RELATIONSHIPS BETWEEN STUDENTS' TASK ENGAGEMENT AND LEARNING OUTCOMES IN CHEMISTRY

Orji, Nna Sunday
Nigerian Educational Research and Development Council (NERDC), Sheda, Abuja
C/o Box 895 Gwagwalada, Abuja;
E-mail: nsorji@yahoo.com;
Phone No: +234-806-925-9978

Abstract
To promote Science and Technology at the classroom level, for national growth and global competitiveness, nations are now paying more attention to various aspects of student efforts in the learning of science. This study investigated Students' Science Task Engagement in relation to their learning outcomes (attitude and achievement) in Chemistry. A stratified sample of 60 students drawn from 10 schools was used in the study. The student task engagement record (STER), a classroom observation instrument, was used to record students' on-task and off-task behaviour (engagement) during chemistry lessons. At the end of the observation period (6 weeks), the Chemistry Achievement Test (CAT) and chemistry Attitude Questionnaire (CAQ) were administered to ascertain students' chemistry achievement and attitude respectively. The engagement scores of the students were correlated with their achievement and attitude scores using Pearson's product moment correlation. Students' task engagement was found to have significant, positive correlation (r = .74) with achievement in chemistry; and non-significant negative correlation (r= -0.03) with attitude toward chemistry. It was therefore recommended that strategies for promoting task engagement should be taught and promoted in schools. Both practicing and trainee science teachers should build capacity in fostering engaging learning activities.

Introduction
Advancement in Science and Technology has become a global phenomenon; science now permeates almost all facets of human endeavor, and nations are increasingly investing huge resources into the 'doing' and 'learning' of science for development and global competitiveness. Consequently, scientists and science educationists are today more recognized as playing crucial roles in advancement. At the classroom level, students' active involvement in 'doing' and 'learning' of science is being regarded as a predictor of success in and sustainable advancement of science (Adesoji, Ige, Iroegbu & Olagunju, 2003).

Several researches (Chapman, 2003; Cangelosi, 1993; Capie and Tobin, 1981; Orji, 2011; and Yair, 2000) have studied students' engagement in relation to academic achievement and attitude. They assert that student variables – including their pursuits (efforts) or active participation influence their learning outcomes. Students' active involvement in science task is regarded as a predictor of success in science; and is a mark of high performing schools and high achieving students (Howe & Raleigh, 1996).

Researchers (Chapman, 2000; Sandholtz & Dwyer, 1994; and Orji, 2011) proffered various definitions of students' engagement based on their individual perspectives of students' engagement; their theoretical inclinations (whether sociological, psychological, ecological or cognitive); the aspect of student activity they wish to monitor; and their purpose for and use of the study. According to Orji (2011), students' engagement refers to students' mental and social involvement in learning task. He described it by sociological factors (feeling belonging, cooperation and group work), psychological factors (interest personality, motivation) and situational factor (institutional classroom variables). This description agrees with the assertion that 'human is made up of cognition (have cognitive ability) and is a social being (Piaget, 1978 & Knowles, 1978 in Orji, 2011).

Orji (2011) cited studies (Cangelosi, 1993; Courtney, 1989; Knowles, 1978) that focused on sociological indicators of student engagement (the need to be part of an activity, pressure from peers, expectations and values) with emphasis on 'cooperation', 'involvement', 'participation', 'taking-part-in' and 'attendance' in an organized social activity. Other studies (Piaget, 1978 and Lowe, 1970 in Orji, 2011) focused on psychological indicators (interest personality, motivation) such as 'involvement', 'attentiveness', 'student initiative', 'curiosity' and 'enthusiasm'. There are also the ecological or situational/institutional explanation /determinants of student engagement. For instance, conducive classroom climate and instructional management promote students' task engagement (Chapman, 2003; Cangelosi, 2000).

Chapman (2003) cited some researches (Brophy, 1983; Fisher et al., 1980; McIntyre, et al., 1983) that made use of time-based indices (e.g. time-on-task) to describe overt student engagement, and others (Dintrich & De Groot, 1990; Pintriah's Schranben, 1992) that described cognitive engagement (covert engagement). He described student engagement as student's "willingness" to participate in routine school activities such as attending classes, submitting required work and following teachers' directions in class.

Task engagement includes students' psychological presence in or focus on task activities and is often manifested in the time and effort that people devote to a particular activity; it includes students' affective responses to learning task (Orji, 2006). According to Newman (1986) cited in Sandholtz and Dwyer (1994), student engagement involves students' devotion of substantial time and effort to a task, and their concern for quality of their work, and their committing themselves because the work seems to have significance beyond its personal instrumental value.

Measuring Student Task Engagement

Various measurements of student task engagement have appeared in several researches (Adeyele, 1987; Beasley, 1983; Chapman, 2003; Capie and Tobin, 1981; Kounin, 1970; McIntyre and O'Hair, 1996; Orji, 2011; Ramadas & Kulkami, 1982). Chapman (2003) measured students' cognitive, behavioral and affective task engagement using 'time-on-task', 'involvement' and 'willingness to participate' index. He measured the extent to which students were attending to and expending mental effort in the learning task (use of cognitive and meta-cognitive strategies); the extent to which students actively respond to the tasks (asking relevant questions, solving task-related problems, and participating in relevant discussions with teachers/peers); and the level of student's investment in and their emotional reactions to the learning tasks (e.g. high levels of interest or positive attitudes towards the learning tasks). His instruments for assessing student task engagement included student self-report measures, checklists and rating scales, direct observations, work sample analysis, and focused case studies.

Orji (2011) utilized index of participation that emphasize 'effort-on-task' rather than 'time-on-task'. He noted that measurement of student engagement/participation could be on individual basis (that is by judging acts of individual students who performed them) or on whole-class or group–basis (measuring total number of students involved in required task). He also used terms such as 'intensity', 'extent', 'forms' and 'degree' of participation in learning activity as criteria for measuring and describing engagement. Using questionnaires, checklists and participation chart/scale, he measured participation index of motivation, interest, activity, appearance, attentiveness, attitude/values, concern for skill, contribution to group discussions, earliness to class, emotional balance, helpfulness in class, home work submission, independent study, influence popularity, initiatives, interest in study, motivation, outspokenness, regularity of attendance, responsibility self-control and social interaction.

Adeyele (1987) measured students' participation during classroom/laboratory interaction using a 5-point student classroom participation scale (SCPS). Student activities included: questions, answers, discussions, students work on problems or writing of answers, material provision or improvisation by students, attentive involvement of student (listening), suggestions, utilizing opportunity to participate, copying notes on dictation, and sharing of jokes to releases tensions. Ramadas and Kulkarni (1982) measured student engagement in terms of spontaneous participation of pupil and pupil initiation, taking note of: the frequency of occurrence of spontaneous responses; and the time during which there were no individual responses and most of the pupils were showing a lack of interest.

Beasley (1983) adapted the approach of Kounin (1970) for measuring observed pupil task involvement behaviours. Students were rated as 'definitely in', 'probably in', 'waiting' and 'out' of the task. The task engagement included: student performance of requested activity, listening, watching, answering questions, writing note, watching teacher, watching demonstration, manipulating apparatus, collating data, reading and solving problems and summarizing material. According to Capie and Tobin (1981), it is important the observer makes two inferences relative to each pupil observed: "what does the teacher expect to be the focus of the pupils' attention? And "is the pupil indeed attending to the desired focus?" The percentage of positive responses becomes the on-task rate for the pupil or the class and multiplying this by the allocated time yields the actual engaged time for a lesson. Other researches prefer to use of the 'time indices', rather than frequency/effort indices to measure student task engaged (Johnson & Butts, 1983; McGarity and Butts, 1984; Sandholtz & Dwyer, 1994). This study used "on-task" and "off-task" index to record student engagement in science.

Student Task Engagement in Science

Students' active engagement is crucial for success in science, considering the nature of science and science learning. Johnson and Butts (1983) studied student science achievement in relation to engaged time (observed and perceived), and personal characteristics of academic aptitude, reasoning ability, attitude towards science, and locus of control. Engaged time was positively related to achievement, reasoning ability, attitude and locus of control, but negatively related with academic aptitude. Ramadas and Kulkarni (1982) found that relating science content to students' experiences, cooperative learning, and use of teaching aids and experiments enhanced task engagement in science. Problem-solving activity or process-skill activities have also been shown to promote students' engagement (Simpson and Troost, 1982; Bloom, 1980 in Tobin, 1986).

Shymansky and Penick (1977) in Orji (2006) investigated the relationship between students' self-perception, problem-solving and engagement in science task. They found that students' willingness to take charge of their learning with the materials and activities on hand fosters engagement. Okebukola and Ogunniyi (1986) asserted that teachers' direct/indirect verbal behaviours affect student participation; while Capie and Tobin (1981) suggested the promotion of science engagement through group work.

Problem and Objective of the study

Low attitude and poor achievement in the sciences have been the concern of education stakeholders in developing countries including Nigeria. More worrying are students' recurring dis-engagement, ill-motivation, absenteeism and disinterestedness during chemistry lessons which tendencies are said to impact negatively on their school success.

This study, therefore, focused on science task 'engagement' and its relation to students' achievement and attitude chemistry. It sought to obtain information about the pattern and nature of student involvement in science learning task; as well as to ascertain the relationship between students' 'on-task'/'off-task' behaviours and their achievement in and attitude towards chemistry.

Research Questions

This study sought to address the questions:

1. What is the nature and extent of students' task engagement in chemistry?
2. What is the relationship between students' task engagement and
   (i) Achievement in chemistry?
   (ii) Attitudes towards chemistry?

Hypotheses

The following hypotheses were tested in the study:

HO_1: There is no significant relationship between students' engagement and their achievement in chemistry

HO_2: There is no significant relationship between students' engagement and their attitude towards chemistry

Methodology

Research Design

The study used correlation design. This descriptive survey allowed the researcher to investigate the nature and extent to which variations in student task-engagement corresponds with variations in students' achievement and attitude towards chemistry. It did not, however, seek to determine cause-effect relationship among the variables. Recent studies (Chapman, 2003) utilized correlation design to investigate students' engagement in relation to learning outcomes.

Sample and Sampling Techniques

The study population included the entire SS II science students of all secondary schools in Ibadan, Oyo State. 10 public secondary schools that offer chemistry at the SS II level were randomly selected for the study. From these, 60 SSII chemistry students (6 per school) were selected by stratified random sampling. The 6 selected students were from same science class and had average achievement scores in chemistry [ascertained via school records].

Instrumentation

Data were collected using a direct classroom observation instrument - the Student Task Engagement Record (STER) and 2 questionnaires - Chemistry Achievement Test (CAT) and Chemistry Attitude Questionnaire (CAQ) developed by the researcher and validated by science education experts.

The Student Task Engagement Record (STER) is a two-point scale for recording student overt task-engagement (appendix Ia). Each of the six selected students is observed in 20 second turns. STER classified students' behaviour as: 1 = engaged behaviour (on-task) and 0 = non-engaged (off-task). Evidence of engaged behaviour included students' activities of:

(i) Physically attending; looking at the teacher or the chalkboard;
(ii) Working at desk i.e., taking notes from the lecture or chalkboard; and
(iii) Interaction with teacher or students; such as, asking questions, responding to questions, or commenting on the objective-related issues.

Any behaviour that was not classified as one of the above was judged to have been non-engaged or off-task. Inter-raters reliability coefficient of 0.65 was obtained for the instrument [comparing ratings from two independent concurrent observation of students' engagement during a chemistry lesson].

The Student Chemistry Achievement Test (CAT) is a 30-item multiple choice objective test (4 options) covering the topics: Acids, Bases, Salts and Carbon/Carbon Compounds. These topics, contained in the term's scheme of work, were covered by the teachers at the study period. Science Education experts subjected the test to face validation; while test blueprint (see appendix III) ensured content validity. A test-retest reliability coefficient of 0.72 was obtained for the CAT. This was calculated by comparing two sets of scores by 25 students who took, at two weeks intervals, two versions of the same test with test items rearranged.

The Chemistry Attitude Questionnaire, CAQ (appendix II) comprised a 30-item scale with 4-point loading ranging from strongly Agreed (SD) to strongly Disagreed (SD). It gave a Crombach alpha reliability coefficient of 0.68. The CAQ specification include statements on: 'Likeness for chemistry', 'Emotional climate of the chemistry classroom', 'Chemistry curriculum', 'Chemistry teacher', 'Physical environment of the chemistry classroom/laboratory', 'Friends' attitude towards chemistry', 'Achievement motivation', 'anxiety', and 'Chemistry self-concept' (see appendix III). Experts in science education provided face validation for it.

Procedure for Data Collection and Analysis

The principals (Head teachers) of the selected school granted the researcher their consent to visit and observe intact classroom lessons in chemistry (Acid, Base, Salt, and Carbon/Carbon Compounds). These lessons were already in the SSII science curriculum/scheme of work for the term. Participant observation was used. Only the researcher observed and scored the STER to ensured uniform scoring across the selected students and schools. At the outset of observation, all students choose their seating position but were requested to maintain their sitting position for the remainder of the observation periods. Student locations were numbered to allow for stratified random selection of 6 students [school record was consulted to ensure that the 6 selected students were representatives of the class in terms of aptitude/achievement.

Each selected student was observed for 20s to determine whether they were engaged or not - using criteria spelt out in the instrumentation; the engagement status was scored as 1 or 0. The observations continued for rest of the lesson period moving from first student to the sixth. The STER shows interval of 2-min observation time (20s each of the 6 students) and 2-min interval break [the break allowed for scoring and observation of other teacher variables not reported in this study].

Same topics were taught across the classes/schools observed, and the CAT and CAS were administered during the last week of the classroom observations (which lasted 4-6 weeks). Each class was observed three times for the research (at least once each week).

The data from the continuously coded STER (Appendix I), the CAT and CAS were analyzed using Pearson's product moment correlation and simple descriptive statistics. Average scores for each of the ten schools were calculated and correlated. Specifically, the SPSS 15.0 for Windows Version was used for the analysis.

Results

The research question 'What is the nature and extent of students' task engagement in chemistry?' is answered by tables 1. Table 1 shows simple statistics of various variables including Task Engagement (STDTASK) for all 10 classes.

Table 1: Simple Statistics for the 3 Variables: STDTASK, ACHIVT & ATTITUDE

Variable	N	Mean	Std Dev	Sum	Min	Max	MaxExp	½ Max
STDTASK	10	11.2600	1.0069	112.6	9.0000	12.6000	15	7.5
ACHIVT	10	12.1200	2.9491	121.2	5.3000	15.3000	30	15
ATTITUDE	10	90.9250	3.4378	909.3	83.3000	96.2500	120	60

Table 1 shows a STDTASK mean score of 11.26 (Std = 1.0069, Min = 9, Max = 12.6) for all 60 students, which is more than half the maximum expected value (Max_e = 15; each student was observed 15 times during a 45-minute lesson period). This indicates an overall high task engagement. There is also a pattern of high task engagement within each of the 10-science classroom observed (Appendix 1b).

HO_1: There is no significant relationship between students' task engagement and their achievement in chemistry. Table 2 contains the Pearson's product moment correlation between student task engagement and achievement in Chemistry.

Table 2: Correlation analysis for students' task engagement (STDTASK) and achievement in chemistry (ACHIVT)

		STDTASK	ACHIVT
STDTASK	Pearson Correlation	1.00000	0.74366
	Sig. (2-tailed)		0.0273
	N	60	60
ACHIVT	Pearson Correlation	0.74366	1.00000
	Sig. (2-tailed)	0.0273	
	N	60	60

Table 2 reveals a strong, positive and significant correlation between students' task engagement and achievement in chemistry ($r = 0.74$; $p<0.05$). This suggests that increase in students' task engagement corresponds with increase in achievement in chemistry. The null hypothesis Ho_1 is, therefore, rejected.

HO_2: There is no significant relationship between student task engagement and students attitude toward chemistry. Table 3 shows the Pearson's correlation between students' task engagement and attitude towards chemistry.

Table 3: Correlation Analysis for students' task engagement (STDTASK) and attitude towards chemistry (ATTITUDE)

		STDTASK	ACHIVT
STDTASK	Pearson Correlation	1.00000	-0.02869
	Sig. (2-tailed)		0.8277
	N	60	60
ACHIVT	Pearson Correlation	-0.02869	1.00000
	Sig. (2-tailed)	0.8277	
	N	60	60

Table 3 shows a weak negative, insignificant relationship ($r = - 0.03$; $p<0.05$) between students' task engagement and attitude toward chemistry. This near zero correlation suggests that task engagement and attitudes in chemistry are almost independent of each other. Therefore, the null hypothesis Ho_2 <u>is not</u> rejected.

Discussion/Recommendations

Students' science task engagement was found to have significant positive relationship with achievement in Chemistry. That is, students with higher level of task engagement scored higher in achievement test. This finding agrees with Orji (2011) and Johnson and Butts (1983) assertion that learner variables – including their pursuit (efforts) or active participation influenced learning outcomes. On the contrary, no significant relationship was found between students' task and attitude towards chemistry suggesting that any trend between students' engagement and attitude was a chance occurrence.

The study therefore makes the following recommendations:

(i) In addition to exposure to subject contents, students should be taught "what it takes to be actively engaged in science lessons;
(ii) Science teachers should seek practical ways to foster students' engagement for academic excellence;
(iii) Pre-service and serving teachers should be trained on designing and conducting appropriate learning task that will physically, mentally and socially engage students;
(iv) Schools should create enabling environment for student cooperation, as well as pay attention to factors that encourage students' willing and motivation to devote substantial time and effort to learning tasks.

Conclusion

Promoting science and technology for national growth and global competitiveness has been the priority of nations. At the classroom level, educationists and researchers are now focusing on the contribution of students' variables to successful learning and doing of science. This study sought to ascertain the relationship between students' science task engagement and achievement and attitude toward chemistry. It found that students' engagement had positive significant relationship with achievement, but was insignificantly related with attitude. Thus, school science improvement projects should target preparing and motivating students' for active task engagement in science.

References

Adeleye, F. B. (1987). *The relationship between teacher questioning styles and students' classroom participation and achievement in biology.* Unpublished Doctoral Dissertation, University of Ibadan, Ibadan.

Adesoji, F. A., Ige, T. A., Iroegbu, T. O. & Olagunju, A. M. (2003). Innovations in science teaching for new millennium. O. Ayodele-Bamisaiye, I. A. Nwazuoke and A. Okediran (Eds) *Education this Millennium – Innovation in Theory and Practice.* Ibadan: Macmillan Publishers.

Beasley, W. (1983). Teacher management behaviours and pupil task involvement during small group laboratory activities. *Journal of Research in Science Teaching, 20 (8), 713 - 719.*

Capie, W. & Tobin, K. (1981). Pupil engagement in learning tasks: A fertile area for research in science teaching. *Journal of Research in Science Teaching, 18, 409 - 417.*

Cangelosi, J. S. (1993). *Classroom management strategies: Gaining and maintaining students' cooperation*. London: Longman.

Chapman, E. (2003). *Alternative Approaches to assessing student engagement rates. Practical Assessment, Research & Evaluation, 8* (13). Retrieved from http://PAREonline.net/getvn.asp?v=8&n=13.

Howe, A. C. & Raleigh, N. C. (1996). Adolescents' motivation, behavior and achievement in science. Retrieved from http://www.narst.org/publications/research/Adolescent.cfm

Johnson, T. F. & Butts, D. P. (1983). The relationship among college science student achievement, engaged time, and person characteristics. *Journal of Research in Science teaching, 20 (4), 357 - 366.*

Kounin, J. S. (1970). *Discipline and group management in classrooms*. New York: Holt, Rinehart & Winston.

McGarity, J. R. & Butts, D. P. (1984). The relationship among teacher classroom management behaviour, student engagement and student achievement of middle and high school science students of varying aptitude. *Journal of Research in Science Teaching,* 21, 55 - 61.

McIntyre, D. J. & O'Hair, M. J. (1996). *The reflective roles of the classroom teacher.* Califonia: Wadsworth.

Okebukola, P. A. & Ogunniyi, M. B. (1986). Effects of teacher's verbal exposition on students level of class participation and achievement in biology. *Science Education*, *70 (1), 45 - 51.*

Orji, N. S. (2006). *Relationship among teacher classroom management behaviours, students' task engagement, and students' outcomes in chemistry.* Unpublished Master's Thesis, University of Ibadan, Ibadan.

Orji, N. S. (2011).The influence of adults' socio-psychological characteristics on their active participation in adult educational programme. *Nigerian Journal of Teacher Education and Teaching, 9 (1), 356-370.*

Ramadas, J. S. & Kulkarni, V. G. (1982). Pupil participation and curriculum relevance. *Journal of Research in Science Teaching, 19 (5), 357 - 365.*

Sandholtz, J. H. & Dwyer, D. C. (1994). *Student engagement revisited: Views from Technology- rich classroom.* Cupertino: Apple.

Simpson, R. O. & Twoost, K. M. (1982). Influences on commitment to and learning of science among adolescent students. *Science Education, 66 (5), 763 - 781.*

Yair, G. (2000). Educational battle field in America: The tag-of-war over students' engagement with instruction. *Sociology of Education, 73, 247 - 269*.

APPENDIX I

A: Student's Task-Engagement Record (STER)

Time (min] Stud. No./	02-Mar	05-Jun	08-Sep	11-Dec	14-15	17-18	20-21	23-24	26-27	29-30	32-33	35-36	38-39	41-42	44-45	*Total*
1																
2																
3																
4																
5																
6																
Total																

**Key: 1 = on-task/engaged 0 = off-task/disengaged*

B: Class Average scores for: STDTASK, ACHIVT & ATTITUDE

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
AVE STDTASK	11	11	12	11	13	12	11	12	9	12
AVE ACHIVT	15	14	13	13	12	9	12	12	5	16
AVE ATTITUDE	91	95	95	90	10	90	91	96	92	83

APPENDIX II

Chemistry Attitude Questionnaire (CAQ)

The statements in this questionnaire seek to find out how you feel about chemistry. Select freely the option that expresses your feelings toward Chemistry. There is no right or wrong answers.

Instruction: Please tick in the appropriate column to show your feelings toward the statements. SA – Strongly Agree; A = Agree; D = Disagree; SD = Strongly Disagree.

Name of student: ____

Sex: __________ Class: ___________

CHEMISTRY ATTITUDE STATEMENTS

S/N	ITEMS	SA	A	D	SD
1	Chemistry is a fun				
2	I have good feelings towards chemistry				
3	I like chemistry				
4	I would enjoy being a chemist or chemical scientist				
5	Everyone should learn chemistry				
6	I feel nervous in chemistry class				
7	I usually look forward to my chemistry class				
8	We do a lot fun activities in chemistry class				
9	We learn about important things in chemistry class				
10	We cover interesting topics in chemistry class				
11	I love spending my free time studying chemistry				
12	I consider our chemistry classroom attractive and comfortable				
13	Our chemistry classroom/laboratory contains a lot of interesting equipment				
14	My chemistry teacher encourages me to learn more chemistry				
15	I enjoy talking to my chemistry teacher after class				
16	My chemistry teacher makes good plans for us				
17	Sometimes my chemistry teacher makes me feel dumb				
18	My chemistry teacher expects me to make good grades				
19	My best friends like chemistry				
20	Most of my friends do well in chemistry				
21	I always try hard, no matter how difficult the work				
22	When I fail that makes me try that much harder				
23	I always try to do my best in school				
24	I try hard to do well in chemistry				
25	Chemistry makes me feel as though I am lost in a bush				
26	Chemistry tests make me afraid				
27	I would probably not do well in sciences if I took it in college.				
28	I consider myself a good chemistry student				
29	I think I am capable of becoming an engineer, scientist, chemist or doctor				
30	In chemistry class, I feel being in control of my learning				