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THE EFFECTIVENESS OF INDIVIDUALIZED, COLLABORATIVE F1ELDWORK, AND EXPOSITORY LEARNING ON BIOLOGY STUDENTS' ABILITY TO SOLVE PROBLEMS.

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ABSTRACT

This study investigated the effects of involving students in participatory ecology fieldwork either in small groups or as independent investigators on their eventual ability to solve ecology' problems. Three intact classes (two experimental and one control) were used for the study. Two major instruments - written lesson plan for both the experimental and control classes for the three ecology topics selected for investigation and an Ecological Problem-Solving Test (EPST) consisting of 14 multiple choice items drawn from the three content areas selected for the study were used. Fifteen teaching sessions were carried out in all the selected schools. Data were generated as pre and post-test scores and analyzed using Analysis of Covariance. Results reveal the superiority of individualized fieldwork over collaborative fieldwork and expository approach. The inability of the collaborative group students to achieve significantly better was explained by a lack of deep conceptual understanding, poor domain-specific knowledge, and the short period of treatment, which may not have allowed for adequate collaboration. Considering that individualism ensures and reveals each student's abilities, shortfalls, and aptitude and collaboration may provide a cover for them by promoting group excellence. It was recommended that biology teachers be sensitized to utilize the inherent benefits of independent work and intersperse them with some measure oj group or collaborative
work.

Key words: Fieldwork; Collaborative fieldwork; Problem-solving; Individualized fieldwork

INTRODUCTION

In a bid to preserve and protect nature's greatest gift to mankind, calls have gone out globally drawing man s attention to the realities of his environment. In Nigeria, the National Environmental Task Force and the National Environmental Protection Agency often lament the gross threat to land, water, atmosphere, and wildlife and the combined effect of all these on the sustainability of human life and healthy living. Consequently, United Nations Education Scientific and Cultural Organization (UNESCO) and Nigerian Educational Research and Development Council (NERDC) in 1992 recommended that ecology teaching should be reformed to include environmental education. Several studies on biology concepts in Nigerian secondary schools have revealed poor achievement (Adeniyi, 1996; Abimbola 1986; Okeke & Ochuba, 1986). Issues raised from these studies include poor attitude toward the subject, poor cognitive competence, socio-economic deficiency of teachers, inadequate administrative policies, and inadequate instructional strategies. Abimbola (1997) also identified inadequate resources for ecology teaching, and teachers' unsatisfactory use of fieldwork and practicals in ecology. Ecology being the aspect of biology that deals with the study of the environment and the interrelationship amongst organisms, has become a very important part of the biology curriculum. Even with the innumerable knowledge inherent in ecology, it has remained one of the most evaded and poorly understood aspects of biology by both teachers and students. This practice has often times translated into poor performance in certificate examinations (Aworanti and Abimbola, 1997; Okeke and Ochuba, 1986). Above all factors, inadequate use of instructional approaches either in form of fieldwork or practical seems to top the list in science education literature for such poor performance. Johnstone and Mahmoud (1980) had earlier stated that ecology ranks as one of the most difficult concepts in biology, and called for revolutionized instructional strategies that promote field experiences to stem the tide. Duggan, Johnson, and Gott (1996) have stressed the importance of fieldwork in ecology, however, no successful implementation has been recommended. Investigations are sparse in biology, and the adoption of a purely investigatory approach to the learning of ecology has not been reported. The implication of this is that science educators are still unaware of the effect of studying ecology either by individualized or collaborative fieldwork on learning as well as their application in problem-solving. It follows that no meaningful teaching of biology and by implication ecology can be achieved without adequate field and practical experiences.

Being the highest intellectual manifestation of learning (Gagne 1977) problem-solving tendencies emerge as veritable measures of learning in the true sense. Gagne conceived problem-solving as a process by which the learner discovers a combination of previously learned rules which can be applied to achieve a solution for a novel situation. Thus, solving a problem is more than just applying already learned rules; it must generate new learning. This can only result when learners' thinking processes involve an analysis of various hypotheses and their suitability in the problem situation. It is therefore informative to note that for a learner to operate at the level of problem-solving, appropriate instructional strategies that will exercise some demand or his mental processes and intellectual abilities are required. To this effect, a series of research has aimed at evolving strategies that will help improve students' problem-solving skills (Pestel, 1993: Parkin, 1987; Keys, 1994; Moemeke, 1999; Omoifo and Moemeke, 2002). The use of collaboration in learning has also been reported. Its benefits in helping learners to carry out scientific inquiry and gain in their scientific knowledge have been reported (Rosebergy, Warren & Conant, 1992; Brown et al., 1993; Dunbar, 1995). It is also beneficial in the development of rich scientific reasoning structures, higher domain knowledge, and sophisticated critical thinking abilities. Approaches used in the studies include socially distributed expertise, jigsawing, and majoring. None of the studies, however, involved fieldwork in ecology. Thus, its effect needs further investigation so as to understand its position. Dunbar and Klahr (1989) have shown that as an instructional approach, working in an individualized fashion develops in children, the understanding of the scientific reasoning process. This they concluded is evidenced in their abilities to test hypotheses and make general summary statements. These outputs manifest (Sodian, Zaitchdt, and Carey, 1991) as early as seven years of age. If both approaches are as potent as the literature has stated in everyday science classrooms, it becomes absolutely necessary to determine their effectiveness when applied to fieldwork and problem-solving in ecology. This study, therefore, attempted to investigate the effects of involving students in participatory ecology fieldwork either in small groups or as independent investigators on their eventual ability to solve ecology problems.

STATEMENT OF THE PROBLEM

A look through science education literature in the past two decades reveals that a prevalent theme in science education has been the unsatisfactory level of students' problem-solving competencies. This has culminated in the high rate of underachievement in the sciences in Nigerian schools. Evidence in literature has shown that between 1990 and 1994, only about 31.16% of students who sat for the West African School Certificate Biology passed at credit level and above (Urevbu, 1997). This has raised questions about the effectiveness of biology teaching in our secondary schools. Odubumni (1981), Olarevvaju (1983), and Jegede (1982) explain that teachers usually fail to create problem situations, which are supposed to trigger off in student the development of mental processes necessary to solve them. Ecology, which forms about 45.1.7% of the total biology curriculum in Nigerian secondary schools has also suffered gross neglect. It is common knowledge that ecology topics are often not taught. Where they are taught, it is usually in a hurry, and as such fieldwork is not employed. Several studies have emphasized the superiority of student participatory fieldwork over classroom expository teaching. They have called for a drastic revolution of the attitude to and method of teaching ecology by incorporating fieldwork. However, the appropriate pedagogical arrangement for the proper implementation of this call has not been ascertained. Nigerian science curriculum for the senior secondary requires a study of one science subject even by non-science majors. Often, biology is chosen, and this has made the subject a core subject at the senior secondary school level. Unfortunately, inadequate classrooms and other resources have resulted in large class sizes. It is not uncommon to find between 90 and 120 students in a biology classroom. Although some authors have recommended the use of individualized inquiry during fieldwork, one wonders to what extent the strategy will be feasible in large classes as characterized in many secondary schools in Nigeria. Others have extolled the efficiency of students' collaboration in small groups during fieldwork. This, they say, encourages student-student interactive learning, saves time, and makes the management of a large student population prevalent in biology classrooms possible during fieldwork. The cognitive implication of these on Nigerian secondary school science students is still not known. To what extent will these strategies affect students' learning and problem-solving ability in ecology in Nigeria? This study, therefore, sought to answer these questions

PURPOSE OP THE STUDY

The purpose of this study was to identify the influence of engaging students in a participatory field study of ecology either in individualized or collaborative form and the ease and accuracy with which they solve ecology questions and to assess such effects for males and females.

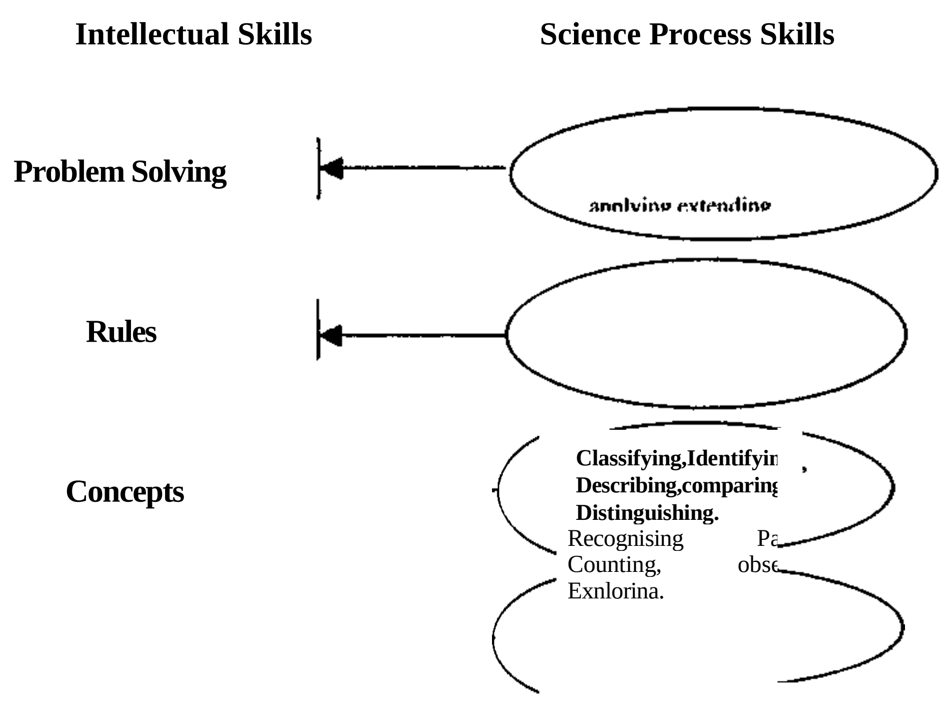
RESEARCH HYPOTHESES

The following null hypotheses were tested.

1. There is no significant difference in Biology student's mean performance in Ecology Problem-Solving Test (EPST) by those who studied ecology by individualized fieldwork, collaborative fieldwork, and those who studied the same concepts but without fieldwork.
2. Students' performance in the Ecology Problem Solving Test (EPST) is not significantly different for males and females taught using practical ecology fieldwork and those taught using the expository method.
3. There is no significant interaction effect between method and gender on biology students mean achievement on the EPST.

THEORETICAL AND CONCEPTUAL FRAMEWORK FOR THE STUDY

This study is anchored on the theoretical and conceptual basis of Gagne (1962, 1977) and Vygotsky (1978). Gagne's guided learning or guided discovery theory expressed the proposition that guided learning proves the most effective instructional device but depending on the extent and amount of guidance provided during instruction, he explains the relationship between discovery and creativity and their mutual relationship with problem-solving. Thus learning in his explanations involves the use of the individual's mental capacities to find solutions to problems and such solutions must be generalizable to similar other problems. Gagne (1977) also explicates that both problem-solving and discovery are the final steps in a sequence of learning that extend back through the many prerequisite learning that must precede it. These steps are hierarchical and relate to the intellectual and process skills of science as shown in fig I



Discrimination

Verbal Information, Cognitive strategies Motor skills

Fig 1: Adapted from Gagne and Briggs (1979) Intellectual Skills and the Associated Process Skills in a hierarchical order.

Of recent emphasis is shifting from individualized to social interaction. Vygotsky (1978) propounded the social interaction theory of cognitive development. He noted that in collaboration, individuals utilize the social interactive mechanism to grow cognitively especially when a member of a collaboration proves to be more competent and provides assistance within his partner's "zone of proximal development" through shared understanding. Tudge, Wintenoff, and Hogan (1996) in line with Vygotskian thinking investigated the application of feedback during collaborative problem-solving. They concluded that even, in the absence of feedback, competent partners positively influence the less competent partners by exposing them to higher reasoning which in turn influences problem-solving tendencies. Based on these theories and concepts, this study is designed to investigate the effect of individualized and collaborative strategies on students learning and problem-solving ability in ecology in Nigeria.

SIGNIFICANCE OF THE STUDY

This study is significant as it will:

(1) Provide biology teachers with information on the best pedagogical arrangement for carrying out students* participatory ecological fieldwork.

(2) Identify the efficacy of collaboration and individualization of fieldwork in achievement in biology.

(3) Provide more information to curriculum developers for reforms in ecological and biology curriculum

METHODOLOGY

A quasi-experimental design (pre-test post-test control group) with intact classes was used for the experimental and control groups. It is quasi-experimental because it offered less rigorous experimental controls compared to true experimental designs (Ali, 1996 p. 66). Intact classes were used for the experimental and control groups. Thus the subjects in each class were not randomly selected. However, the selection of the intact classes (experimental and control classes) from all the arms of SSII in the schools used was by simple random sampling (ballot). This is because all students in SS classes of Delta Slate schools study biology as a core science subject. Also, each class consists of students of mixed abilities. Thus some are high achievers while others are low achievers. The subjects consisted of 186 secondary class two students with an age range of 14 to 20 from three secondary schools in Delta State. Seventy-eight students carried out fieldwork in selected ecology topics, 31 carried out the same fieldwork but in groups while seventy-seven did not receive any fieldwork treatment. The third group's instruction on the selected ecology topics was basically expository and teacher-dominated. The topics covered by the treatment include estimation of the density/estimation of the population of a named plant using a quadrat tropical rainforest and feeding relationship in an ecosystem. All topics were taken from the senior secondary biology (ecology aspect) syllabus. The possibility of sensitization of subjects to the experimental treatment was ruled out with the use of intact classes for both the experimental and control classes.

Two major instruments were used for the study - written lesson plans for both the experimental and control classes for the three ecology topics selected for investigation (both the experimental and conventional lesson plans are similar in each case in objective and content but different in the application of activity method in the experimental version), an Ecological Problem Solving test (EPST) consisting of a 14 item multiple choice questions drawn from the three content areas selected for the study. It conforms to the pattern usually adopted by the West African Examination Council; in the Senior School Certificate Examination but tested problem-solving abilities. All subjects answered all the questions. The EPST served as both a pretest and a posttest. Both instruments were validated by two science educators and an experienced Masters in Science Education (Biology) graduate who also acted as a research assistant in the girls' school used for this study. The validation exercise covered content, face, and construct validity. Their scrutiny introduced some corrections in the original EPST before it was administered for the study. The EPST was administered to 30 SS II students of a non-research school (co-educational) in Agbor. The reliability of 0.70 was calculated by Kuder Richardson formula 21 since the test was scored dichotomously.

Fifteen teaching sessions were carried out in all the selected schools. Nine of these formed the experimental instructional package. Each experimental class in each school had three instructional sessions. The other six instructional sessions were for the two control classes. Treatment lasted for five weeks and both the experimental and control classes were subjected to the same treatment (study of ecology concepts) but with different instructional approaches and individualized field study. Collaborative field study (for the experimental classes), and expository classroom instruction (for the control groups). In the first week, an introductory session in which the investigators, assisted by trained biology teachers administered a 14-item multiple-choice Ecology Problem Solving Test (EPST). This generated the pretest data. The following three weeks were used to administer the instructional packages while the last week saw a re-administration of the EPST. This also generated the post-test data for this study. The statistical technique employed in this study is basically the 2-way Analysis of Covariance (ANCOVA). This was to enable the investigators to establish the differences between the means of the three groups (two experimental and a control group) in the pretest and posttest. It was also used to determine the presence or absence of significant differences in the EPST scores based on gender as well as determine if an interaction effect exists between instructional approaches and gender. In addition, descriptive analysis using the means and standard deviation was also used to determine group and gender achievement in pre and post-tests. The decision to accept or reject a null hypothesis was made at a 0.05 level of significance.

RESULTS

The 2-way analysis of covariance (ANCOVA) with respect to hypotheses 1.2 and 3 is presented in Table 1.

TABLE 1: ***Two-Way Covariate Analysis of Pastiest Achievement Scores of the Three Instructional Groups based on Gender.***

Dependent variable Post-test Scores

Source	Type III Sum of Squares	Df	Mean Square	F	Sig
Corrected Model	1929.255[b]	6	321.543	26.052	.000
Intercept	2239.158	1	2239.158	181.424	.000
PRET	976.077	1	976.077	79.085	.000
GROU	374.146	2	187.073	15.157	.000
SEX	11.890	1	11.890	.963	.328
GROU'SEX	43.129	2	21.564	1.747	.177
Error	2209.239	179	12.342		

Total	36410.000	186
Corrected Total	4138.495	185

a. Computed using alpha = .05
b. R^1 = .466 (Adjusted R^2 = .448)

Results revealed significant differences for the three groups on the bases of instructional design (F=15.157) (design). They also showed that the students did not differ significantly on the basis of their sexes, and so did not interact with teaching design to affect achievement in ecology problem-solving. Thus the hypothesis of no significant difference in achievement for students taught through the different designs was rejected, while that based on gender was retained. To determine the direction and contribution of each group to the difference observed variance within the groups, pairwise multiple comparisons were carried out and are shown in Table 2.

TABLE 2: Pairwise Comparisons Based on Groups (Teaching Strategies) Dependent Variable Post-test Scores

					95% Confidence interval for Difference	
(1) Groups based teaching method	(J) Groups based on teaching method	Mean Difference (I-J)	Std Error	Sig*	Lower Bound	Upper Bound
First treatment Group-(Individualized Fieldwork	Second Treatment Group (Collaborative fieldwork	2.340*	.761	.002	.837	3.842
	Control Group Expositor	.3.105'	.576	.000	1.968	4.241
Second Treatment Group (Collaborative Fieldwork)	First Treatment Group (Collaborative fieldwork	-2.340*	.761	.002	-3.842	-.837
	Control Group Expositor	.765	.762	.317	-.738	2.269
Control Group (Expositor)	First Treatment Group (Individualized fieldwork	-3.105*	.576	.000	-4.241	-1.968
	Second Treatment Group (Collaborative fieldwork	-.765	.762	.317	-2.269	.738
First treatment Group-(individualized Fieldwork	Second Treatment Group (Collaborative fieldwork	2.340*	.761	.002	.837	3.842
	Control Group Expositor	.3.105*	.576	.000	1.968	4.241

Based on estimated marginal means
* The mean difference is significant at the .05 level.
a. Adjustment for multiple comparisons: Least significant difference (equivalent to no adjustments)

Results from Table 2 reveal a significant difference in problem-solving achievement in ecology between the individualized group and the collaborative group (mean difference = 2.340, 4 significant at .002) and, the individualized group and control group (mean difference - 3.105, significant at 0.0005). However, the significance between the collaborative group and the expository group was 0.317, much greater than the set alpha level of 0.05.

DISCUSSION OF RESULT

Results from this study revealed the superiority of individualized fieldwork over collaborative fieldwork and the expository approach. The superiority of the individualized fieldwork approach reported in this work makes a case for individualism in the development and construction of knowledge structures. Since individual experiences influence learning, exposure of learners to situations that present gaps in their knowledge and creates in them the natural urge to fill these gaps may well be encouraged. Though collaboration has been highly acclaimed by authors as potent in the development of problem-solving abilities (Johnson et al., 1981; Judge, 1989), the results of this study differentiate individualized problem-solving from collaborative problem-solving. Collaborative work prepares students for enhanced group problem-solving; it 'however does not provide a forum for group members to solve problems in an entirely unassisted situation. This may be the basis for the observed difference. The result of the individualized fieldwork approach reported in this study is supportive of that reported by Dunbar and Klahr (1989). They report that children's unassisted individualized inquiry promotes an understanding of the scientific reasoning process which is a necessity in scientific problem-solving. Metz (1998) has also pointed out that carrying out individualized learning deepens the individual's domain-specific knowledge which is an important factor in gaining expertise and conceptual understanding. The inability of the collaborative group subjects to achieve significantly better may possibly be explained by a lack of deep conceptual understanding and poor domain-specific knowledge. It may also be a result of the short period of treatment which may not have allowed for adequate collaboration as for individual exposure.

IMPLICATIONS AND RECOMMENDATION

All efforts directed at improving the teaching and learning of biology are geared towards the achievement of the objectives of senior secondary school biology. For students to develop field skills in biology, they must fully participate in fieldwork. Apart from enhancing meaningful learning for transfer to problem situations, it develops the spirit of inquiry and investigation, which have been found to positively affect knowledge acquisition. This is a Nigerian secondary school curricular requirement. What this study has done is exposed the fact that contrary to thinking among biology teachers that adequate application of fieldwork in ecology teaching only promotes manipulative and affective growth as well as the science process skills, it also enhances better cognitive performance. It must thus be seen as a priority measure in improving ecology learning. By implication, the use of individualized fieldwork should not be substituted by group work in its entity. While individualism ensures and reveals each student's abilities, shortfalls, and aptitude, collaboration may provide a cover for them by promoting group excellence. Biology teachers should, therefore, utilize the inherent benefits of independent work and intersperse them with some measure of a group or collaborative work. This should be the rule since most (if not all) certificate practicals are independent in nature.

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