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Relative Abstract Nature of the Three Core Science Subjects at the Senior Secondary Level in Nigeria as Exemplified by Classroom Interaction Patterns

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Abstract - This study examined relative abstract nature of Biology, Chemistry and Physics offered at the senior secondary schools (SSS) in Ankpa education zone of Kogi State of Nigeria based on the analysis of classroom interactions. In each of the three comparable public schools used, the same class of Senior Secondary 2 (SS 2) or 11th grade students were each taught Biology, Chemistry and Physics. In each school, reproduction, chemical kinetics and refraction were taught in Biology, Chemistry and Physics respectively. The researchers personally took record of interactions during the 9 periods (taught by 9 science teachers) lasting for 35 minutes each using Flanders' Interaction Analysis Categories (FIAC). Inter observer's rater reliability was 0.69 using Scott's Phi coefficient. Using a 10 by 10 matrix and percentage for final analysis, the extent of students' participation in the lesson which its decreasing order was used to estimate the degree of the abstract nature or difficulty experienced in each subject was determined. The result revealed that the physical sciences were more abstract than the biological science with physics having the highest index. There was no close match between teachers' level of motivation during the lessons and students' participation except in Biology. Consequent upon these, it was recommended that chemistry and physics teachers should always ensure that there is a close match between cognitive ability of learners and cognitive demands of the subjects or lessons taught; that concrete teaching materials be used in the two more abstract subjects to reduce the formal reasoning or abstract requirements in the lessons to concrete demand levels, among others.

Key words: Classroom interaction, abstract, cognitive ability, cognitive demand, motivation, teacher talk, student talk, concrete.

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Introduction

In a general sense, people equate abstract nature of a subject to its difficulty. Therefore, by implication a generally difficult subject could be said to be abstract or vice versa. This is premised on the assumption that teaching went on well in a conducive classroom environment.

The subject being abstract is one thing and the learner being capable of learning abstract things is yet another issue. For instance, cognitive scientists have shown variously that most learners are not able to reason abstractively at certain maturity age thereby finding learning materials that are abstract in nature or demand formal reasoning difficult (Achor, 2004, 2003; Prosser, 1983; Shayer & Adey, 1981). In particular, Achor (2004) found that 73.5% of senior secondary school (SSS) physics students who ought to be abstract or formal operators are concrete operators whereas 67.2% of the curriculum in use requires formal reasoning, an indication of mismatch. Furthermore, Shayer and Adey (1981) based on their studies over the years said that only about 30% of adults eventually use all the cognitive strategies characteristic of formal operational thinking; the 70% majority may find abstract or formal learning materials difficult.

Science subjects are generally regarded as difficult or abstract subjects. This may have influenced why a few opt for them except Biology at the senior secondary level (10^{th} to 12^{th} grade) compared to subjects in Arts and Social Sciences. Biology is a compulsory subject offered by non science students with Health Science as the only alternative in Nigeria. The Choice of Biology as against Chemistry or Physics again is another thing to worry. Aside its general application, could there be some reasons attributable to its abstract nature (high or low)? This begs the question of whether the extent of student participation during the lessons in each of these science subjects is comparable. In specific terms, could students' active participation in a lesson depend on how abstract they find a subject? Are there observable relationships between students' participation in a lesson and the abstract nature of the subject? Abstract in this paper therefore connotes difficulty. A subject could be regarded as abstract or difficult if it requires on the average higher or formal reasoning to understand or participate in the lesson during the teacher-learner interactions.

Flander Interaction Analysis Categories (FIAC) developed in 1959 show how classroom interactions between the teacher and the learner could be analyzed to point out what exactly happens in the class. Specifically, two of the major stages (student talk and silence) indicate the level of student participation. Implicitly, students who find a subject and a lesson abstract are expected to be less active in the class and perhaps observe some level of silence.

The Nigeria national policy on education (2004) regards Biology, Chemistry and Physics as core subjects offered in the secondary schools. Also, Chemistry and Physics are regarded as physical sciences while Biology is regarded as biological science. One wonders if this natural boundary is a factor in their abstract nature, and to what extent one can group these subjects on the basis of their abstract nature or difficulty. The undoing which this paper intends to address is, to what extent is there a possibility of making mostly non formal thinkers to learn a subject which may be considered abstract? It is on this premise that the need to have empirical evidence on the relative abstract nature of the three core science subjects (i.e., Biology, Chemistry and Physics) at the secondary school level is contemplated using Flanders' classroom interaction analysis approach.

Theoretical Basis for the Study

Interactions in science classroom have both human and pedagogical considerations. On the one hand, the extent of attainment in the class could be dictated by the extent of social cohesion between the teacher and the learners and among the learners. On the other hand, the extent to which the teacher could facilitate positive interaction in the class could also be dictated by the potentials developed by the teacher over the years in classroom management and teaching. The theory developed by Vigotsky, a Russian Scientist, becomes very relevant. Vigotsky (1978) based his theory on socio-cognitive and multi cultural principles. The social interdependence theory claims that learning should be socially mediated. By implication, the degree of social interaction in any class is assumed to influence learning. It is along this line that Johnson and Johnson (2000) reiterated that in real science classroom settings, interaction means the interdependence and active involvement of all in the social construction of learning. This theory emphases social orientation with conceptual growth, and equally stresses the role of culture and its transmission through social interaction within a shared cultural framework. This implies that learning should be based on learners' culture and sub-science culture, a fact that places this theory within the confines of constructivism.

Further, Vigotsky (1978) says that the more socially skillful students are and the more attention teachers pay to teaching involving the learners in activities through the use of social interaction, the more it would lead to the achievement of self goals. The implication of this theory for the present study is that whatever happens within the confines of the science classroom is expected to transmit into sub science culture and facilitate understanding through the student-student, student-teacher interactions as well as the restrictions placed by the procedure for gathering data. However, for this study too, the level of abstract of the content (which also means the subject) is considered a factor that could be revealed from the interaction. This means that ability of both the teacher and the learner to handle the abstract nature of the subject would reflect in the relative interaction patterns for the subjects which could culminate into extent of student participation.

Another relevant theory to the present study is Piaget's theory of cognitive development. Piaget (1970) talks about four major developmental stages of man; sensory motor, pre-operational, concrete operational and formal (or abstract) stages. He further stresses that when chronological age and developmental age rhyme, the learner is more likely to learn materials expected for his/her age or class. However, if there is a mismatch between the chronological age and the developmental age, there is the likelihood that the learners may not be able to learn what is expected for their age or class. Researches over the years have confirmed that many learners do not transit from the concrete stage to formal stage going by the prescribed chronological age by Piaget (Achor, 2003, 2004; Proser, 1983; Shayer & Adey, 1981). By implication, such students who form the majority in most classrooms in secondary schools (e.g. Achor 2004 talks about 73.5% from the study conducted in Nigeria while Shayer & Adey talk about 70% based on studies conducted elsewhere) may remain inactive in their classrooms if they find the subjects/contents abstract. Therefore abstract in this study is expected to be exemplified by the non participation or less interaction between teacher and students in the class.

Research Method

Emphasis of this type of study is on the number of classes observed and particularly the records of interaction per class. In all, three schools who had presented students for public examinations (i.e., West African School Certificate Examination, WASSCE and National Examination Council, NECO) in the three core sciences for a minimum of five years were randomly sampled out of 12, and used in the study. In each of the three schools, three Senior Secondary 2 (SS 2) or 11th grade teachers (one for each subject) were observed while teaching biology, chemistry and physics for 35 minutes giving a total of nine teachers.

To allow for comparison, only professional graduate teachers who had between five and six years teaching experience from three public schools in Ankpa Education Zone of Kogi State of Nigeria were randomly sampled to teach each of the three subjects. The content taught during the study was the same and new in all classes as agreed upon by all participating teachers.

Senior Secondary two (SS2) or the 11th grade was the study class. The decision to use SS2 (or 11th grade) was based on the fact that the class is stable. It is neither facing the problem of being freshly introduced to senior secondary core sciences (as in the case of SS1 or 10th grade) nor preparing for any end of course or terminal examination (as in the case of SS3 or 12th grade). It was, therefore, easy to obtain permission of the school authorities to use them. The same groups of students were taught biology, chemistry and physics in each school to take care of differences that could arise due to differing entry behavior. In each school, reproduction, chemical kinetics and refraction were taught in Biology, Chemistry and Physics respectively.

The instrument adapted for use in the study was Flander's Interaction Analysis Categories (FIAC). It was developed by Ned A. Flander in 1959 at the University of Minnesota. In FIAC, the total classroom interaction is arranged into four major sections.

a. Indirect teacher-talk influence

b. Direct teacher talk influence

c. Student talk

d. Silence

Categories C & D are directly relevant to the present study.

Details of all the categories include:

a. *Indirect teacher-talk influence*

1. Accepts feeling

2. Praises or encourages

3. Accepts or uses ideas of students

4. Asks questions

b. *Direct teacher- talk influence*

5. Lecturing

6. Giving directions

7. Criticizing or justifying authority

c. *Student talk*

*8. Response

*9. Initiation

d. *Silence*

*10. Silence or confusion.

Details are contained in the original document (Flander, 1970). Items with asterisks, i.e., items 8, 9 and 10 were considered to have direct bearing to this study. However, because silence or confusion could be introduced either through the teacher or the learner, item 10 is particularly de-emphasized in this study. Talk by students in response to teacher and talk initiated by students, expressing their own ideas, initiating a new topic, freedom to develop opinions and line of thought, going beyond the existing structure are assumed to have a strong link to their level of understanding of the lesson or how abstract the lesson is to them. Therefore, in this study records of classroom activities attributable to items 8 and 9 would be interpreted directly as index of their understanding of the lesson. By implication, the higher the records of activity the higher is their index of understanding and, the lower their records of activity under items 8 and 9, the lower also is their index of understanding or the higher is their index of difficulty (i.e., the abstract nature). Thus, as their level of understanding increases, the level of difficulty or abstract nature decreases and vice versa.

The instrument has assumed that all interactions in the classroom could be grouped into these 10 unit (or four major) categories, which are all measured by one form of acts of verbal expression or the other. Though non-verbal acts of influence do occur, they are rarely recorded by interaction analysis. This is supported by the fact that verbal behavior of the teacher is consistent with his non-verbal gestures (Chauhan, 1979). Verbal behaviors of the teachers could be observed with higher reliability (Anwukah, 1990; Udoh, 2008). It equally determines to a large extent the reactions of the students and, also under the teacher's control could be used to advantage to modify students' behavior. In this study, though emphasis was on verbal behaviors of the teachers, a few non-verbal behaviors such as gestures, nodding for approval were recorded.

There are 14 ground rules put in place by Flander to help in developing consistency in trying to categorize teacher behavior. The rules were adapted in this study (e.g Chauhan, 1979).

Since there are 10 unit items of observation on FIAC and as recommended by the author, a 10 by 10 matrix (i.e. the minimum) was developed. This was a result of taking records of activities of the teacher and the learners in the classroom including periods of silence every 3 seconds for a total of 35 minutes for the nine classes. What constitutes the data for this study is a cumulative record of observations for each of the three classes and subjects by two observers.

Inter-observer rater reliability was estimated using Scott's Phi-coefficient formula. The reliability coefficient was found to be 0.69.

The data collected were further transformed into what could be interpreted. A 10 by 10 matrix was constructed with the data. The figure under each unit item on FIAC was converted into percentages. Ratio was also used to allow for comparison of the three subjects at a glance.

Results

The results of this study are presented in two stages. The first stage, as shown in Table 1, is the general analysis of interaction showing the student related items alongside other items for easy comparisons. The second stage is as presented in Table 2 whereby the relationship between the three science subjects (i.e., biology, chemistry and physics) by way of their abstract nature or difficulty is shown in ratio form.

Table 1 Percentage analysis of classroom interaction patterns in the three core Science subjects

Categories		**Interactions**	
	Biology	Chemistry	Physics
A) Indirect Teacher Talk influence			
1. Accepts feelings	20(8.1%)	7(2.8%)	9(2.5%)
2. Praises or encourages	20(8.1%0	30(11.9%)	40(11.2%)
3. Accepts or uses ideas of students	42(17.0%)	30(11.9%)	80(22.5%)
4. Asks questions	7(2.8%)	7(2.8%)	20(5.6%)
Total	**89(36.0%)**	**74(29.4%)**	**149(41.8%)**
B) Direct Teacher Talk influence			
5. Lecturing	36(14.6%)	65(25.7%)	130(36.5%)
6. Giving directions	30(12.1%)	45(17.8%)	28(7.9%)
7. Criticizing or Justifying authority	16(6.5%)	35(13.8%)	18(5.1%)
Total	**82(33.2%)**	**145(57.3%)**	**176(49.3%)**
C) Student Talk			
8. *Response	40(16.2%)	18(7.1%)	9(2.5%)
9. *Initiation	30(12.1%)	10(4.1%)	10(2.8%)
Total	**70(28.3%)**	**28(11.1%)**	**19(5.3%)**
D) Silence			
10. Silence or confusion	6(2.4%)	6(2.4%)	12(3.4%)
G. Total	**247(100%)**	**253(100%)**	**356(100%)**

In Table 1, the percentages across the three subjects and for items 8 and 9 are indicative of how high students participated in the lesson. Under students' response it is 16.2%, 7.1% and 2.5% for biology, chemistry and physics respectively. Similarly, under students' initiation it is 12.1%, 4.1% and 2.8% for biology, chemistry and physics in that order.

Table 2 Ratio of interactions in Biology, Chemistry and Physics under student talk with respect to physics

Category: Student Talk	Interaction Ratio		
	Biology	Chemistry	Physics
A) Students' Response	(16.2%) 6.4	(7.1%) 3.0	(2.5%) 1.0
B) Students' Initiation	(12.1%) 4.3	(4.1%) 1.4	(2.8%) 1.0

Table 2 expresses the ratio of the percentage of activities for each of the three subjects with respect to physics being the least for students' response and students' initiation. For instance, the ratios of 1: 3: 6.4 for physics, chemistry and biology respectively show that physics has the least and biology has the highest records of participation by students for students' response. Similarly, the ratios of 1: 1: 4.3 for physics, chemistry and biology respectively under students' initiation was obtained.

Discussion

A close examination of Table 1 reveals that biology appears to strike a balance between indirect teacher talk influence, direct teacher talk influence and student talk (i.e., the 3 major subdivisions of FIAC) compared to that of chemistry and physics. For instance, we have for Biology 36.0%, 33.2% and 28.3%; for Chemistry 29.4%, 57.3% and 11.1%; and for Physics 41.8%, 49.3% and 5.3%. Apparently, students' participation records are far too low for chemistry and physics with physics being the least (5.3%). This finding is corroborated by the relational ratio for the 3 subjects which is 1:3:6.4 under students' response for physics, chemistry and biology respectively. It appears that the extent to which the students could respond to teachers' questions or contributions to teacher initiated statements is limited by their understanding of the lesson. Therefore, where the lessons appear difficult, abstract and cannot be conceptualized, the students will be at sea on what to say or provide as answers to questions raised by the teacher and therefore do not make any response.

On the contrary, the relational ratio for the 3 subjects under students' initiative is 1.0:1.4:4.3 for physics, chemistry and biology respectively. It thus appears that the experienced abstract nature or the students’ inability to relate the lessons to their environment could have seriously affected their initiatives. For instance, physics and chemistry that are physical sciences appear to be more difficult for students to conceptualize in the class and make inputs. However, biology that could be easily applied to life, environment and visualized had higher records of activity during the observation period.

Table 1 also reveals a sharp disagreement between motivationally related items (i.e., items 1, 2, 3, 6, and 7) and students’ participation in the lesson (i.e., items 8 and 9). This appears to contradict earlier views. For instance, Achor and Orji (2009) and Chauhan (1979) identify items 1, 2, 3, 6 and 7 to stimulate motivation and invariably leading to improved performance. With high level of motivation by the teacher as indicated by records of activity in Table 1, one expects a similarly high record of student participation in the lesson. Udoh (2008) records that class room interaction of chemistry teacher was not lively enough as only insignificant percentage participated in the lesson. Shuaibu and Iroegbu (2003) express that the classroom behaviour of teachers has motivational effect on the learning process and on the performance of the students. For instance, despite the high motivation in physics (i.e, 11.2% for praises and encouragement and 22.5% for acceptance or use of students’ ideas), the same student’s record of response during the lesson stood at 2.5%. Further, Shuaibu and Iroegbu (2003) reveal that even the students that are intellectually competent need teachers’ leadership for motivation and achievement. One wonders why the result of this study is to the contrary. A possible explanation could be that the lesson (both content and cognitive development level) may have to be at the student available mental schemas to be able to consummate it. By implication, if a lesson and a subject appear abstract to the learner, even high level of motivation of the learner by the teacher in the class may not have much influence; it appears like putting the cart before the horse. Accordingly, while physics and chemistry appear to be at higher cognitive demands compared to the cognitive ability of the students, biology seems not to experience such mismatch. The corollary is that biology must have appealed to the sense of vision in addition to hearing in forms of concrete shapes, models, charts, the students’ physical body, ’realics’ (real life objects) probably used as teaching aids or illustrative activities that students can call to remembrance quite unlike physics and chemistry except during practical that come once in a while. Since the same group of students participated in each school for the three subjects indicating same cognitive ability across the subjects, biology must have been presented mostly at concrete levels using concrete materials or its lesson objectives demanding a reasoning level that was probably available to the learners.

Conclusion and Recommendations

One of the findings of this study has implicated the physical sciences as being more abstract than the biological science with physics having less participation by students, an indication of high abstract nature. The ratio of responses of the students during the lesson is 1:3:6.4 for physics, chemistry and biology respectively and 1.0:1.4: 4.3 for their initiatives in the same order. Based on the findings and discussion, the following recommendations are advanced:

1. For teachers' motivation during a lesson to be effective, he should ensure that the mental schemas of the learners is not at variance with the cognitive requirement of the lesson taught i.e., should watch out for mismatch.
2. Biology appears to have advantage over the physical sciences because of the possibility and availability of concrete materials for use during the lesson and perhaps its direct application to life. The physical sciences need to be stepped down in terms of demand level by using concrete materials during the lesson to avoid mismatch. Achor (2003, 2004) and Prosser (1983) similarly recommended that teachers should strive to present materials demanding formal reasoning at concrete levels using concrete materials.
3. The trend in the finding especially with the physical sciences calls for a replication of this study to include mathematics. The assumed relationship of physics with mathematics in terms of their abstract nature would be laid bare through such study.

References

Achor, E E & Orji, B C (2009). Level of students' motivation in classroom interactions in Integrated Science. *Journal of Research in Curriculum and Teaching*, 4(1), 294-303.

Achor, E E (2004). The relationship between curriculum demands and physics achievement of senior secondary school students in Kogi *State. Journal of the National Association of Science, Humanities and Education Research*, 2(1), 20-26.

Achor, E E (2003). Cognitive correlates of physics achievement of some Nigeria senior secondary students. *Journal of Science Teachers Association of Nigeria*, 38(1&2), 10-15.

Anwukah, T. G. (1990). An after use reflection on the observation technique of interaction analysis, procedure and limitations. *International Journal of Education Research*, 4, 6-123.

Chauhan, S.S. (1979). *Innovations in teaching learning process*. New Delhi: Vilas publishing House.

Flander, N. A. (1970). *Analyzing teacher behavior*. Addison-Wesly: Reading Mass.

FRN (2004). National policy on education. Yaba, Lagos- Nigeria: NERDC press.

Johnson, D. W. & Johnson, R. T. (2000). Cooperative learning method. University of Minnesota, http://www.co-operation.org. Retrieved 22/05/09.

Piaget, J. (1970). Piaget theory. In P.H. Musen (Ed.): Garnichael's manual of child psychology (703-732). New York: Wiley.

Prosser, M. (1983). Relationship between the cognitive abilities of a group of tertiary physics students and the cognitive requirements of their textbooks. Science Education, 67(1), 075-083.

Shayer, M & Adey, P (1981). *Towards a science of science teaching: Cognitive development and curriculum demand*. London: Oxford Pub.

Shuaibu, A.A.M & Iroegbu, N. (2003). A study of the relationship between parents and teachers' motivational support and secondary school students' achievement in science. *Jos Journal of Education*, Vol.6, No.2, pp.114-121.

Udoh, A. O. (2008). An analysis of classroom interaction of senior secondary school chemistry teachers in Ikot Ekpene Local Government Area of Akwa Ibom State Nigeria. *Journal of Science Teachers Association of Nigeria*, 43(1&2), 16-22.

Vigotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Pub.