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The Influence of Identified Student and School Variables on Students' Science Process Skills Acquisition

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Abstract
Process skills are very fundamental to science but there is still a serious educational gap in bringing these skills into the classroom for students' acquisition. The purpose of this study therefore was designed to ascertain the influence of selected variables such as: sex, students' attitude, school location, school type, laboratory adequacy and class size; on students' science process skills acquisition. The design adopted for the study is an ex-post facto design. The sample consisted of 450 SS III science students from Adamawa and Taraba States of Nigeria using stratified random sampling technique. The research instrument was Science Process Skills Knowledge Test (SPSKT) which was subjected to both content and face validity using Kuder Richardson formula 21 to obtain the correlation value of 0.78. The SPSKT was analyzed using means and t-test statistics. The study revealed that sex; school location and school type does not influence students' acquisition of science process skills while students' attitude, laboratory adequacy and class size influences students' acquisition of science process skills. Based on the findings, recommendations were made amongst which are equipping all secondary schools laboratories to enable teachers adopt methods that will lead students to have the appropriate skills and have positive attitude towards science and using enabling environment which discourages large class sizes in science classrooms.
Keywords: Sex, students' attitude, school location, school type, laboratory adequacy and class size

Introduction

The search for a more effective approach for the teaching and learning of science that will enhance the acquisition of process skills has persisted over the years. This is because; the acquisitions of science process skills are the basis for scientific inquiry, development of intellectual skills and attitudes that are needed to learn concepts. Science process skills are cognitive and psychomotor skills employed in problem solving. They are the skills which the sciences use in problem-identification, objective inquiry, data gathering, transformation, interpretation and communication. Science process skills can be acquired and developed through training such as are involved in science practical activities. They are the aspect of science learning which is retained after cognitive knowledge has been forgotten. Using science process skills is an important indicator of transfer of knowledge which is necessary for problem-solving and functional living. The knowledge of process skills in science is very important for proper understanding of concepts in science. Alfredo, et al. (2006) stated that process skills are fundamental to science, which allows everyone to conduct investigation and reach conclusions. They observed that there is a serious educational gap in this area, both in bringing these skills into the classroom and in the training of teachers to use them effectively.

The skills in qualitative and quantitative analysis cannot be completed without creativity. Practical work is not just putting the apparatus together when seen, but it needs planning, designing a problem, creating a new approach and procedure and also putting familiar things together in the new arrangement. This implies that the knowledge of creativity exhibited by candidates in any practical class helps them to manipulate some practical equipment. According to Giddings and Fraser in Akinbobola and Afolabi (2010), achieving the objectives of science practical work depends a lot on the mode of assessment of laboratory work adopted by teachers and examination bodies. According to them, the mode of assessment directly influences teachers' teaching methods, students' learning styles and attitudes towards practical activities.

Students are to be made able to acquire scientific knowledge by the processes of thinking, analyzing and interpreting observed facts. A new approach capable of triggering the processes of thinking, analyzing and inferring in the students' mind is needed. Process approach is designed to attain these objectives in teaching science. Process approach presents the instruction in science in an intellectually stimulating and a scientifically authentic way. Here, emphasis is given to the ways of acquiring knowledge rather than to the content. This is a shift from the traditional approach.

The process approach to teaching science is meant to foster inquiry and manipulative skills in students and discourage rote learning. This approach embraces other methods of science teaching and is mainly activity based, superior to those in which students are not actively involved in the learning process (Akinbobola, 2008). This reason has made the West African Examinations Council (WAEC) and bodies that conduct Senior Secondary School Certificate Examination (SSSCE) stipulate that practical work should form the basis of teaching sciences. During examination, practical work in the science subjects is also assessed separately. In both internal and external examinations, practical work in the sciences is assessed separately as an integral part of the subject and students are expected to have acquired certain science process skills on completion of the senior secondary school.

The basic science process skills are useful in science and non-science situations while the integrated skills are the working behaviour of scientists and technologists. Thus, both basic and integrated science process skills are relevant and appropriate for all science subjects, at the senior secondary schools. Hence, there is need to find out the level of acquisition of the process skills, including the factors influencing their acquisition; and also to identify the science process skills inherent in the West African Senior Secondary School Certificate (WASSSC) science practical examination in Nigeria and classify them into various hierarchical levels in terms of students' difficulties. Process skills are very fundamental to science which allows students' to conduct investigations and reach conclusions; but there is still a serious educational gap in this area both in bringing these skills into the classroom and in the training of teachers to use them effectively. Therefore, the problem of this study is: will the analysis of senior secondary science students' experienced difficulties in process skills acquisition help in bringing the process skills into the classroom and in the training of teachers to use them effectively? Specifically, this study will investigate the influence of sex, students' attitude, school location, school type, laboratory adequacy and class size on students' experienced difficulties in science process skills acquisition.

Literature Review

A review of literature on science process skills showed out of the 15 science process skills recommended for science curricula, about 70% of the students still experience difficulties in acquiring them and also; sex and school location had no influence on students experienced difficulties (Akpokorie, 2000 and Omajuwa 2011). More also, literature suggestions showed that there are various factors that influence the acquisition of cognitive skills such as science process skills. The teacher plays an important role in learning, including the acquisition of science process skills. Maranzo, Pickering and Pollock (2001) asserted that, although schools make little difference, that is only approximately 10% in students' achievement, the most important factor affecting students' learning is the teacher. According to them, teachers can have a profound influence on students learning even in school that are relatively ineffective. Harlen (2000) also identified three main aspects of teacher's role: setting up the learning environment; organizing classroom activities; and interacting with students. Among these aspects, the most important aspect is teachers' interaction with students during their teaching. A teacher has to help students in engaging them to think while performing the task given. The teacher should ask the right question in order to engage students' thinking, facilitate them by asking how they would test their ideas, encourage them to further explore and serve as expert when they needed one. Apart from the teacher's role, readiness/motivation is another factor that influences the acquisition of science process skills. Students' readiness is perceived as learner's developmental level of cognitive functioning. It is the cognitive maturity that is assumed to determine the extent to which learners are capable under consideration in teaching students. Motivation to learn is an important factor controlling the success of learning and teachers face problems when their students do not all have the motivation to seek to understand due to their negative attitude towards the subject. However, the difficulty of a topic, as perceived by students, will be a major factor in their ability and willingness to learn it (Ghassan, 2007).

A review of the literature revealed that science process skills can be developed by engaging learners in authentic learning activities (Keys and Bryan 2001). These are activities that should provide learners with design investigations for solving these problems. This requires teachers to adopt inquiry-based approaches to science teaching and learning. It has been observed from studies carried out by Smolleck et al (2006) and Lanka (2007) that school laboratory experiences introduce important aspects of science to students while simultaneously assisting them in developing knowledge in regard to specific science concepts. Thus, science teachers should have the necessary knowledge and skills for planning and executing learning experiences that will expose learners to inquiry experience, thereby allowing them to apply both cognitive and manipulative processes in solving scientific problems; but the problem of inadequate laboratories had made this approach a nightmare. From the preliminary study conducted by Lanka (2007) with 17 physics teachers from four senior secondary schools, he found out that: large classes cannot be effectively used to facilitate investigative inquiry activities, they are impracticable. According to Ajaja (2010) very large class sizes, which exist in schools, have made healthy interactions between students and teachers almost non-existent.

Literature also showed that the new science curriculum worldwide stresses science process skills and places emphasis on the development of higher cognitive skills through the student-centred approach (Shulman and Tamir, 2004). This approach, according to Molitor and George (2001) develops the understanding of science process skills through participation of students in activities in science classrooms. Ogunnniyi (2000) opined that the relevance of acquisition of process skills in science teaching is that it involves students' in "doing science". The acquisition of process skills by "doing science" will enable students understand the concepts of Chemistry easily. But, despite the importance of science to mankind and the efforts of researchers to improve on its teaching and learning, the performance of students in the subject remains low in Nigeria. Among the factors that have been identified are class size (Adeyemi, 2008), poor methods of instruction (Millar, et al. 2002), students' attitude (Yara, 2009), teachers' attitude (Adediwura and Bada, 2007), laboratory inadequacy (Adeyegbe, 2004 and Koray, et al., 2007), and poor science background (Ugwu, 2007). Adesokan (2002) asserted that in spite of realization of the recognition given to the science subjects, it is evident that students still show negative attitude towards the subject, thereby leading to low acquisition of science process skills. Science is also taught in most schools as a bundle of abstractions without practical experiences due to ill-equipped laboratories. This has resulted to students' low acquisition of science process skills which has become more evident in the mass failure of students in the subject in public examinations. All the questions asked to test Chemistry students' knowledge in practical skills require that they demonstrate one form of process skill or the other. The inability of students to carry out these activities properly results in low scores in the test of practical knowledge.

Research Hypotheses

To guide the study, the following research hypotheses were formulated for testing at the 0.05 level of significance (P<0.05):

Ho_1: There is no significant difference in the mean difficulty process skills scores between male and female science students.

Ho_2: There is no significant difference in the mean difficulty process skills scores between students with negative attitude towards science and those with positive attitude towards science.

Ho_3: There is no significant difference in the mean difficulty process skills scores between science students in urban and in rural schools.

Ho_4: There is no significant difference in the mean difficulty process skills scores between science students in single sex and in mixed schools.

Ho_5: There is no significant difference in the mean difficulty process skills scores between science students who were taught with well-equipped laboratories and those who were taught with ill-equipped laboratories.

Ho_6: There is no significant difference in the mean difficulty process skills scores between science students in small-class size and in large-class size.

Materials and methods

The design adopted for the study is an ex-post facto design. The population of the this study comprised all senior secondary school III (SS III), science students in the three senatorial districts of Adamawa and Taraba States of Nigeria. The sample of the schools consisted of 30 senior secondary (public) schools while the sample of students consisted of 450 SS III Chemistry students. Fifteen science students who offered Biology, Chemistry and Physics were selected from each of the sampled schools. The sample was composed by using stratified random sampling technique.

The research instrument that was used for this study is a test called Science Process Skills Knowledge Test (SPSKT). The test consisted of two sections. Section A demanded personal information on the school and respondent (bio data). Section B consisted of a 60 questions (20 questions each on biology, chemistry and physics) on test of knowledge on Science process skills, having options A-D where students are expected to choose only one correct answer. The test of knowledge on Science process skills covers both the basic and integrated skills and these were extracted from WAEC/ SSCE Alternative on the science subjects (biology, chemistry and physics) practical past questions. The SPSKT was subjected to both content and face validity by three experts in science education and two in test and measurement. Six Science teachers who have taught these subjects for more than eight years also helped in the validation of the instrument. The experts rated the relevance of each item as an indicator of the construct, pointed out those aspects of the construct that was not covered adequately and also rated the clarity and conciseness of each item. The data obtained was subjected to Kuder Richardson formula 21 to obtain the correlation value. A correlation coefficient of 0.78 was obtained which was considered adequate for this study.

The SPSKT was administered with the help of the Science teachers (research assistants) and the researcher in the schools. After the administration of the SPSKT, students' answers were collected and scored using means and percentages. The level of difficulty of a particular process skill was determined by the value of means as follows: means percentages less than 50% (< 50%) as Simple, and means percentages equal to or above 50% (≥ 50%) as Difficult. The influence of the independent variables, student-related (sex and students' attitude) and school-related (school location, school type, laboratory adequacy and class size) on students' science process skills acquisition, was analyzed using t-test statistics.

Results

In Table 1, the t-calculated value of 1.1759 is less than the t-critical value of 1.960 at; 0.05 level of significance. The result showed that there was no significant difference in the mean difficulty process skills scores between male and female science students. Based on this, hypothesis one was retained.

As indicated in Table 2, the t-calculated value of 6.32 was higher than the t-critical value of 1.960 at; 0.05 level of significance hence hypothesis two was rejected. This showed that there was a significant difference in the mean difficulty process skills scores between Chemistry students with negative attitude and those with positive attitude towards science.

Table 3 shows that the t-calculated value of 1.144 is less than the t-critical value of 1.960 at; 0.05 level of significance. The result showed that there was no significant difference in the mean difficulty process skills scores between urban and rural science students. Based on this, hypothesis three was retained.

Table 4 showed that the t-calculated value of 0.6855 is less than the t-critical value of 1.960 at; 0.05 level of significance. The result showed that there was no significant difference in the mean difficulty process skills scores between science students in single sex and in mixed schools. Based on this, hypothesis four was retained.

In Table 5, the t-calculated value of 3.076 was higher than the t-critical value of 1.960 at; 0.05 level of significance hence hypothesis five was rejected. This shows a significant difference in the mean difficulty process skills scores between science students who were taught with well-equipped laboratories and those taught with ill-equipped laboratories.

As indicated in Table 6, the t-calculated value of 7.186 was higher than the t-critical value of 1.960 at; 0.05 level of significance hence hypothesis six was rejected. The result showed that there was a significant difference in the mean difficulty process skills scores between science students in small-class size and those in large-class size.

Discussion

The result of the test as shown in Table 1 showed that the t-calculated value of was less than the t-critical value at; 0.05 level of significance. The result showed that there was no significant difference in the mean difficulty process skills scores between male and female science students. Based on this, hypothesis one was retained. The findings of this study is in agreement with those of Akpokorie (2000) and Omajuwa (2011) who found that sex have no influence on students science process skills acquisition.

The result of the test as indicated in Table 2, revealed that the t-calculated value was higher than the t-critical value at; 0.05 level of significance hence hypothesis two was rejected. This shows that there is a significant difference in the mean difficulty process skills scores between science students with negative attitude and those with positive attitude towards science. This result agrees with Yara (2009) who found that students' negative attitude influences their performance in science.

The result of the test as shown in Table 3 also revealed that the t-calculated value was less than the t-critical value at; 0.05 level of significance hence hypothesis three was retained. The result showed that there was no significant difference in the mean difficulty process skills scores between urban and rural schools. The findings of this study is in agreement with that of Akpokorie (2000) and Omajuwa (2011) who found that school location have no influence on students experienced difficulty in science process skills acquisition.

The result of the test as shown in Table 4 revealed that the t-calculated value was less than the t-critical value at 0.05 level of significance hence hypothesis four was retained. The result showed that there was no significant difference in the mean difficulty process skills scores between students in single sex and in mixed schools. The findings of this study contradicts that of Wong, et al. (2002) but was in agreement with that of Omajuwa (2011) who found that school type have no influence on students experienced difficulty in science process skills acquisition. This may be due to the fact that since the science process skills are activities to be performed by individuals, sex, school location and school type may not hinder the activities to be carried out.

The result of the test as shown in Table 5 revealed that the t-calculated value was higher than the t-critical value at 0.05 level of significance hence hypothesis five was rejected. This shows a significant difference in the mean difficulty process skills scores between science students who were taught with well-equipped laboratories and those taught with ill-equipped laboratories. This agrees with the assertions by Burak (2009) who noticed a positive significant in process skills acquisition.

As indicated in Table 6, the result of the test showed that the t-calculated value was higher than the t-critical value at; 0.05 level of significance hence hypothesis six was rejected. The result showed that there was a significant difference in the mean difficulty process skills scores between science students in small-class size and in large-class size. This result agrees with the work of Adeyela (2000) whose study revealed that large class size is un-conducive for serious academic work for students and process skills acquisition but; disagrees with the works by Afolabi (2002) and Commeyras (2003) who found no relationship among class size and students academic performance and process skills acquisition. According to Ajaja (2010) very large class sizes, which exist in schools, have made healthy interactions between students and teachers almost non-existent. But, Brophy (2004) opined that large class size can be handled through proper classroom management and group or cooperative teaching in science laboratories.

Conclusion and Recommendations

Process skills are very fundamental to science and identifying some of the student and school variables would help greatly to remedy the serious educational gap in bringing the skills into the classroom for students' acquisition. It can be concluded from the findings of the study that sex, school location and school type does not influence student' acquisition of science process skills but; students' attitude, laboratory adequacy and class size have great influence on students' science process skills acquisition. Based on the above findings, the recommendations made are:

1. Laboratories should be equipped and expanded to accommodate and enable teachers to adopt methods that will lead students to have the appropriate skills. Government should be implored to give enough grants to equip laboratories with chemicals and apparatus, and also to provide useful materials and appropriate teaching aids to help reduce the problems of ill-equipped laboratories.
2. The need for training of science teachers on process skills is also recommended to educate them on student-activity centred methods which promote active learning in science classrooms.
3. The number of periods per week for science lessons should be increased to create room for more elaborate laboratory activities with students which will help eradicate students' difficulties in process skills.
4. The student-teacher ratio should be drastically reduced to help improve small class sizes such that adequate attention will be paid to students during laboratory exercises.
5. Science teachers should present the process skills in clearer terms, starting from simple to complex to help develop in students' positive attitude towards science.

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Tables

Table 1: t-test summary table comparing process skills difficulties experienced by male and female science students

Sex	Number of students	Mean	Standard deviation	df	t-cal	∝ level	t-crit	Decision
Male	222	64.76	36.4375	435	1.1759	0.05	1.960	Not significant
Female	215	60.64	36.7798					

Decision=Not Significant at ∝= 0.05 level ($H0_1$ Not rejected or Retained)

Table 2: t-test summary table comparing process skills difficulties experienced by students with positive attitude and those with negative attitudes towards science

Group	Number of students	Mean	Standard deviation	df	t-cal	∝ level	t-crit	Decision
Positive attitude	298	55.17	57.77	438	6.32	0.05	1.960	Significant
Negative attitude	142	78.99	20.624					

Decision= Significant at ∝= 0.05 level ($H0_2$ Rejected)

Table 3: t-test summary table comparing process skills difficulties experienced by science students in Urban and Rural schools

Type of schools	Number of students	Mean	Standard deviation	df	t-cal	∝ level	t-crit	Decision
Urban schools	218	64.45	33.64	435	1.144	0.05	1.960	Not significant
Rural schools	219	60.87	31.73					

Decision=Not Significant at ∝= 0.05 level ($H0_3$ Not rejected or Retained)

Table 4: t-test summary table comparing process skills difficulties experienced by science students in Single-sex and Mixed schools

Type of schools	Number of students	Mean	Standard deviation	df	t-cal	∝ level	t-crit	Decision
Mixed school	326	62.69	50.4980	444	0.6855	0.05	1.960	Not significant
Single school	120	60.07	19.1260					

Decision=Not Significant at ∝= 0.05 level ($H0_4$ Not rejected or Retained)

Table 5: t-test summary table comparing process skills difficulties experienced by Science students in schools with well-equipped and ill-equipped laboratories

Group	No. of students	Mean	Standard deviation	df	t-cal	∝ level	t-crit	Decision
Not well equipped Labs	271	68.33	23.939	433	3.076	0.05	1.960	Significant
Well equipped Labs	164	56.50	45.60					

Decision= Significant at ∝= 0.05 level ($H0_5$ Rejected)

Table 6: t-test summary table comparing process skills difficulties experienced by science students in large class and small class sizes

Type of class	No. of students	Mean	Standard deviation	df	t-cal	∝ level	t-crit	Decision
Large class	307	73.16	46.397	438	7.186	0.05	1.960	Significant
Small class sizes	133	44.20	35.080					

Decision= Significant at ∝= 0.05 level ($H0_6$ Rejected)