The Effects of Process-skill Instruction on Secondary School Students' Formal Reasoning Ability in Nigeria

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Abstract

The authors investigated the effects of a process-based instructional strategy, vis-a-vis the traditional lecture method, on the achievement of Nigerian secondary school students on tasks involving formal reasoning. A total of 76 students made up the sample. Their average chronological age was 17 years. The Group Assessment of Logical Thinking Test, developed by Roadranka et al. (1983) was adopted and used. The design of the study was the pretest-posttest, matched groups design. The treatment, which involved process-skills instructional approach, lasted six weeks. The results showed that the experimental group exposed to the process-skills instructional approach performed significantly better than the control group exposed to the traditional instructional strategy. The implications of these findings for meaningful science teaching and learning in the secondary schools are also discussed.

Key words: Process-skills instructional strategy, enhancing formal reasoning ability of secondary school students, interactions of formal reasoning ability and competence in learning science concepts.

INTRODUCTION

For the past two decades or so, researchers in science education have demonstrated, through findings from their studies, that many secondary school students are not able to apply abstract reasoning to concepts in science programmes (Bender & Milakofky, 1982). Studies based on developmental views have argued that concept acquisition and ability to solve problems have several interrelationships with formal reasoning ability (Johnson & Lawson, 1998). These studies suggest that students, who have not acquired formal reasoning ability, may not learn science concepts meaningfully, and this could be responsible for their poor performance in science. Therefore, science educators have stressed the need to employ teaching methodologies that promote the acquisition of formal reasoning by learners.

Several authors have hypothesized the existence of relationships between integrated process skills instruction and formal reasoning abilities (Padilla et al., 1983). This seems reasonable as individual's development is indeed a function of multiple activities, having direct interaction with the environment (Barbel & Chipman, 1976). Since the use of process-based teaching afford learners opportunity for interacting with the environment through rich and stimulating activities, it is quite a possible influence on individuals' reasoning ability. The purpose of this study was to determine whether exposure of secondary school students to process-skills instruction would significantly improve their formal reasoning ability.

METHODOLOGY

A total of 76 Senior Secondary II Students (eleventh-grade students), obtained from two schools through a process of simple randomization, comprised the sample. Their average chronological age was 17 years. The two schools were located in Zaria metropolis in Kaduna State of Nigeria. The sample size was 76, drawn from both schools (38 students from each school). The subjects were classified, in the first instance, into concrete and formal operators based on their scores on the Group Assessment of Logical Thinking Test (GALT). After the pretest, students from one school were assigned to the experimental group and students from the second school to the control group. The experimental and control groups were not significantly different in their formal reasoning ability before treatment commenced. The experimental group was exposed to process-based instruction that lasted six weeks and for three hours a week. The control group was taught the same topics as the experimental group but via the use of the traditional instructional method that also lasted six weeks for three hours

a week. At the end of exposure to the instructions, both groups were post-tested using the GALT test adopted from Roadranka et al. (1983), with a reported reliability coefficient of 0.85. The post-test scores of both the experimental and the control groups were collated and analyzed using the t-test statistic to determine if there were any significant differences in the mean scores between the experimental and the control groups. The six dimensions of formal reasoning investigated were conservation, control of variables, combinational reasoning, proportional reasoning, probabilistic reasoning, and correlational reasoning.

RESULTS

The results of the study are presented in Tables 1, 2, 3, and 4.

The results in Table 1 show that there was a significant difference, p.< 0.05, between the mean scores of the experimental and control groups in formal reasoning, in favor of the experimental group after exposure to treatment. This indicates that science process-based instruction is potentially effective in increasing the students' reasoning ability. The results support the observation of Lawson (1985) that performance on formal reasoning tasks can be significantly enhanced if the right instructional medium is provided.

The results in Table 2 indicate that there was no significant difference in the performance of the control group in formal reasoning tasks before and after treatment. This shows that the lecture (traditional) method was not effective in enhancing the acquisition of formal reasoning in the subjects. This finding also supports the observation by Lawson (1983) that certain instructional methods are not effective in promoting the acquisition of formal reasoning ability in students. This study has shown that the didactic, chalk-and-talk instructional approach, is one of such methods.

The results in Table 3 show that among the students of the experimental group, 10 students (26.2%) were operating at the formal operational level, while 28 students (73.7%) were operating at concrete operational level before treatment started. The results indicate a very low performance in Piagetian formal tasks among the subjects. The results also show that 24 students (63.2%) were operating at the formal operational level, while 14 students (36.8%) were still operating at the concrete operational level after administration of treatment. It meant that 14 students, representing 37% of the sample, have moved from the concrete operational level to the formal

Table 1
Comparison of the Mean Scores of the Experimental and Control Groups in Formal Reasoning after Treatment.

Group	N	X	SD	df	t-value	P
Experimental group	38	4.45	2.19	74	1.81	0.048
Control group	38	3.58	1.98			

* = Significant at P<0.05

Table 2
Comparison of the Mean Score of the Control Group Before and After Instruction.

Groups	N	X	SD	df	t-valve	P
Control group before instruction	38	3.58	1.98	74	0.12*	0.47
Control group after instruction	38	3.53	1.96			

* =Not significant at P< 0.05

Table 3
Distribution of the Scores of the Control Group in the Reasoning Ability Test Before and After Instruction (N=38)

Reasoning Ability Level	Before treatment				After treatment			
	Number of the subjects at each of Reasoning Level		Total	%	Number of the subjects at each level of Reasoning		Total	%
	Male	Female			Male	Female		
Concrete level	14	14	28	73.7	8	6	14	36.8
Formal level	8	2	10	2.3	14	10	24	63.2
Total	22	16	38	100.0	22	16	38	100.0

stage as a result of the treatment. This is an indication that the process-based instruction was effective in improving the formal reasoning.

The results in Table 4 show that 10 students (26.3%) in the control group were operating at the formal operational level, while 28 (73.7%) were operating at the concrete operational level before exposure to instruction. The results also show that 14 of the students were operating at the formal level, while 24 were still operating at the concrete level after instructions. This shows that only 4 students (10%) attained formal reasoning after instruction. This is a relatively low improvement in acquisition of formal reasoning compared to the experimental group. It is an indication that the mode of instruction adopted in secondary schools in the teaching and of learning of science has the effect of either promoting or hindering the acquisition of formal reasoning ability.

DISCUSSION

The experimental group, taught using the Science Process-skill approach, performed significantly better than the control group taught using the traditional lecture method ($t = 1.81$, $p. < 0.05$). This shows that the process-based instruction used was effective in enhancing the acquisition of formal reasoning in the students, relative to the traditional lecture method. Lawson (1985) observed that students' formal reasoning ability can be enhanced through effective instruction. Jones (1983) also made similar observations.

Table 4
Distribution of the Scores of the Control Group in the Reasoning Ability Test Before and After Instruction (N=38)

Reasoning Ability Level	Before Treatment				After Treatment			
	No. of the subjects at each level of Reasoning		Total	%	No. of the subjects at each Reasoning level		Total	%
	Male	Female			Male	Female		
Concrete level	13	15	28	73.7	10	14	24	63.3
Formal level	9	1	10	26.3	12	2	14	63.6
Total	22	16	38	100.0	22	16	38	100.0

The effectiveness of process-based instructional strategy as a means of promoting reasoning ability may be attributed to the nature of the instruction. It is less teacher-directed and more learner-centered, and, thus, provides a variety of activities for the students to control their own actions in the process of learning. The relatively poor performance of the subjects in the control group in formal reasoning ability is an indication that the lecture method, usually used by science teachers in teaching science in Nigerian secondary schools, is not quite effective in promoting students' formal reasoning (Lawson, 1980). On the contrary, the results indicate that process-skills instructional strategy can promote the development of students' formal reasoning ability.

The findings of the study show that the existence of a wide range of the subjects' performance on GALT, where only some students successfully applied most of the formal reasoning abilities, while the rest could not do so, calls for an urgent need for teachers to identify the cognitive characteristics of their students prior and after instruction. GALT could be used as a suitable instrument to gain knowledge of students' formal reasoning ability prior to instruction. Such information could be used as a guide for science teachers in taking remediation steps that might be necessary in enhancing formal reasoning abilities of their students. The need to identify the formal reasoning ability of students prior to instruction seems to be an important pre-requisite to meaningful learning of science, and, thus, a major challenge to science teachers and science educators in the search for improved quality of science teaching and learning in Nigerian secondary schools, and, possibly, other developing countries of the world as well.

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