

RELATIONSHIP AMONG TEACHERS' SCIENCE PROCESS SKILLS, SCIENTIFIC ATTITUDES AND STUDENTS' PERFORMANCE IN CHEMISTRY

Dr. B. O. Ogunleye

Department of Teacher Education, University of Ibadan, Ibadan, Nigeria

Abstract

The nature of Science which is both experimental and experiential makes it imperative for the teacher to possess adequate knowledge, skills and attitude towards it. By extension, effective Chemistry teaching not only requires these attributes of the teacher but demands the inculcation of such capabilities in the students most of whom hitherto had demonstrated poor performance in the subject. The study investigated the relationship among teachers' Science process skills, scientific attitudes and students' performance in Chemistry. The two factors had positive vicariate and multiple relationships with students' performance while they also explained 4.1% of the total variance in the dependent variables. It was recommended that teachers, government and professional bodies should increase efforts towards the improvement of teachers' Science process skills and scientific attitudes.

Background and Literature

Science serves as the key to modern society. Okeke (2007) asserts that scientific knowledge, skills and products now dominate our lives to the extent that we are forced to become increasingly dependent on them for nearly everything. Science has also been variously described by individuals based on their perception of what science is and what it offers (Seweje & Jegede, 2002). Whiles science can be defined as an orderly collection of facts, principles, techniques and methods, Akindehin and Odine (1994) conceptualized science as the human activity embodying the acts of planning, observing, experimenting, measuring and drawing conclusion. In other words, science is a systematic process of obtaining testable and verifiable knowledge about nature and natural occurrences utilizing careful observation and experimentation (Okeke, 2007). These definitions emphasize the process and product nature of science. Viewed this way, science as a process is characterized by skills which culminate in the product, i.e knowledge and other tangible materials useful in everyday life and living in the areas of agriculture and food production, information and communication technology as well as wealth generation just to mention a few.

Other benefits of Science and Technology in today's world as listed by Okeke (2007) include:

- Improved health and longevity of human species;
- Scientific knowledge, skills and attitudes;
- Prevention, control and treatment of common diseases;
- Testable explanation to many of naturally occurring phenomena;
- Applications such as computers and internet facilities;
- Modern means of information dissemination and communication;
- Production and exploitation of raw materials and their processing into goods; and
- Introduction of mechanical devices for planting, tending, harvesting and processing of various crops.

Hence, the pride of place accorded Science Education in all economies both developed and developing. One of the aims of science education is to enable individuals use

science process skills. In other words, it is to be able to define the problems around them, to observe, to analyze, to hypothesize, to experiment, to conclude, to generalize and to apply the information they have with the necessary skills (Aktamis and Ergin, 2008). Indeed, the goal of science education is universal and is concerned with the development of scientifically literate individuals with high competence in rational thought and action (Seweje, 2004). This goal is based on the belief that achieving scientific literacy involves the development of attitudes, process skills and concepts necessary to meet the more general goals of education. It involves individuals using concepts, process skills and values in making everyday decision as they interact with other people and with the environment, understanding that the generation of scientific knowledge depends upon inquiry process and upon conceptual theories and distinguishing between scientific evidence and personal opinion. Furthermore, a scientifically literate person will use the achievement of science and technology for the benefit of mankind and these goals need to be achievable at least in part, during the immediate school experience of the child.

Science as a body of knowledge comprises Chemistry which stands in a central position among the basic sciences. It is also an integral part of the science curriculum which is expected to tend towards attaining the general aims and objectives of scientific literacy and should employ scientific methods of investigation in its teaching and learning. Chemistry is both an intellectual and practical activity with the practical activity being as important as the theoretical aspect in every respect (Ogunleye, 2002). In Chemistry teaching, the importance of integrated practical work with theory creates a fulfilled and an enjoyable scene which makes the subject matter easily grasped by the learners. It also makes the subject matter to be fully understood as the basic principles underlying various theoretical concepts in Chemistry. Hence, the effective teaching of practical Chemistry in secondary schools which lays emphasis on benchmark is of utmost importance to teachers and parents. Concerted efforts should therefore be made towards achieving the aims of science education in schools (FME, 1985).

Research (Ugwu, 2007; Opataye, 2009) as well as WAEC Chief Examiners' Reports (2005) and (2007) have indicated that students are failing in science courses, Chemistry inclusive. These have been attributed to some weaknesses such as lack of understanding the use of language in science, inability to record experiment, lack of process skills experimentation ability and weakness in expression of ideas when writing answers to examination questions. These have implications for the improvement of students' practical skills. Based on the objective of using laboratory work in science teaching, learning of science process skills, concepts, scientific attitudes, cognitive abilities and understanding of the nature of science, science is conceived as essentially a practical subject which demands acquisition of science process skills and concepts required for the interpretation of natural phenomena and the development of appropriate technology (Ajewole, 1990). Indeed, students acquire the skills of science, equipment manipulation and scientific approach through guided experimentation from laboratory exercises (Joju, 2003).

Erhokhon (2004) in his finding about strategies for effective teaching ascertained that although no teaching strategy is most effective in teaching every subject, the inquiry method has proved more efficacious in enhancing students' achievement. This means that the teaching and learning of science depends so much on the science process skills used in the inquiry procedure but the challenges to the effective teaching and learning of Chemistry in schools include poor teaching methods (Abdullahi, 1982; Ogunniyi, 1986; Ogunleye, 2002). Most science classrooms in Nigeria are dominated by the lecture mode of instruction, close-ended laboratory investigations and inadequate facilities for individual or group work.

Teacher effectiveness in Chemistry is a prime determinant of students' performance in the subject. Koleoso (2005) conceptualized the science teacher as a person who has the

mastery and competence in the subject to enable him handle the content of the curriculum effectively. The science teacher must have adequate grasp of the processes of science and is expected to have initiative, must possess a scientific mind and be properly trained (Mamanu, 1997). The teacher must also exhibit the scientific attitude and behaviour that will enhance teaching and pleasant learning. In support of this, Koleoso (2005) stressed that the science teacher is expected to teach the science process skills and methods of science by exposing students to various scientific activities using pertinent pedagogical approaches that include guided inquiry and laboratory investigative procedures. Mamanu (1997) also identified attributes that a good science teacher must possess to include high knowledge of the subject matter far beyond the level he is teaching. An aspect of such knowledge is science process skills.

In the science process skills form the foundation of scientific methods six basic science process skills were identified by Rezba (1995) and Yockey (2001). These are; observation, communication, classification, measurement, inference and prediction. It was further explained that these basic skills are integrated together when scientists design and carry out experiments. Also science is based upon everyday values even as it questions our understanding of the world and ourselves. In many respects, it is the systematic application of some highly regarded human values and attitudes such as integrity, diligence, fairness, curiosity, open mindedness to new ideas, perseverance, ability to accept failure, skepticism, objectivity and suspended judgement (Mathew, 1994). Scientific attitudes are necessary products of knowledge of the arts of science and they evolve as one carries out scientific activities using the science process skills. Hence, teachers need scientific attitudes which promote desirable human values and foster positive attitudes in the students especially towards better performance in Chemistry.

Statement of the Problem

Chemistry stands as the most important school science subject and contributes significantly to science education without which a nation cannot develop scientifically and technologically. Effective Chemistry teaching, especially within the context of current poor student performance, depends on the use of the science process skills as well as proper scientific attitudes both by the teachers and students in the classroom. Since teachers are centrally placed in the organization of learning experience and as the facilitators of the desired outcomes of Chemistry teaching, it is expected that they possess adequate science process skills and scientific attitudes towards improved student performance in the subject. Hence, this study investigated the relationship among teachers' science process skills, scientific attitudes and students' performance in Chemistry.

Hypotheses

The following hypotheses were formulated for the study;

1. There is no significant relationship between Chemistry teachers'
 - a. Science process skills
 - b. Scientific attitudes and
 - c. Students' performance in chemistry
2. There is no significant composite effect of Chemistry teachers' science process skills and scientific attitudes on students' performance in Chemistry.
3. There are no significant relative effects of Chemistry teachers' science process skills and scientific attitudes on students' performance in Chemistry.

Research Design

This study adopted the *expost facto* type of the descriptive design. It is also correlational as it investigates the relationship among the two teacher variables and students' performance in Chemistry.

Population and Sample

The study population consists of SS II Chemistry students and their teachers in Ogun West Senatorial District of Ogun State, Nigeria. From the list of public Senior Secondary Schools, fifty students were randomly selected. Twenty SS II students were also randomly selected from each school while the SS II Chemistry teachers of the selected students were purposively included in the study. In all, one thousand Chemistry students and sixty-one teachers participated in the study.

Research Instruments

Three instruments were developed and employed for the study. These included:

1. Chemistry Teachers' Science Process Skills Questionnaire (CHESPROQ)
2. Chemistry Teachers' Science Attitudes Scale (CHETSAS)
3. Test of Students' Performance in Chemistry (TESPIC)

Chemistry Teachers' Science Process Skills Questionnaire (CHESPROQ)

This questionnaire designed to measure teachers' science process skills consists of thirty items. Thirty content areas in the Senior Secondary School Chemistry curriculum were listed and the teachers had to identify the process skills needed to effectively learn the content. They were to match the content areas with the science process skills they choose. This was scored by allotting 1 mark to any correct match made.

Chemistry Teachers' Scientific Attitudes Scale (CHETSAG)

The Teachers' Scientific Attitudes consists of twenty item statement presented on a 4-point Likert scale of Strongly Agree, Agree, Disagree and Strongly Disagree. These were developed from the attributes expected to be exhibited by Chemistry teachers in the course of teaching the subject. They include objectivity, perseverance, honesty, punctuality, curiosity, skepticism, open mindedness, creativity and aversion to supervision. The statements were scored, 4, 3, 2 and 1 for Strongly Agree, Agree, Disagree and Strongly Disagree respectively.

Test of Students' Performance in Chemistry (TESPIC)

This test on students' performance consists of twenty question items on second year Senior Secondary School Chemistry curriculum. The topics included volumetric Analysis, Acids, Bases, Salts, Pollution, Kinetic theory and States of Matter, Oxidation, Reduction, Electrical nature of chemical substances, Carbon and its compounds and Energy changes in chemical reactions. The questions were multiple choice objective tests with 5 options A-E. Each correct response attracts 1 mark.

Validation of the Instruments

All the three instruments were subjected to peer/expert review for construct, content and face validities. The improved drafts were further administered for reliability using the different relevant methods. For CHESPROQ, the test-retest method was adopted. This yielded a reliability index of 0.81. The CHETSAS had a reliability value of 0.83 through Cronbach method while the TESPIC tested by KR-21 yielded a reliability index of 0.79 and item difficulty indices ranging from 0.43 to 0.59.

Research Procedure

The two instruments for the Chemistry teachers viz: Chemistry Teachers' Science Process Skills Questionnaire (CHESPROQ) and Chemistry Teachers' Scientific Attitudes Scale (CHETSAS) were administered to the teachers across the fifty schools. Then, the teachers were employed as Research Assistants to administer the Tests on Students' Performance in Chemistry (TESPIC) to their students. The period of instrument administration lasted 10 weeks.

Data Analysis

Data collected were analysed using Pearson Product Moment Correlation as well as Multiple Regression. The hypotheses were tested at 0.05 level of significance.

Results

Hypothesis 1a: There is no significant relationship between Chemistry teachers' science process skills and students' performance in Chemistry.

Table 1: Pearson Correlation of Teachers' Science Process Skills, Scientific Attitudes and Students' Achievement in Chemistry

Variables	Achievement	Process Skills	Scientific Attitudes
Pearson Correlations (r)			
Achievements	1.000	.221	.114
Process Skills	.221*	1.000	-.360
Scientific Attitudes	.114*	-.360	1.000
Sig. (p)			
Achievement	-	.001	.005
Process Skills	.001	-	.000
Scientific Attitudes	.005	.000	-

* Significant at $p < .05$

From Table 1, the relationship between Chemistry teachers' science process skills and students' performance in Chemistry is weak and positive ($r = .221$; $p < .05$). This is also significant. Hence, the null hypothesis (H_{01a}) is rejected. This implies that as teachers' science process skills improve, students' performance also improves.

Hypothesis 1b: There is no significant relationship between Chemistry teachers' scientific attitudes and students' performance in Chemistry.

From Table 1, the Pearson Correlation shows that the relationship between scientific attitudes of the Chemistry teachers' and students' performance in Chemistry is weak, positive and significant ($r = .114$; $p < .05$). Hence, the null Hypothesis (H_{01b}) is rejected. This implies that as the scientific attitudes of the Chemistry teachers improve, students' performance in Chemistry also tends to improve.

Hypothesis 2: There is no significant relationship between Chemistry teachers' scientific attitudes and students' performance in Chemistry.

Table 2: Summary of Regression of Teachers' Science Process Skills and Scientific Attitudes with Students' Performance in Chemistry

R	R square	Adjusted R square	Std Error of the Estimate
.224	.050	.041	10.987

From Table 2, the relationship among Chemistry teachers' science process skills, scientific attitudes and students' performance is weak and positive ($R = .224$). Also, the adjusted R^2 value of .041 means that 4.1% of the students' performance in Chemistry is accounted for by teachers' science process skills and scientific attitudes. The remaining 95.9% is due to other factors not included in this study as well as residuals. The R value was tested for significance using the ANOVA part of the Multiple Regression result.

Table 3: ANOVA Table for the Regression Analysis

Source of Variance	Sum of Square	Df	Mean square	F	Sig.
Regression	3719.071	2	1859.536		
Residual	120334.62	997	120.697	15.407	0.000*
Total	124053.70	997			

*Significant at $p < 0.05$

Table 3 shows that the adjusted R value of .224 is significant ($F = 15.407$; $p < 0.05$). This implies that the science process skills and scientific attitude have significant composite effect on students' performance in Chemistry. Hence, the null hypothesis 2 is rejected.

Hypothesis 3: There are no significant relative effects of Chemistry teachers' science process skills and scientific attitudes factors on students' performance in Chemistry.

Table 4: Relative Effects of Teachers Factors on Students' Performance in Chemistry

Factors	Unstandardized coefficient			Rank	T	Sig.
	B	Std Error	Beta			
(Constant)	43.748	2.955			14.806	.000
Process Skills	-.306	.058	.163	1 st	-5.239	.000*
Scientific Attitudes	-7.133E-02	.040	.055	2 nd	-1.774	.076

*Significant at $p < 0.05$

Table 4 shows that Chemistry teachers' science process skills made the greatest contribution to students' performance ($\beta = .163$; $p < 0.05$). This is followed by scientific attitudes ($\beta = .055$; $p < 0.05$). The contribution of teachers' science process skills is significant while that of teachers' scientific attitudes is not significant. Hence, the null hypothesis (H_{03}) is rejected for science process skills but not rejected for scientific attitudes.

Discussion

The findings showed that there is significant relationship between teachers' science process skills and students' achievement in Chemistry. This implies that the poor performance of students in Chemistry could be traced to inability of students to report experiments, state measurements made, draw inferences and explain the processes of scientific events which could in turn be traced to the poor capacity of teachers in demonstrating these processes and transferring them to the students (Aktamis & Ergin, 2008). This affirms the importance of science process skills to students' effective learning of Chemistry. In fact, the central focus of Chemistry education should be to promote scientific knowledge and the use of the science process skills for effective teaching and learning of Chemistry which would definitely bring about improvement in the performance of students in the subject.

Findings also revealed that there is significant relationship between teachers' scientific attitudes and students' performance in Chemistry. To this end, it could be said that scientific performance which scientific development relies entirely on, does not rest on the

intellectual or cognitive skills, manipulative or psychomotor skills only but on the attitudes or affective orientation of individuals as well. This implies that science teachers need to teach and encourage students to develop good scientific attitudes which must first be acquired by the teachers as one cannot give what one does not have.

The composite effect of teachers' science process skills and scientific attitudes on students' performance in Chemistry is a confirmation of the complementary roles of the two factors in effective student learning of Chemistry towards good performance in the subject. The use of science process skills for investigation of facts and in the process, exhibiting good attitudes towards science will enhance effective teaching and learning of Chemistry in the schools and thus improve students' performance in the subject. Further, the greater contribution of teachers' science process skills to students' performance lends credence to the fact that this factor plays greater role in impacting students' performance in Chemistry as reported by Aktamis and Engin (2008). Indeed, while cognitive knowledge may be forgotten by learners, the process skills and knowledge acquired thereof is always retained (Njoku, 2002).

Conclusion and Recommendations

The improvement of students' performance in Chemistry, a subject which is not only experimental but experimental both in process and product requires students' acquisition and use of science process skills and attitudes. This would remain impossible except Chemistry teachers who are facilitators of students learning, organizers of learning activities and providers of models to follow by students, possess adequate science process skills and scientific attitudes. Based on these, it is recommended that Chemistry teachers should make frantic efforts to acquire the science process skills through enrolment for further training, in-service training, attendance at workshops and seminars.

Also, the government, its agencies, professional bodies like Science Teachers' Association of Nigeria (STAN) and the Chemical Society of Nigeria (CSN) among others should invest more in changing teachers' orientation about science, scientific activities and Chemistry teaching towards increasing the gains of Chemistry teaching and learning specifically and science education is general.

References

- Abdullahi, A. (1982). *Science Teaching in Nigeria*. Ilorin: Atoto Press Limited.
- Ajewole, G. (1990). Effects of guided discovery and expository instructional methods in students transfer of learning. *Journal of the Science Teachers Association of Nigeria*, 26(2), 59-66.
- Akindehin, O. & Odine, J. E. (1994). *Understanding Scientific Process*. Marina, Lagos: Stainless Publications Limited.
- Aktamis, H. & Ergin, O. (2008). The effects of scientific process skills education on students' scientific creativity, science attitudes and academic achievement Asia – Pacific Forum in Science Learning and Teaching, 9(1).
- Erhokhon, E. M. (2004). The effects of inquiry method on interest and achievement of Senior Secondary School Students in physics *International Journal of Children in Science and Technology*, 2(1).
- Federal Ministry of Education (1985). *Senior Secondary School Science Curriculum*. Lagos: Government Printers.
- Joju, A. (2003). Education of the availability of Chemistry practical materials in some secondary school laboratories in *Journal of Nigeria Science Education and Practice* 1(1).

- Koleoso, A. (2005). Science teachers' skills: implication for the teaching and learning of Physical Sciences. Paper presented at the 3rd Ondo State Science Teachers Association of Nigerian Annual workshop in Akure, Ondo State.
- Mamanu, I. (1997). The role of science teachers in using science for self reliance. *Bichi Journal of Education* 1(1), 74-78.
- Mathew, R. M. (1994). *Science Teaching: The role of history and philosophy of science*. New York: Routledge.
- Njoku, Z. C. (2002). Enhancing girls' acquisition of science process skills in co-educational schools: An experience with sex grouping for practical Chemistry in *Journal of the Science Teachers' Association of Nigeria* 37(1&2), 69-75.
- Ogunleye, B. O. (2002). *Evaluation of the Environmental Aspect of the Senior Secondary School Chemistry Curriculum in Ibadan, Nigeria*. An unpublished PhD Thesis University of Ibadan, Ibadan.
- Ogunniyi, M. B. (1986). *Science Teaching in Africa*. Ibadan: Salam Media.
- Okeke, E. A. (2007). Making science education accessible to all. An inaugural lecture presented at the University of Nigeria, Nsukka.
- Opataye, J. A. (2009). Effects of diagnostic adoptive, action based on pair testing modes on senior secondary school students' learning outcomes. *Electro-Chemistry*. An unpublished PhD Thesis; University of Ibadan. Ibadan.
- Rexba, R. T. (1995). *Learning and assessing science process skills*. Dubuque. IA: Kendall/Hunt Publishing Company.
- Seweje, R. & Jegede, S. A. (2002). *Science education and science teaching methods*. Ikeja, Lagos: Atlantic Association Publishers.
- Seweje, R. O. (2004). Strategies for sustaining children interest in science and technology: A Challenge of Basic Science *International Journal of Children in Science and Technology*, 2(1), 72-77.
- Ugwu, A. (2007). Towards inculcation of chemistry practical skill in students: teachers' difficulties. 50th STAN Annual Conference Proceedings, 106-109.
- West African Examinations Council (2005). *Chief Examiners' Reports on West African Senior School Certificate Examinations (Nigeria)*
- West African Examinations Council (2007). *Chief Examiners' Reports on West African Senior School Certificate Examinations (Nigeria)*.
- Yockey, J. A. (2001). Science process skills. *A key to science learning* 38(7), 36-41.