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Procedural Knowledge and Students' Academic Achievement in Map Work

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ABSTRACT This study sought to determine under which learning strategy (cooperative or individualistic) procedural knowledge is better taught, that will result in higher students' academic achievement in map work. The possible mediating influence of gender was also investigated. The study employed a pretest, posttest, control group, quasi-experimental design. Samples comprised 164 Senior Secondary II (SSII) geography students (109 boys and 55 girls). Two instruments were used to collect the requisite data – Procedural Knowledge Achievement Test (PKAT) and Treatment Implementation Guides. Two null hypotheses were tested at 0.05 level of significance. Data collected were analysed using ANCOVA. Results showed that the treatment had a significant main effect on students' procedural knowledge [F (2, 163) = 36.548, p< .05]. Cooperative learning strategy was most effective for the teaching of procedural knowledge. Recommendations include that Nigerian schools must make efforts to use cooperative learning strategy in alleviating students' learning difficulties in procedural knowledge for map work.

INTRODUCTION

Geography may be described as a subject that seeks to study and show the interrelationship and interaction between humans and their environment. It shows how humans are being influenced by their environment (physical and social), and how in turn, they exert their own influence on the environment (International Geographical Union Commission on Geographical Education {IGUCGE} 2015). Humans live in a specific place on the earth, and therefore surrounded by the physical features of the space occupied by them. In the process of interacting with these physical features, certain social, historical, cultural features develop within the community of people who settle in the place. Thus, the study of geography is not only the study of physical features of the environment, but also, the study of social, economic and cultural features of the particular environment under consideration (Ande 2003; IGUCGE 2015).

However, the way and manner this subject is being taught remains a major issue of concern and topic for discourse among scholars and researchers. Several studies (Marshall and Gonchar 2012; Zenelaj 2013; Ajaps 2015; Shimura 2015) have been carried out on how to improve on the teaching and learning of geography in schools.

Schee et al. (1992) observe the fact that geography teaching is designed to equip young people with skills which will enable them to participate in various social and life situations in the spatial relationships of which they are part: their own environment, the European and the world community. These researchers carried out a study titled "Geographical procedural knowledge and map skills". Schee et al. (1992) identify both education and procedural knowledge as different but complementary knowledge necessary for the understanding of map skills. This group of researchers described declarative knowledge as consisting of facts and generalizations, while they defined procedural knowledge as "the subject skills which students manifest in the process of carrying out different tasks in the subject. The results of this study showed that while some students have some problems with applying procedural knowledge, most students have little problem recognizing declarative knowledge. The study concluded that applying procedural knowledge is quite difficult for most students in map interpretation. The study represents one of the most popular

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studies in procedural knowledge in geography all over the world to date. Following this ground breaking study, several other studies (Star 2005; Schmidmier et al. 2013; Star and Gabriel 2013; Rittle-Johnson and Schneider 2014) have been conducted in different subjects and fields of study, particularly in the sciences like mathematics, biology, chemistry, including medical practice, all of which have proved the efficacy of procedural knowledge in promoting effective learning in these fields of study.

The current study is part of the continuous search for more effective methods of teaching and learning of geography in general, and map reading in schools in particular, with special focus on the identification of what constitutes procedural knowledge in map work.

It is argued in this paper, that even though declarative knowledge and procedural knowledge are complementary, there is a dire need to pay special attention to each of them if we truly want to teach map work in the most meaningful way that would be attractive to students, thereby leading to higher academic achievement in geography.

Procedural knowledge could be described as the knowledge of the procedure stipulated for carrying out particular tasks (Star 2005; Schmidmier et al. 2013; Star and Gabriel 2013). Every human activity or task has a way of executing it. The same is true of map work in geography.

For example, if the student is required to calculate the gradient of two given points, first, it would be assumed that such student has been intimated with the procedure of carrying out such task in stages. He or she needs to first identify the requirements for the execution of the task. It may not be enough for the student to demonstrate the declarative knowledge of the vertical interval (VI) and the horizontal equivalent (HE), which may be said accounts for about thirty-forty percent of the knowledge requirement to solve this problem. More importantly, the student needs to demonstrate the knowledge of procedure (procedural knowledge) for the calculation of the gradient, which in this case includes the following: Measuring the horizontal equivalent (HE); determining the difference in height between the two points (VI); converting VI and HE to same unit; dividing the VI by the HE; ensuring that the numerator is 1; expressing your answer as a ratio and interpreting. As could be observed from this example, the knowledge requirement here for solving this problem is about seventy percent of the total requirement. This is why it is argued in this paper that procedural knowledge is critical to the solution of problems in map work and therefore deserves special attention.

Collaborative learning in small groups has been observed to increase interests and participation in class, giving students time to think during class and increasing students' positive attitude to learning, hence leading to higher students' academic achievement (Owel et al. 2002). In addition, it was found that this approach made female students more comfortable in the classroom (Chase and Edward 2000).

Cooperative learning is a subset of active learning that usually involves formally structured groups of three or more students assigned multistep exercises, research or development projects or presentations (Brenda and Robert 2003). Many studies have been carried out on active learning techniques and students' attitude towards learning. In a study carried out by Owen et al. (2002) on cooperative active learning strategies, using small groups in programming courses as introductory to advanced levels, at Duke University, Durham, it was found that students' interest and participation in class increased in group discussions. The researchers also observed that this approach increases students' confidence and self-esteem. They also found that students who were reluctant to speak in class became eager to volunteer and discuss a solution that their group developed. Other studies (such as Majoka et al. 2011; Saleh 2011; Adams 2013; Sani 2015) also reported the effectiveness of cooperative learning strategy in improving students' learning than any of the competitive or individualistic learning strategy.

Individualized instructional learning, on the other hand, is a form of active learning which is based on constructivist theory that individuals must construct their own knowledge and skills in relation to his environment. In this strategy all students are taught in one style (usually through a structured set of materials developed by the instructor). The theory behind this instruction is that teachers should vary and adapt their approaches in order to allow the students to construct their own knowledge (Hall 2002). Most importantly, this type of learning allows a student to proceed in the process of investigating a given problem. Individualised instruction provides the opportunity for students to learn at their own pace, in their own way and to be successful (Omiola et al. 2012). In the study carried out by Christian and Pepple (2012), it was

found that individualised learning strategy promotes more positive attitudes and academic performance than the conventional lecture method.

Gender is a factor whose influence on students' learning outcomes has been vigorously examined by researchers. Divergent reports abound from fields of research on gender issue. Okeke (2007) in his review of studies concluded that gender differences exist in students' achievement in science and all other subjects. Studies have shown various conflicting findings; some in favour of boys (Bilesanmi-Awoderu 2002); some in favour of girls (Ogunleye 2002) and some have shown no significant difference between boys and girls in relation to their achievement and attitude in different science subjects (Okoye 2010). The findings of Ajitoni (2007) revealed that there were significant differences between female and male students in terms of attitude in favour of females. Aremu and John (2005) state that the search for strategies to bridge the gap in the achievement of males and females is an ongoing one. Gender as a moderating variable therefore attracted further investigation in this study because of the conflicting nature of results, as revealed in the above studies that focused on gender and science related-subjects.

Statement of Problem

This study sought to determine the learning strategy (cooperative or individualistic) under which students would better acquire procedural knowledge in map work. The study also investigated the possible mediating effects of gender on students' procedural knowledge in map work.

Objectives of the Study

The study was guided by the following specific objectives:

To determine whether cooperative or individualistic learning strategy will better enhance students' acquisition of procedural knowledge in map work.

To investigate the effects of gender on students' acquisition of procedural knowledge in map work.

Hypotheses

Based on the problem stated above, the study tested the following null hypotheses:

$H_0 1$: There is no statistically significant main effect of learning strategy on students' acquisition of procedural knowledge

$H_0 2$: There is no statistically significant main effect of gender on students' acquisition of procedural knowledge

METHODOLOGY

Design

A pretest-posttest control group quasi-experimental design was adopted in this study to determine the relative effects of the learning strategies – cooperative and individualistic – on secondary school students' achievement of procedural knowledge in map work. The moderating influence of gender was also investigated.

Participants

The sample for this study were 109 boys and 55 girls, giving a total of 164 drawn from Senior Secondary Two (SSII) geography students in Ilesa East and West Local government areas of Osun State, Nigeria. The intact class method was used to draw the sample for the study. This method was found to be suitable for the selection of participants due to low enrolment in geography classes.

Three (3) schools (one from each zone) were randomly selected by simple balloting procedure for the study. The selection of one school from each zone was done in order to control for "contamination effects".

All the participating students and schools were randomly assigned to Cooperative, Individualistic and Control groups respectively.

Research Instruments

The research instruments consisted of the testing and stimulus instruments. These included the Procedural knowledge Achievement Test (PKAT) and Treatment Implementation Guides on cooperative, individualistic and the conventional learning strategies respectively.

Validity and Reliability of PKAT

This instrument (PKAT) had two sections. Section A contained 20-item objective questions, while section B consisted of six short essay questions. Section A of this instrument was subjected to further statistical treatment in order to de-

termine the difficulty level, as well as the discrimination power of the test items, using the appropriate formulae. This yielded a difficulty index of between 0.40 and 0.65, while the discrimination index ranged between 0.43 and 0.68. As a result, five of the twenty-five items initially designed for this section were dropped because they were found inappropriate in terms of the difficulty level and/or the discrimination power, thereby leaving 20 items that were found appropriate in this section.

The reliability coefficients for both sections were calculated. While the split-half method was used for section A, the inter-rater method was used for section B, in order to generate two sets of scores for each subject. These were then correlated using Pearson Product Moment Correlation coefficient formulae (r). Thus, a reliability coefficient of 0.84 was obtained for section A of PKAT, while the reliability coefficient of 0.76 was obtained for section B of the test, which was found satisfactory.

The administration of PKAT on the subjects in all the groups as *pretest* was carried out before the treatment proper. This was followed by a series of lessons designed for the different groups involved in the study. Subjects were presented with class exercises at the end of each period, while PKAT was again administered on the subjects as a *posttest* at the completion of the entire treatment sessions in the different groups.

Data Analysis

The data collected were analysed through inferential statistics of Analysis of Covariance (ANCOVA), in which the pretest scores served as covariates. The Multiple Classification Analysis (MCA) was also used to find out how each of the groups performed, while Scheffe's post hoc test was applied to show the direction of the significant differences (if any) among the groups. The hypotheses for this study were tested at 0.05 alpha.

RESULTS

$H_0 1$: There will be no statistically significant main effect of learning strategy on students' acquisition of procedural knowledge.

The ANCOVA on Table 1 shows the main effect of treatment on procedural knowledge achievement test . As could be observed from this Table, the treatment had a significant effect on Procedural Knowledge Achievement Test PKAT [$F(2,163) = 36.548$; $P < 0.05$] based on this, the hypothesis 1 is rejected.

The Multiple Classification Analysis (MCA) on Table 2 gives an indication of the performance of each of the experimental groups and the control group. The cooperative group had the highest mean score of 30.37 followed by the control group, with 24.08, while the individualistic group had the least adjusted mean score of 15.10. The computed Beta scores shows further that treatment contributed the greatest proportion to the variation in the scores. Thus, treatment contributed 32.5 percent ($.57^2$) of the variance in Procedural Knowledge Achievement (PKAT), while the MCA table reveals multiple R square values of 0.434.

To further search for the source of the significant differences observed among the treatment groups, as indicated in the ANCOVA, a Scheffe post-hoc analysis was carried out on the mean scores of the groups in PKAT, as displayed on Table 3.

The results on Table 3 show that the cooperative group with a mean of 30.27 differed significantly from both the individualistic group and the control group whose means are 24.43 and

Table 1: Summary of ANCOVA on posttest PKAT scores according to treatment and gender

Source of variations	*SS*	*DF*	*MS*	*F*	*P*
Covariates	3351.260	1	3351.260	54.430	.000
Pretest	3351.260	1	3351.260	54.430	.000
Main Effects	5135.275	5	1027.055	16.681	.000
Treatment	4500.506	2	2250.253	36.548	.000
Gender	242.397	1	242.397	3.937	.049
Explained	10648.207	18	591.567	9.608	.000
Residual	8927.695	145	61.570		
Total	19575.902	163	120.098		

Source: Adeyemi and Cishe (2015)

Table 2: Multiple classification analysis of the posttest PKAT scores according to treatment and gender

Grand Mean = 22.976					
Variable category	*N*	*Unadjusted deviations*	*Eta*	*Adjusted for independents + Covariates*	*Beta*
Treatment					
Cooperative	51	7.3		7.4	
Individualistic	56	-8.14	0.58	-7.87	0.57
Control	57	1.46		1.11	
Gender					
Male	109	0.04		-0.88	
Female	55	-0.08	0.01	1.75	0.11
Multiple R^2					0.434
Multiple R					0.658

Source: Adeyemi and Cishe (2015)

Table 3: Summary of Scheffe post-hoc analysis on posttest means in PKAT according to treatment groups

Groups	*Means*	*Group 2*	*Group 3*	*Group 1*
Group 2	14.8393			
Group 3	24.436	*		
Group 1	30.2745	*	*	

Source: Adeyemi and Cishe (2015)
Legend:
* denotes pairs of group significantly different
Group 1 = Cooperative Learning Strategy
Group 2 = Individualistic Learning Strategy
Group 3 = Control

14.83, respectively, in PKAT. The control group was also found to significantly differ from the individualistic group.

Thus, it is revealed in these Tables that the cooperative group performed consistently better than the other two groups in the achievement test in PKAT. Hence, the cooperative group is superior to both individualistic and control groups in the achievement test. While the control group had the second best posttest mean score, the individualistic group had the least posttest mean score in the test.

H_o2: There is no statistically significant main effects of gender on students' acquisition of procedural knowledge in map work.

The ANCOVA in Table 1 also shows the main effect of gender on procedural knowledge. As could be observed from this Table, gender had a significant effect on the Procedural Knowledge Achievement Test (PKAT) [F (1,163) = 3.937; P <0.05], consequently, hypothesis 2 is rejected.

The Multiple Classification Analysis (MCA) on gender reveals that the female students in the sample performed better than their male counterparts in the Procedural Knowledge Achievement Test (PKAT).

DISCUSSION

The main focus of this study was to determine whether or not there would be any significant difference in the acquisition of procedural knowledge in map reading and interpretation of subjects exposed to cooperative and individualistic learning strategies. The findings indicated that there were significant differences among the treatment conditions.

The result of the analysis of covariance (ANCOVA) confirmed that learning strategy had a significant main effect on variation in subjects' mean scores in map work. The results indicated a high significant main effect of treatment on PKAT. The Multiple Classification Analysis clearly showed that the cooperative group had a higher mean score over and above the other two groups. This indicated the apparent superiority of the cooperative learning strategy in teaching map work in secondary schools.

These findings lend further empirical support to other findings on the usefulness of cooperative learning strategy over and above other learning strategies (Alebiosu 1998; Esan 1999; Majoka et al. 2011; Saleh 2011; Adams 2013; Sani 2015). Similarly, Johnson and Johnson (1978), in a meta-analysis involving 122 studies, concluded that cooperation is considerably more effective than competitive or individualistic efforts. But on the contrary, Okebukola and Ogunniyi (1984) find that com-

petition was more superior to cooperative and individualistic class structures in laboratory work. Alebiosu (1998) finds a significant main effect of treatment involving two cooperative learning models on the achievement of subjects in chemistry, while Esan (1999) finds that mathematical problem solving skills are best enhanced by cooperative learning environment.

What seems evident from these results is that the cooperative learning strategy has a great potential for effective learning of map work at secondary school level. This may be due to what scholars (Veenman et al. 2000; Slavin 2000) describe as task and reward structures that characterize the cooperative method of teaching. In the task structure, individual member of the cooperative group is expected to master all aspects of the assignment or task given and be able to explain them. Members help themselves to achieve mastery where and when necessary. In other words, every member is supposed to be actively involved in the task so as to get rid of the "free rider" effect (Veenman et al. 2000). The fact that the failure of a member of the cooperative group may have adverse effect on individuals or groups reward encourages every member of the group to be fully involved in the study. This makes the individual members to be responsible for their learning and that of their mates, giving rise to individual accountability (Johnson and Johnson 1994). The opportunity provided by the cooperative learning strategy, whereby peer tutoring takes place, makes it attractive in the teaching and learning of map work in the secondary schools.

The results further showed that subjects in the control group performed better than subjects in the individualistic group. This is because subjects in the control group could assit one another in the form of giving further explanations on difficult areas. The teacher may even clarify some 'knotty' areas before the students are left on their own, to provide solutions to the class assignments given by the teacher.

Subjects in the individualistic group had the least posttest mean score. This is probably so because the individualistic learning structure offers less opportunity for peer interaction (Ojo 1992), whereas cooperative learning environment requires constructive interaction among students (Johnson and Johnson 1986). Students-in the individualistic learning group and the control class, ignore the achievement striving of other students in the class. This type of learning environment is not likely to stimulate students towards higher achievement (Esan 1999).

CONCLUSION

The results of this study seem to warrant the following conclusions in relation to the learning strategy to which the participants were exposed:-

Cooperative learning strategy is superior to both the individualistic learning strategy and the conventional method in procedural knowledge in map work;

The control group which was exposed to the conventional method of teaching performed better than the individualistic group, which had the least posttest mean score owing to the non-interactive nature of the strategy among its members;

The cooperative learning strategy may be seen as one that is capable of making students less dependent on the teachers;

Geography teachers should endeavour to identify what constitutes procedural knowledge in map work and devote time to teach the students in order to enhance students' performance in map work. Cooperative learning strategy is finally recommended to be popularised among geography students and teachers.

One other major finding of this study has to do with the influence of gender on students' achievement in map work. The results showed that the female subjects performed better than their male counterparts in Procedural Knowledge Achievement Test (PKAT). This implies that the females are better in lower cognitive activities of just knowledge and comprehension calling for recall and definitions of terms and concepts in most cases.

RECOMMENDATIONS

Based on the findings of the study, the following recommendations are made:

In order to solve the problem of students' poor performance in map work at both internal and external examinations, the teaching/learning process should be restructured so as to accommodate new instructional strategies that will enhance students' performance. Cooperative learning strategy, which has proved effective, is hereby recommended for use. Hence the old and stereotyped lecture method of teaching map work should be discouraged.

Geography teachers who are already in schools should be given training through organised workshops, seminars and symposia where they would be exposed to all aspects of cooperative learning strategy.

Geography teachers should be made to recognise the fact that procedural knowledge is central to good performance in map work. Hence, teachers should make concerted efforts to specifically devote time to these areas during lessons. The curricula of all Teacher Training institutions in the country should be broadened to encompass this learning strategy that promotes effective learning.

The secondary school geography curriculum should be such that it would enable the teachers to identify problems, stimulate students' thinking ability, and allow for individual and group approaches to solving problems in map work.

The school authorities and the teachers of geography should work together to ensure that enough instructional materials are provided for the students, to enhance their learning.

It was found in this study that most students perceived geography as a very wide subject. Hence more time should be allocated to it on the school timetable, as the present 3 periods per week is inadequate. It is hereby suggested that between 6 and 8 periods be allotted to geography a week for mastery learning.

Finally, geography teachers should endeavour to encourage the students generally, and the female ones in particular to show more interest in the study of geography through pieces of advice emphasising the importance and advantages of geography to mankind, as well as stimulating ways of handling the subject.

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