

## The Relationship between Acquisition of Science Process Skills, Formal Reasoning Ability and Chemistry Achievement

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### Abstract

*This study was undertaken to determine the relationship between acquisition of science process skills and achievement in science. The sample consists of 320 senior secondary II students from selected schools in Bauchi state, Nigeria. The instruments used were a test of logical thinking, test on process skills which were administered to the students as well as student's third term results from SSI examination in Chemistry. The students' scores on the three attributes were correlated using the Product Moment Correlation Coefficient. The findings showed a positive relationship between formal reasoning ability and acquisition of process skills, formal reasoning and chemistry achievement and acquisition of science process skill and chemistry achievement. The implication of and some suggestions were made for improvement of science teaching in our secondary schools.*

**Key words:** Science process skills, formal reasoning ability, chemistry achievement, logical thinking

Chemistry deals with abstraction, conceptual thinking, and generalization of facts, all of which require the use of cognitive (mental) processing. For students to achieve this, they must have attained the last level of Piaget's intellectual development, the period of formal operation which is usually from 12 years to adolescent. At period of formal operations the child's thought process becomes quite systematic and reasonably well integrated. The child thinks formally, logically and in abstraction. He is able to understand and transfer understanding from one situation to another. He shows a particular orientation to problem solving.

Much of what is taught in chemistry appear to require formal reasoning that is reasoning based on abstraction that transcends concrete experience. Poor performance in chemistry can therefore be attributed to lack of appropriate formal operational thought in the students.

Piaget and Inhelder (1969) discovered that many students find abstract subjects such as chemistry and physics difficult to learn. The difficulty is believed to be associated with the students' intellectual development. Most students are not able to apply knowledge acquired in the class environment to other situations including other class environments. This is due to not having an appropriate cognitive level of comprehension and application. Oloyede (1997) noted that;

“It is not unusual to find students who can describe the procedure for volumetric analysis perfectly but are unable to carry out the exercise in the laboratory. It is also not rare that students cannot link the dissolution of sugar in their tea to any chemistry activity carried out in the class talk less of relating such activities to home situations.”

Studies have shown that when secondary school students respond to Piagetian type tasks which Piaget asserts measures formal – operational thinking as much as between 50-70% of these students fail to demonstrate formal reasoning (Gyuse, 1990; Oloyede 1998; Demide 2000). Do these results indicate that a large percentage of students have in fact not developed formal reasoning abilities? Or do students fail to respond formally for other reasons?

If some secondary school and college students are indeed limited to concrete modes of thoughts, it seems reasonable to expect that these students would exhibit lower scores than their peers on aptitude and achievement measures in subjects such as English and Mathematics as well as in science in general and chemistry in particular.

The purpose of this study was therefore to investigate the relationship among formal reasoning ability, acquisition of science process skills and chemistry achievements.

The following research questions were raised;

1. Is there a relationship between students' formal reasoning ability and acquisition of science process skills?
2. Is there a relationship between students acquisition of science and chemistry achievement?
3. Is there a relationship between students' formal reasoning and science achievement?

### **Methodology**

The study subjects consist of 320 SS II students from eight secondary schools in Bauchi state, Nigeria. Forty students offering chemistry were used as study subjects in each school. The instruments used to collect data were;

1. The Test of Logical Thinking (TOLT) constructed by Tobin and Capie (1981), it has a reliability of 0.85 using Cronbach's alpha.
2. The test of Process Skills (TPS) constructed by Okey and Dillashaw (1980) with a reliability of 0.60 determined using the split half. Both tests were sensitized and found to be culture fair.
3. Students third term results in chemistry prodded the information on students' achievement.

The TOLT and TPS were administered to the 320 students and the mean of their scores from the achievement test computed. The data collected were analyzed using the product moment correlation coefficient.

### **Results and Discussion**

Data in *Table 2* reveal that;

- (i) The relationship between students formal reasoning ability and process skill acquisition is positive ( $r = .38$ ).
- (ii) The relationship between acquisition of science process skill and chemistry achievement is positive ( $r = .31$ ).
- (iii) The relationship between students formal reasoning and science achievement is positive ( $r = .30$ ).

*Table 1: Mean scores of the students on the various attributes*

Attribute	Mean
Formal reasoning	41.74
Process skill	45.90
Achievement	55.20

*Table 2: Correlation coefficient of the various attributes*

Attributes	Process Skill	Chemistry Achievement
Formal Reasoning	0.38	0.30
Chemistry Achievement	0.31	-
Process Skill	-	-

These correlations are not as high as were expected but they did show some positive correlations. These findings were in agreement with the work of earlier researchers. For instance, Danjuma (2005), Demide (2000) and Oloyede (1998) all agreed that formal reasoning is the strongest predictor of process science achievement. Shayer and Adey (1994) pointed out that operational reasoning abilities are significantly related to achievement. Bello (1993) reported that formal reasoning is positively related to science achievements. In the same vein, the works of Cantu and Herron (1978) and Tobin and Capie (1982) suggested that students that have learnt process skills think analytically and are more successful with new problems. This implies being more able to relate with and solve/answer questions in aspects of science including chemistry. This will lead to greater achievement. The findings of this study have therefore indicated that there is a positive relationship among formal reasoning ability, acquisition of science process skills and chemistry achievement.

### **Implications and Conclusions**

Students who can utilize formal thought tend to achieve more than the students who cannot utilize formal thought. It follows that students with low level of reasoning ability would be expected to have difficulty in understanding chemistry concepts and this could lead to poor achievement. Students equipped with science process skills tend to achieve higher than students with low process skills. This is because such students tend to reason intelligently and tackle problem situations more effectively leading to higher achievement. Students who are able to make use of formal thought are also able to solve problems beyond the capabilities of those who did not possess modes of reasoning. Moreover students who acquired process skills tend to think analytically and are more successful with new problems than those who do not possess process skills.

The implication of the above is that chemistry teachers should use the inquiry method starting from mere observations of simple objects and lead on to higher process skills which includes hypothesizing, inferring and predicting. Teachers should take more time in explanations, make use of graphic materials and also make use of simple examples to enhance learning. Chemistry teachers should engage students maximally with activities that should help them develop the spirit of enquiry through their exploration of nature from their local environment. This will help them in developing reasoning ability and also equip them with intellectual skills normally employed in the classroom as well as other life situations.

### References

- Bello, O. O. (1993). Secondary school chemistry students' reasoning skills and performance in chemistry. *Journal of the Science Teachers Association of Nigeria*, 28(1&2), 177-181.
- Cantu, L. I., & Herron, J. D. (1978). Concrete formal Piagetian stages and science concept attainment. *Journal of Research in Science Teaching*, 15(2), 135-143.
- Danjuma, I. M. (2005). *Relationship between students' mathematical problem solving skills and chemistry achievement*. Unpublished Ph.D thesis of Abubakar Tafawa Balewa University, Bauchi.
- Demide, C. O. (2000). *Cognitive intervention among senior secondary school students*. Unpublished M.Ed Thesis of Abubakar Tafawa Balewa University, Bauchi.
- Gyuse E. Y. (1990). *Predicting students chemistry achievement from their reasoning level*. Unpublished Ph.D Thesis of University of Jos, Jos.
- Shayer, M., & Adey, P. (1994). *Really raising standards. Cognitive intervention and academic achievement*. (1<sup>st</sup> ed.), London: Routledge.
- Okey, J. R., & Dillashaw, F. G. (1980). Test of the integrated science process skills for secondary science students, *Science Education*, 64(5), 601-608.
- Oloyede, O. I. (1997). *Relationship between students' cognitive level and the cognitive demand of the chemistry curriculum*. Unpublished Ph.D thesis of Abubakar Tafawa Balewa University, Bauchi.
- Oloyede O. I. (1998). The effect of present, feedback and overview on senior secondary school students achievement. *Journal of the Science Teachers Association of Nigeria*, 33(1&2), 26 – 31.
- Piaget, J., & Inhelder, B. (1969). *Judgement and reasoning in the child*. London: Routledge and Kegan Paul.
- Tobin, K. G., & Capie, W. (1982). Relationship between formal reasoning ability, loans of control, academic engagement and integrated process skills achievement. *Journal of Research in Science Teaching*, 19(2), 13-121.
- Tobin, K. G., & Capie, W. (1981). Development and validation of a group test of logical thinking. *Education and Psychological Measurement*, 41(2), 413-424.

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