIMARY MATHEMATICS METHODS COURSE

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Abstract

Hands-on/mind-on activity-based instructional strategy has been identified as being effective in increasing learning of rule-governed subjects. However, research findings have shown that this strategy is not adopted in training pre-service primary mathematics teachers in colleges of education in Nigeria rather, direct instruction is commonly used. Past studies on activity-based have focused more on the effectiveness of such strategies on pupils/students performance but did not sufficiently determine the effect of the strategy on the teachers’ subject matter knowledge (SMK), hence this study. Pretest-posttest control group quasi-experimental research design was adopted and the participants were 215 pre-service primary Mathematics teachers in two colleges of education in Southwestern Nigeria. Primary Mathematics Achievement Test (0.81) and two instructional guides were the research instruments used. Hands-on/Mind-on activity-based strategy enhanced pre-service primary mathematics teachers’ subject matter knowledge more than the conventional strategy. This study has shown the instructional strategy that can be used to develop the capacity of pre-service primary mathematics teachers in the area of subject matter knowledge in a way to ensure sustainable effective mathematics learning. It was recommended that lecturers of primary school mathematics methodology courses in the colleges of education should be encouraged to acquire and utilise hands-on/mind-on activity-based strategy.

Keywords: hands-on/mind-on activities, instructional strategies, pre-service teachers, primary mathematics, subject matter knowledge

INTRODUCTION

The only way by which the younger generation could be integrated into the society in order to sustain and improve upon development is either through formal, informal or non-formal education. Any of these forms of education relies heavily on the human teacher for its effectiveness. This, in effect, means that any effort towards improving teacher effectiveness is tantamount to an effort to improve the effectiveness of the educational system and this should be the concern of every nation (Amobi, 2006). The most common and generally accepted way of impacting knowledge is the knowledge acquired through instructions. In this regard, every human being in any part of the world is considered to be deficient if such a person has no opportunity to experience formal education in which learning through instructions permeates. The teaching process, through any methodology or strategy, has been recognized for centuries as an important, inevitable and effective means by which knowledge could be imparted and acquired effectively (TRCN 2004; Moronkola 2011; Osanyin & Adebayo, 2011). The teaching process could then be said to be as effective as the teacher. Whether students learn or not depends, to a great extent, on the teacher.

Studies have shown that teacher effectiveness as a variable is a strong determinant of differences in students’ learning. The consequence of teacher effectiveness as a variable is often greatly felt, much more than the effect of any other school-related variables, on the students’ learning outcome (Oparah & Faloye, 2011; Osanyin & Adebayo, 2011; Njeru, 2012). Therefore, the training of teachers is given a paramount place in every society (Awolola & Fabunmi, 2012; Njeru, 2012). UNESCO (1998), in the World Declaration on Higher Education, Article 1, section F, submits that higher education must contribute to the development and training of teachers. The Federal Government of Nigeria has also made it clear in the National Policy on Education that no educational system can rise above the quality of the teachers (FGN, 2004; Oparah & Faloye, 2011). This reveals the need to build the capacity of the pre-service primary mathematics teachers and to sustain their development. This is why teacher education is considered vital in curriculum development and instructions (Moronkola, 2011).

Some of the goals of teacher education in Nigeria are to produce highly motivated, conscientious and efficient classroom teachers for all the levels of our educational system; to provide teachers with the intellectual and professional background adequate for their assignment and make them adaptable to changing situations (FGN, 2004; Oparah & Faloye, 2011). The type of teachers envisaged by these policy makers is what Anderson (2004) termed ‘effective teacher’. According to this scholar, effective teachers are those that possess the knowledge and the skills needed to attain the desirable educational goals, and are able to use the acquired knowledge and skills appropriately if these educational goals are to be achieved.

The goals of education in Nigeria as mentioned earlier, made it clear that there are two important knowledge required for any effective teacher. These are the intellectual knowledge, which is closely related to what is
known as subject matter knowledge (SMK) and the second is professional knowledge which is also called pedagogical content knowledge (PCK). SMK is highly needed for anyone that will teach Mathematics at any level of education. The demand for SMK at the basic education level is so high because this is the level at which the foundation for further knowledge in Mathematics and other science related subjects is laid. It is a fact that no matter how good a teacher is, he can only teach what he knows.

The performances of pupils in Mathematics over the years have made one doubt the SMK of the primary mathematics teachers. Recent research findings in Nigeria have shown that the performance of pupils in primary Mathematics is below average and, also, that the problem solving skills of the pupils is poor. In a report prepared by Nigeria Education Sector Analysis (ESA, 2004), the national mean percent scores of primary four and six pupils in numeracy are put at 33.7 and 35.7 respectively. Again, the National Assessment of the Universal Basic Education Programme presented the performance of primary six pupils across the nation in 2009. The results shows that only three states out of the thirty-six states and the Federal Capital Territory have mean scores that is up to average- Bayelsa State (Mean = 55.96%), Jigawa (mean = 58.26%) and Osun (mean = 54%). Fifteen states have mean scores that is not up to pass mark. Their scores range from 23.35% for Kano State to 29.23% for Ondo state. The national mean score is 42.87% which is below average (NAUBEP, 2009).

As a saying goes, a problem tree is best controlled right from the root. One of the root causes of the poor performance of primary school pupils is the SMK of the primary Mathematics teachers. In order to have permanent solution or to reduce this drastically, there is the need to develop the capacity of the current pre-service primary mathematics teachers in the area of subject matter knowledge. In other to sustain this development, lecturers in the colleges of education must adopt instructional methods that will expose the pre-service teachers into in-depth understanding of primary mathematics concept. One instructional method that can develop the capacity of the pre-service teachers in the area of subject matter knowledge is activity-based instructional methods. There are various types of activity-based instruction, like pupil-centred activity-based (Marley, Levin & Glenberg, 2010; Aremu & Salami, 2013), Teacher demonstration activity-based (Loeffler, 2010; Rodrigues, 2010; Aremu, Salami & Ishola 2012) and hands-on/mind-on activity-based (Salami & Egiethua, 2012).

Hands-on/mind-on activity-based instructional strategy facilitates the learning of new skills, knowledge acquisition and gaining of experience through active participation of learners in the process of knowledge acquisition (The Ontario Curriculum Unit Planner, 2002). Many research findings have shown that this type of activity-based instructional strategy is very effective for teaching abstract subjects such as Mathematics (Epstein, 2007; Marley, Levin & Glenberg, 2010). Engel (2002) sums this up by saying that activity-based strategy may meet all the major demands that apply to modern Mathematics, such as preparing students to represent and analyze real situations, solving problems, making decisions using mathematical reasoning, communicating their thinking and making connections. Furthermore, learning by doing creates more neural networks in the brain and throughout the body, making the entire body a tool for learning (Hannaford, 2005). Marley, Levin & Glenberg (2010) affirm that motor memory system is present in activity-based strategy that provides an additional pathway for the encoding and retrieval of target information to and from long-term memory.

Hands-on/mind-on activity-based instructional method is meant to facilitate learners’ active participation in the learning process. In such a lesson, learners engage in activities that are learners’ initiated; that is, activities that are built upon the natural curiosity of the learners and real life related issues are used as the pivot of mathematics learning. National Association of Education of Young Children (NAEYC, 2009) added that it makes activities and mathematics concepts socially and culturally appropriate.

Another important factor that could affect Mathematics teaching that will be examined in this study is pre-service teachers’ gender. The discussion of gender and Mathematics and science learning is far from being concluded. Scholars are still grappling with the issue in order to determine whether the causal relationship between mathematics teaching-learning and the gender factor is biologically related or it is socially or environmentally related. Many studies still reveals that female students are unable to perform as their male counterparts in mathematics (Gilbert & Gilbert, 2003; James, 2007) while some research findings show that the gap between male and female students’ performance in Mathematics is disappearing (Austin, 2002; Berube & Glanz, 2008). The argument here is that, if female students have low performance in Mathematics, there would be less number of female pre-service primary Mathematics teachers and the few that exist would have little knowledge of the subject matter. This eventually would affect their teaching. It should not be inappropriate, then, to examine the moderating effect of gender on this study that emphasizes the teaching process.

It is against this background that this study determined the effect of hands-on/mind-on activity-based instructional method on the subject matter knowledge of pre-service teachers in primary mathematics. Effect of gender on the pre-service teachers’ SMK was also determined.

Hypotheses

Based on the focus of this study, three hypotheses were formulated, these are:

$H_0$: There is no significant main effect of treatment on pre-service teacher academic performance in primary Mathematics course (PES 122).
The choice of PES 122 was informed by the following conditions: All topics in PES 122 (Mathematics in Primary Education Studies 11) are purely primary mathematics. The course content according to NCCE, 2009 are:

i. Modelling and drawing of plane/2D shapes and method of teaching it
ii. Modelling and properties of 3D shapes and methods of teaching them
iii. Construction and bisection of angles
iv. Non-standard and standard measuring strategies for
   a) Capacity (b) Volume (c) Perimeter (d) Length (e) Area (f) Mass (g) Money and (h) time.

Besides this, it is the only primary Mathematics course in the second semester of the 100 level that the pre-service teachers would be prepared with, for the upcoming Micro Teaching Practicum (EDUC 224).

This study is considered significant because it has successfully shown the strength of hands-on/mind-on instructional strategy in developing the capacity of pre-service primary mathematics teachers’ subject matter knowledge which is the only way to sustain the effective learning of Mathematics at the basic level of education. It has also made it clear that when this instructional strategy is used, both male and female primary mathematics teachers will gain almost equal subject matter knowledge, hence increasing the number of good female teachers for primary mathematics.

**METHODOLOGY**

The study adopted a pretest-posttest, control group quasi-experimental research design. Three categories of variables are recognised in the study. These are: independent variable, moderator variable and dependent variable. The independent variable is the teaching strategy to be used in the teaching of PES 122 to the pre-service primary school Mathematics teachers. This was manipulated at two levels: (i) Hands-on/Mind-on activity-based Instructional Method and (ii) Conventional Instructional Strategy (CIS). The moderator variable recognized in the study is the pre-service teachers’ gender which was manipulated at two levels: male and female while the only dependent variable was the academic performance of the pre-service teachers in PES 122 (Subject Matter Knowledge). Based on these variables, the study adopted a 2 x 2 factorial matrix.

The target population for this study consists of the students studying Primary Education Studies (PES) in Part I of their programme in colleges of education in south-western part of Nigeria. Multi-stage sampling technique was used to select the participants for the study. First, simple random sampling technique was used to select two government owned colleges of education in the south west zone states. Purposive sampling technique was used to select the students that participated in each of the colleges. The selection of the students was based on the following criteria:

1) The students must be in their first year of the NCE programme;
2) The students must be in Primary Education Studies (PES) Department.

In all, two colleges of education that have PES programme were involved in the study and all the PES students in their first year in each of the colleges were involved. At the end of the selection, 73 and 161 students participated from Federal College of Education, Osiele Abeokuta, Ogun State and Federal College of Education Oyo, Oyo State respectively. The two colleges were randomly assigned to treatment groups (a college in a treatment group).

Hands-on/mind-on Activity-based Instructional Package (HM-AIP) and Conventional Strategy Instructional Guide (CSIG) were the two stimulus instrument used to teach PES 122 in both colleges.

HM-AIP is a 54 pages document that shows step-by-step of every lecture had with the pre-service teachers in the experimental group. This package includes the course content, the weekly activities, the activity-based lecture plan, work sheets for different classroom activities. For every activity-based lecture plan, the assessment area, the behavioural objectives, lecturer activities during the lecture, respective pre-service teachers’ activities were clearly stated and followed strictly.

After designing this package, another validity instrument titled Hands-on/Mind-on Instructional Package Validation Tool (HM-AIPVT) was developed. This instrument was a 16-item with 4-point Likert scale measuring level of adequacy and appropriateness of every aspect of the Instructional Package. This instrument was attached with the package and 5 copies of it were given to 4 lecturers in the field of Early Childhood and Primary Education, University of Ibadan and one to an experienced and qualified primary mathematics teacher working in the primary school for validation.

The second stimulus instrument was titled Conventional Strategy Instructional Guide (CSIG). This guide contains the step-by-step of every lecture in the control group. This guide is based on direct instruction strategy which is the common method adopted by almost all the lecturers teaching primary mathematics courses in the colleges (Salami, 2010). The process of developing this guide follows that of HM-AIP only that it is based on teacher-centred method of teaching wherein, all what the pre-service teachers were allowed to do was coping notes and sometimes, ask or answer few questions at the end of the lecturer. The guide was also validated by experts in the university and experienced primary mathematics teachers.
The third instrument used was a response instrument. This is the examination questions set for the examination of PES 122 in the two colleges. Before the commencement of the study, the two lecturers handling the course in the two colleges were asked to set the examination questions based on the content of the course. These were blended together by the researcher to ensure content validity and that the same questions were used in the two institutions. It was given back to the lecturers for their final input and got it moderated in their various colleges before the commencement of the research work. This was used to measure the pre-service teachers’ academic achievement before and after the treatment. The instrument was validated and the reliability tested and the reliability coefficient was 0.81.

A total of 9 lectures of two hours each were held in each of the institution. The pre-service teachers were tested with the examination questions before and after the treatment in both groups. These were marked and scored by the lecturer in-charge of the course in the various institutions. These scores were collected and analysed using Analysis of Covariance (ANCOVA) with necessary post hoc analysis.

**RESULTS**

The results are presented based on the order of the hypotheses.

**H₀₁**: There is no significant main effect of treatment on pre-service teacher academic performance in primary Mathematics course (PES 122).

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std.Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>215</td>
<td>38.95</td>
<td></td>
</tr>
<tr>
<td>Pre-score</td>
<td>215</td>
<td>52.43</td>
<td>.345</td>
</tr>
<tr>
<td>Treatment</td>
<td>72</td>
<td>59.317</td>
<td>.529</td>
</tr>
<tr>
<td>Hands-on/Mind-on (Treatment)</td>
<td>143</td>
<td>45.540</td>
<td>.443</td>
</tr>
<tr>
<td>Conventional Method (Control)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male students</td>
<td>67</td>
<td>52.377</td>
<td>.546</td>
</tr>
<tr>
<td>Female students</td>
<td>148</td>
<td>52.480</td>
<td>.420</td>
</tr>
</tbody>
</table>

Table 2 shows that those exposed to Hands-on/Mind-on activity had the higher academic achievement mean score (59.32) than their counterparts exposed to conventional strategy (45.54). This implies that hands-on/mind-on activity-based strategy improve the SMK of the pre-service teachers in primary mathematics. The post hoc analysis revealed that the mean gain (Difference between post mean score and pre mean score) of experimental group was 20.37 while that of control group was 6.59.

Therefore, the treatment had a great influence on the academic achievement of the pre-service teachers in primary mathematics methodology course. This finding confirms the claim of Hannaford (2005) that learning by doing creates more neural networks in the brain and throughout the body, making the entire body a tool for learning. Many scholars have tested activity-based instructional strategies, just as done in this study and found them effective in helping learners learn at different levels of education (English & Halford, 1995; Cubey & Dalli, 1996). This finding also corroborates the submissions of Engel (2002) that activity-based instructional strategies are based on constructivist theory which believes that learners are capable of constructing their own knowledge if allowed to interact, explore or be actively involved in the process of learning. It was argued further that these strategies allow individuals to create their own new understandings, based upon the interaction of what they already know and believe and the mathematical idea with which they come into contact. Therefore, this finding is of great importance.

**H₀₂**: There is no significant main effect of gender on pre-service teacher academic performance in primary Mathematics course (PES 122)

Table 2 reveals that there is no significant main effect of gender on pre-service teachers’ academic achievement in primary Mathematics (F(1,210) = 0.02; P>0.05; η² = 0.00). Therefore, H₀₂ is not rejected. Table 3 reveals that the academic achievement of female students in primary Mathematics is 52.48 while that of male is 52.38. The difference (0.1) is shown not to be statistically significant. This finding could be as a result of the fact that the strategy employed (Hands-on/mind-on activity-based) has little to do with rigorous mathematical calculations, the area where females do not do as well as males.
their male colleagues, especially at the higher level of education (Berube & Glanz, 2008). Besides this, the instructional strategy used which was able to demystify mathematics concepts while rendering it more comprehensible and concrete and real to life. Becker (2003) supports this opinion by saying that traditional ways of teaching mathematics-stressing certainty, a single correct answer, deduction, logic, argumentation, algorithms, structure, and formality- may be particularly incompatible with the ways in which many females learn. Berube & Glanz (2008) argued that the gap between a male and a female child in mathematics could be diminished and that this gap can be successfully eradicated by using better teaching methods. It has also been suggested that constructivist teaching could alter the imbalance in the mathematics classroom (Berube & Glanz, 2008). The hands-on/mind-on strategy used in this study found their root in constructivism and one of the merits of instructional strategy that adopted this theory is that it allows females to learn abstract subjects as well as their male colleagues. Therefore, the female pre-service teachers were able to understand better because the learning was more of doing than just some abstract explanation from a single source (Hanson, 2001).

**H$_{03}$**. There is no significant interaction effect of treatment and gender on pre-service teacher academic performance in primary mathematics course (PES 122).

Table 2 shows that the interaction effect of treatment and gender on the pre-service teachers’ achievement in primary Mathematics in not significant ($F_{(0.210)} = 1.30$; $P>0.05$; $\eta^2 = 0.00$). Therefore, $H_{03}$ is not rejected. The post hoc analysis reveals that the difference between male and female in both experimental and control group is not statistically significant. The difference between the achievement mean scores of male and female in experimental group is 1.22 in favour of male while that of control group is 2.4 in favour of female. These differences are not to be reckoned with since they are not significant. This finding was in line with the first two discussed earlier. It further revealed the strength of activity-based strategy in enhancing learning of all students irrespective of their gender. This view is also indicated in the suggestion of some scholars (Berube & Glanz, 2008) to the effect that constructivist teaching could alter the imbalance in the mathematics classroom.

**CONCLUSION**

Based on the findings of this study, it is concluded that hands-on/mind-on activity-based instructional strategy is better than modified lecture or direct instruction commonly adopted for the training of primary mathematics teachers in the colleges of education in Nigeria. With the peculiar situation of Nigeria where there are large classes of pre-service teacher, hands-on/mind-on is more effective in exposing them to activity-based primary mathematics lesson. It has also been established that gender of the pre-service teachers are not strong factors that can hinder their acquisition of subject matter knowledge of primary mathematics. Finally, the teaching of primary mathematics methodology courses in Colleges of Education should include the training of how to plan and deliver activity-based lessons for the pupils on each topic.

**RECOMMENDATIONS**

Based on the findings and the discussions on the findings, the following recommendations are proffer:

- Lecturers of primary mathematics methodology courses in the Colleges of Education in south west part of Nigeria should be discouraged from using the conventional method of teaching (modified lecture or direct instruction). Hands-on/mind-on activity-based instructional strategy is better and more effective options. This could be achieved by organizing training workshops for them on this. Besides training, NCCE should ensure compliance by setting up a pedagogical monitoring section in each of the states.

- With hands-on/mind-on activity-based instructional strategy, lecturers of primary mathematics methodology courses should not be concerned so much with the effect of gender of the pre-service teachers. Rather, they should concentrate on developing the creativity skills of the teachers in the area of designing pupils’/teacher’s activities that have the mathematical idea explicitly; selection of materials to be used for the activities and how to evaluate the lesson at the end.

- Hands-on/mind-on activity-based instructional strategy is material-driven; hence, each college should ensure that mathematical manipulative materials are adequately provided for the Mathematics Department. This could be achieved by asking the lecturers to make available the list of materials needed and the quantity at the beginning of each session and the college should now provide the fund with adequate supervision.

- With hands-on/mind-on activity-based instructional strategy, the idea is that there should be a shift from ‘reading mathematics’ to ‘doing mathematics’. Therefore, mathematics laboratory should be created in the colleges because the common lecture theatre will not be appropriate.

**REFERENCES**


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