



Assessing Acquired Science Process Skills Of Senior High Schools In Central Region, Ghana

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ABSTRACT

Development and acquisition of science process skills (SPS) is necessary for understanding of science and offering of solutions to scientific problems. Assessing SPS acquired by students is key to monitor its development and acquisition. The study used descriptive survey to find out the nature of SPS developed and acquired by final year senior high school chemistry students. The study used parametric achievement test instrument called Students' development of science process skills index Test. The test was conducted for 904 students drawn from 20 out of 36 Senior High Schools in the central region of Ghana, that offer elective science courses. The schools and students were sampled from 17 out of 20 districts in the central region of Ghana via multi-stage sampling technique taking into cognizance the school grades categories in Ghana comprising Grades A, B and C. The analysis of the result shows that students acquired mainly basic SPS like *Observing, Communicating*, and integrated SPS like *Interpreting*. However, SPS like *Classifying, Hypothesising, Controlling Variables* and *Experimenting* were hardly developed/acquired. The acquisition of SPS was also found to depend significantly on the type of school attended and gender. It is recommended that more opportunity be given to practice and access SPS, particularly, the integrated SPS.

Keywords: Science Process Skills, Senior High Schools, Science Education, Assessment

INTRODUCTION

In Ghana, science education at the basic and secondary levels aim to equip students with scientific capacity to be curious, innovative, and contribute to solving scientific issues that emerge from their immediate communal environment (Hanson, 2014, Ministry of Education, MOE, 2007a, 2007b, 2010a, 2010b, 2019). In other words, science education in Ghana, aims at preparing individuals who can proceed to become scientists and others who (though may not work directly in scientific environment) can use scientific knowledge to solve problems in their communities. The Ministry of Education and Ghana Education Service (MOE, 2007a & 2007b) ensure the achievement of this aim by:

1. making science education compulsory from the basic level to the secondary level;
2. equipping teachers to not only teach scientific concepts and knowledge to students but also to train them in processes of acquiring scientific knowledge and
3. expecting teachers to help students to transfer their acquired knowledge and skills to identify scientific problems and to contribute toward solving them.

At the primary education level, it is expected that emphasis is placed in developing process skills (Ministry of Education, MOE, 2007a; 2007b) which enable students to connect and transfer their acquired scientific concepts and knowledge to understand scientific phenomena (Harlen, 1999) in their immediate environment. This emphasis is seen in allocating 60% weighting to develop practical and experimental skills and 40% to developing science knowledge and its application (MOE, 2007a). The weighting for practical and experimental skills decreases to 40% for both the junior secondary school level (MOE, 2007b) and the senior high school level (MOE, 2010a). The integrated science curriculum for the Basic 1 to Basic 3 (lower primary) had a general aim of 'developing individuals to become scientifically literate, good problem solvers, have the ability to think creatively and have both the confidence and competence to participate fully in matters of the Ghanaian society as responsible local and global citizens' (MOE, 2019, p. 5). The specific aims of the same document comprise of ten objectives, with the first four stating that the science curriculum is designed to help learners to:

1. develop a sense of curiosity, creativity, innovation and critical thinking for investigating and understanding their environment
2. develop skills, habits and attitudes necessary for scientific inquiry,
3. communicate scientific ideas effectively,
4. use scientific concepts in explaining their own lives and the world around them (MOE, 2019, p. 5).

This aim of science education reflects the emphasis of the SHS chemistry syllabus to develop scientific attitudes and skills (MOE, 2010b). These skills which are examined externally by West African Examination Council chemistry paper 2 & 3 comprise communicating, recording, calculating, observing, inferring, measuring, predicting, drawing, classifying, interpreting, manipulating, investigating and experimenting (Koomson, 2019).

Though the curricular aims of science education in Ghana target achievement of scientific literacy (Bybee & McCrae, 2011) like other nations at the basic and secondary levels, Ampiah (2006) suggests mismatch between Ghanaian curricular aims and the specific objectives use to implement teaching and learning. Nevertheless, the preceding discussion shows that Ghanaian curricular show the intention to use science education to equip the Ghanaian citizens with skills and abilities to approach communal issues and challenges like scientists do. Science process skills have been recognized as skills used by scientists and scientific literate persons to solve scientific problems (Akinbobola & Afolashade, 2010). Science process skills are seen as mental and physical abilities and competencies require to effectively study and understand science and technology as well as solving problems and developing individual and society (Akinbobola & Afolashade, 2010; Harlen, 1999; Nwosu & Okeke, 1995).

According to Harlen (1999) acquisition of science process skills enables the learner to learn with understanding by engaging their previous experiences with new encounters. This sort of engagement allows linkages between the new experiences to previous ones for extension of ideas and concepts. Science process skills have been classified into basic science process skills and integrated science process skills (Ango, 1992). The basic science process skills include observing, measuring, classifying, communicating, inferring, using numbers, using space/time relationship and questioning. The integrated science process skills comprise controlling variable, hypothesizing, defining operationally, formulating models, designing experiment and interpreting data (Ango, 1992). Akinbobola and Afolashade (2010) assert that basic science

process skills are essential for science learning and concepts formation while the integrated science process skills are necessary to solve scientific problems.

Practical activities have been assumed as the medium for developing and acquiring science process skills (Ornstein, 2006); Abraham & Millar, 2008; MOE, 2010b). However, the notion of equating practical activities to conventional laboratories to develop skills has been criticised. Ampiah (2004) for instance, identified some skills which do not need conventional laboratories to develop and acquire including:

- a. classifying and interpreting biological data;
- b. acquiring scientific attitudes for problem solving;
- c. appreciation of scientific method which involves deduction and interpretation of scientific data;
- d. acquiring attitude for accuracy and precision, objectivity, integrity, initiative and inventiveness; and
- e. development of scientific skills and attitudes as pre-requisites for further scientific activities.

Abrahams and Millar (2008); Osborne (2015) have also indicated concern for practical activities where learners are usually made to concentrate on manual manipulations of equipment with little effort to relate such activities to theory. Such practical activities fail to help students to develop and acquire higher order science process skills such as observation, inferences, prediction and hypothesis. Millar (1991) categorises observation, inferences, prediction and hypothesis as high-level cognitive skills and argues that their teaching and development is not tenable under practical work. The basis of such argument is the fact that these high order skills are theory laden (Millar, 1991) and also partly because development of such cognitive skills are limited by genetic epistemological stage (Monk, 1990).

Millar (1991) divides practical skills into three subcategories, including general cognitive processes, practical techniques and inquiry tactics. Millar (1991) argued that the general cognitive processes cannot and need not be taught, but maintained that the subcategories of practical techniques and inquiry tactics however can be taught and improved.

It can however, be argued that students not only need mastering of theory and concepts but also practical situations to apply their acquired knowledge in order to sharpen their higher order skills. Science process skills are both hands-on and minds-on and therefore need activities that are both hands-on and minds-on to develop them effectively. For example, the Ghanaian chemistry syllabus for senior high schools (MOE, 2010b, Koomson, 2019) identifies nine basic science process skills (communicating, recording, calculating, observing, inferring, measuring, predicting, drawing, classifying) and four integrated science process skills (interpreting, manipulating, investigating and experimenting) to be developed and acquired by students via laboratory, case studies, field trips and project activities. These activities could be both hands-on and minds-on.

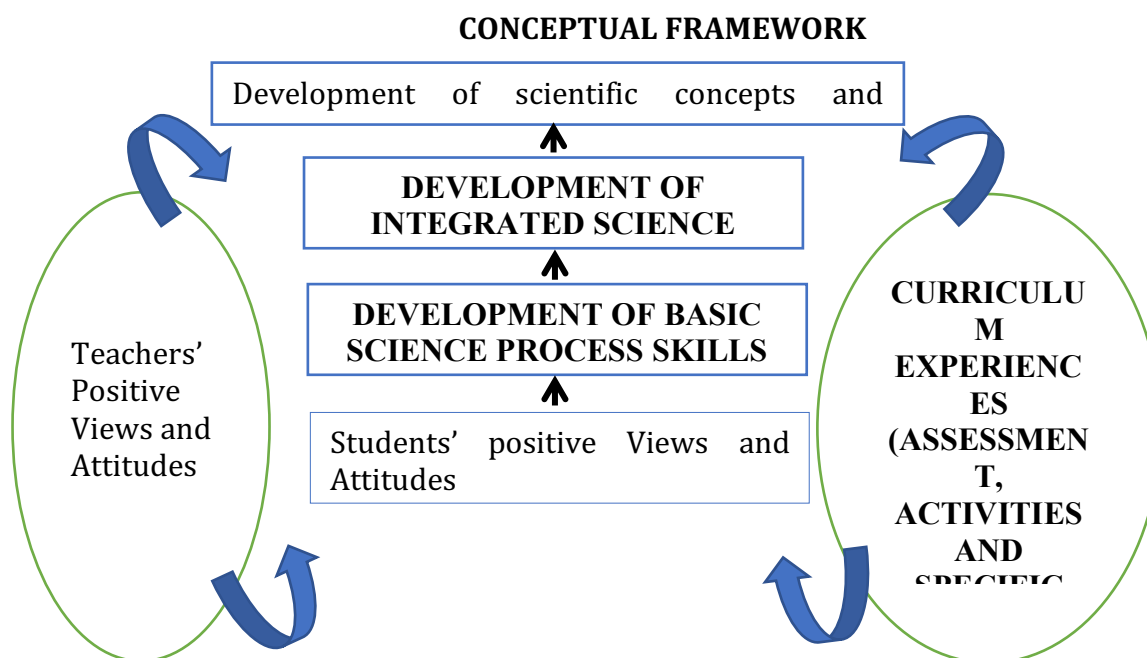


Figure 1: Framework of achieving scientific literacy through science process skills (Koomson, 2019)

Figure 1 shows that teachers' views and attitudes are important to aid students to develop and acquire science process skills (Aydogdu, 2015; Coll & Eames, 2008; Coil, Wenderoth, Cunningham & Dirks 2010; Ornstein 2006). The entire curricular experience, the school system, teacher belief and assessment systems are essential for effective development of science process skills (Harlen & Elstgeest, 1992). Figure 1 shows also that basic science process skills are the foundation of scientific reasoning and learners depend on basic science process skills to master integrated science process skills (Brotherton & Preece, 1995; Rambuda & Fraser, 2004). Integrated science process is required to identify scientific problems and offer solutions (Akinbobola & Afolashade, 2010) towards achieving scientific literacy (Bybee & McCrae, 2011). The framework shows that assessment of students' acquired and developed basic and integrated science process skills is necessary to assist their progression towards achieving the require scientific literacy envisaged by the Curriculum.

Science process skills acquired by students have been assessed using performance-based assessment (Ossei-Anto, 1996) and pencil-paper based assessment (Jack, 2018; Song & Black, 1991; Zeidan & Jayosi, 2015). The contents of high-stake pencil and paper examinations have also been analysed for science process skills (Akinbobola & Afolashade, 2010; Elmas, Bodner, Aydogdu, Saban, 2018; Koomson, 2019; Ongowo & Indoshi, 2013). Assessment of students' acquisition of science process skills have been advocated to be included in national and international assessments (Harlen, 1999) and their integration into Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) has been reported (Mullis et al, 2004).

Harlen (1999) however, observed limited attention given to assessing science process skills and argued that the over-emphasis of scientific content in science education has prevented the development of effective procedure to assess science process skills. It however, appears that

this lack of effective assessment of science process skills even occurs in some instances where there are curricula emphasis in the development and acquisition of science process skills. For example, the Ghanaian science curricular documents (MOE, 2007 a & b) assign at least 60% and 40% weightings to the primary and junior high school levels respectively to develop and acquire science process skills and its related scientific attitudes, notwithstanding, there is no standard nor national assessment regimes to monitor how science process skills are developed and acquired at these levels.

The science process skills developed and acquired at the senior high school level however are assessed by the West Africa Examination Council (WAEC). The core integrated science taken by all students at this level are assessed using pen and paper test called alternative to practical test. Science elective students offering biology, chemistry and physics are also assessed for science process skills developed and acquired in these areas using pen and paper and actual performances of practical activities. Despite these efforts to assess science process skills, content analysis of WAEC examinations have indicated limitations in assessing the science process skills expected to develop and acquired in the curricular documents of the various countries involved in these assessments (Akinbobola & Afolashade, 2010; Koomson, 2019). The limitations identified had serious implications which undermine the curricular aim of science education to equip citizens to solve communal issues through scientific means. The limitations identified include over-emphasized in basic science process skills at the expense of integrated science skills and failure to assess some of the skills.

Akinbobola and Afolashade (2010) analyzed content of WAEC senior high school certificate physics practical examination for the science process skills assessed over a period of ten years. The period captured was from 1998 to 2007. The study identified that 15 science process skills were assessed over the period understudied. However, the 5 prominent science process skills identified (68.2%) out of the 15 used in the study were manipulating (17.20%), calculating (14.20%), recording (13.60%), observing (12.00%) and communicating (11.40%) in descending order of emphasis. The emphasis of 17.20% for manipulating indicates shift from teacher-centered instruction to active learning (Akinbobola & Afolashade, 2010). However, only 1% emphasis was made for interpreting skills. This implies that students are made to manipulate equipment with little opportunity to evaluate and relate their activities to theory. This lack of opportunity to evaluate manual manipulations with the relevant theory is consistent with the observation of Abrahams and Millar (2008) that almost all students' discussion of practical activities is focussed on the manual manipulation skills involved in such activities. The skills of inferring and predicting which relate theory to observations were not found among the 15 science process skills identified by Akinbobola and Afolahade (2010).

Koomson (2019) also did a similar work using WAEC chemistry practical examinations from 2012 to 2016 and observed trend similar to Akinbobola and Afolahade (2010). The emphasis of the skills was in descending order of recording (32.13%), communicating (17.42%), manipulating (12.31%), calculating (6.91%), observing (10.51%), inferring (9.91%), measuring (4.5%), investigating (3.6%), interpreting (1.50%) and experimenting (1.2%). Koomson (2019) though identified that 9.91% emphasis was made for the skill of inferring to allow students to relate observations to theory in the WAEC chemistry practical examinations, the findings collaborate Akinbobola and Afolahade (2010) to assert that WAEC practical examinations over-emphasize basic science process skills at the expense of integrated science

process skills. Akinbobola and Afolahade (2010) also found that the assessment of basic science process skills (62.80%) was significantly over-emphasized at the expense of integrated science process skills (37.2%) with calculated t-value (2.58) being greater than the critical t-value (1.96) at .05 level significance (Akinbobola & Afolahade, 2010).

Considering the significant of emphasis for basic science process skills and the fact that WAEC is main assessing body that assess science process skills acquired by students, it can be predicted that science process skills acquired by students at end of their secondary education will reflect the nature of science process skills assessed by WAEC. This prediction is premised on the following facts: (1) assessment, particularly highly consequential ones like WAEC examinations influence how learning and teaching including development of skills are tailored (Braun & Kanjee, 2006); (2) it is easier to develop basic science process skills than developing integrated science process skills (Akinbobola & Afolahade, 2010) and (3) basic science process skills require concretes operational skills to develop while integrated science process depends on formal thinking (Ongowo & Indoshi, 2013). Based on this prediction, it is hypothesized that students will acquire significantly more basic science process skills than integrated science process skills at the end of their secondary education.

Despites the groundings of the stated hypothesis, Jack (2018) retained the null hypothesis that 'there is no significant difference in the mean difficulty of chemistry students' scores between basic and integrated science process skills' (Jack, 2019, p. 87). However, it is observed that the test items in the instrument used by Jack (2018) was adapted from WAEC's alternative to practical Chemistry past questions. Since these questions were available to the subjects prior to the test, the subjects may be familiar with some of the items and may have practiced some of them. Therefore, the options selected by the subjects to some extent may be influenced by recalling rather than using process ability. This assertion may reduce the discriminative ability of the instrument used. Hence, the need to test the stated hypothesis using novel items which attract subjects to use their process ability. Jack (2018) also claimed that class size influenced development and acquisition of science process skills with t-values of all 15 science process skills tested being lower than .05 significant level in favour of small sized classes.

This finding raises the issue of the effect of student-student and student-teacher interactions as well as access to teaching and learning resources on the development and acquisition of science process skills. In Ghana, senior high schools are categorized based on resources availability and success rate in WAEC examinations (Ghana Education Service, 2016). The main categories are the category A, B and C schools. Since access to resources and performances are known to decrease from category A schools to category C schools via category B schools, it is also hypothesized that the science process skills scores of these categories of schools will be significantly different. Finally, we are interested in testing for gender effect due to lack of consensus in literature. For example, Song and Black (1991) reported significant gender effect in favour of boys, whereas Jack (2018) showed no effect.

The study is therefore purposed to examine science process skills developed by categories of Ghanaian senior high school students and also to look at gender effect on the development and acquisition of science process skills.

RESEARCH QUESTIONS

The study sought to provide answers to one research question and three null hypotheses

Research Question 1:

What basic and integrated science process skills have SHS 3 students developed at the tail end of their science programme?

Hypotheses

H₀₁: The mean scores of students in basic science process skills will not be significantly different from the mean scores of integrated process science skills.

H₀₂: The mean scores of boys will not be significantly different from that of girls.

H₀₃: The mean scores of students from different category A, B and C schools will not be significantly different.

METHODOLOGY

Design for the Study

The study adopted cross sectional descriptive design using multiple-choice achievement test to collect data. Open ended and performance test may have been preferred (Bridgeman, 1992) but these formats have implication for constraint on time, number of skills to assess and resources. Multiple choice however, is the most convenient, fair and inexpensive way to judge performance in science process skills (Elmas *et al*, 2018).

Participants

Multi-stage sampling technique was used to collect data from 904 students in 20 out of 36 schools offering science electives in the Central Region of Ghana. Aside, central region being the accessible population, the region has all the three categories of Senior High Schools (SHS) identified in Ghana (GES, 2016). GES (2016) put all SHS in Ghana into three Categories – A, B and C schools based on academic performance and facilities available to the schools. Since GES assumes schools under the same category to have similar characteristics, it is inferred that locality is not the defining variables for school's characteristics; rather it is the category of the school that determines the character of the school. Central region has all the three school categories, the selection of the region therefore, provides good representative to generalise findings from such study. Central region has 77 schools with 36 schools offering General Science as programme where students select chemistry as a subject. The 36 schools comprising 17 Category C schools (including 4 private schools which are not categorised), 12 category B schools and 7 Category A schools covering 17 out of 20 education districts in the region. The 904 students sampled comprised 451 boys and 453 girls with 352, 288, 264 students from category A, B and C schools respectively.

Data Collection Instrument

The instrument used is named Students' development of science process skills index Test (SDSPS). SDPS is a parametric achievement test comprising 36 questions that assess nine higher order science process skills relevant to the SHS syllabus. There are four questions for each science process skill. The science process skills under examination include Observation (questions 1-4); Measurement (questions 5-8); Classification (questions 9-12); Inference/Prediction (questions 13-16); Communication (questions 17-20); Controlling variables (questions 21-24); Data interpretation (questions 25-28); Hypothesis (questions 29-32) and experimentation (questions 33-36). These skills are all relevant to the Ghanaian SHS

students (MOE, 2010) and were also contained in science process skill instrument used with science attitude questionnaires to determined relationship between the science process skills and science attitude among Palestinian Secondary School students (Zeidan & Jayosi, 2015). Though the style of construction of the test was modelled around that of Zeidan and Jayosi's, the content was based on the Ghanaian curriculum.

Reliability of Instrument

After construction, proof reading and validation by chemistry teachers, the reliability of SDSPS instrument was checked using 42 SHS 3 students within the population frame. The 42 SHS 3 students comprised of randomly selected 21 students each from form three science A and B students. The percentage scores of the two classes, which are parallel but with similar abilities were checked for consistencies using the Cronbach's Alpha reliability test. The test indicated 0.706. According to Pallant (2005), Cronbach's Alpha should be above 0.7. The analysis of the alpha values obtained therefore shows that the reliability of the SDSPS is acceptable.

Data Collection Procedures

The researcher, together with two assistants visited the selected schools with letters of introduction from the Head of the Department of Science Education. Though, some data were taken from some schools on the same day letters were taken to the schools, it took an average of two weeks for some schools to grant access due to protocols in the schools. The average time to complete the SDSPS instrument was 40 minutes. Though students were ensured they were not being tested, they were encouraged to answer the questionnaires independently to the best of their abilities. The questionnaires were collected at the end to ensure 100% return rate.

Data Processing and Analysis

The responses from SDSPS instrument were marked for each student and entered into Microsoft Excel programme using 1 and 0 for correct and wrong answers respectively. This approach allows detail answers for each participant across the 36 items in the instrument instead of entering just the cumulative score of each student. The marking and entering of responses were independently validated. The data from the students' scores were entered according to the three categories of schools (A, B and C) and gender. SPSS analytical tool was used to analysis the data for descriptive statistics like means, standard deviations and inferential statistics like, one way ANOVA and Tukey HSD post hoc tests to answer the research question and the hypotheses set in the study.

RESULTS

The results of the study is presented in the Tables 1-5.

Research question one: What basic and integrated science process skills have SHS 3 students developed at the tail end of their school programme?

Table 1: Descriptive analysis of students' scores in Basic science process skills (N = 904)

S/N	Variable	Max	Mean	SD	%
1	Observing	4	2.56	0.24	64.1
2	Communicating	4	2.36	0.32	59.3
3	Measuring	4	2.2	0.23	55.2
4	Prediction/Inferring	4	1.74	0.35	43.4
5	Classifying	4	1.36	0.24	34.0
SDSPS index		20	10.2	1.38	51.1

Table 2: Descriptive analysis of students' scores in integrated science process skills (N = 904)

S/N	Variable	Max	Mean	SD	%
1	Data Interpretation	4	2.76	0.333	69.0
2	Experimentation	4	1.48	0.257	37.4
3	Controlling variables	4	1.48	0.248	36.6
4	Hypothesis	4	1.44	0.327	35.6
SDSPS index		16	7.16	1.165	44.7

Tables 1 & 2 show that the science process skills prominently acquired by students in decreasing order are data interpretation (69.0%), observation (64.1%), communication (59.3%), measuring (55.2%), prediction/inference (43.4%), experimentation (37.4%), controlling variables (36.6%), hypothesis (35.6%) and classification (34.0%). The analysis in the Table 1 & 2 also indicate that student had acquired more basic science process skills (51.1%) than integrated science process skills (44.7%).

H₀₁: The mean scores of students in basic science process skills will not be significantly different from the mean scores of integrated process science skills.

Table 3: Descriptive analysis of the various variables of students' test scores (N = 904)

	Mean	Std. Dev.	SE.	95% Confidence Interval for Mean		Min.	Max.
				Lower Bound	Upper Bound		
Basic Science Process Skills	.51	.23	.004	.51	.52	.00	1.00
Int. Science Process Skills	.45	.28	.005	.44	.46	.00	1.00
Total	.48	.26	.003	.47	.48	.00	1.00
Girls	.48	.52	.004	.47	.49	.00	1.00
Boys	.50	.50	.005	.49	.51	.00	1.00
Total	.49	.51	.003	.48	.49	.00	1.00
Category A Schools	.53	.50	.004	.52	.54	.00	1.00
Category B Schools	.50	.50	.005	.49	.51	.00	1.00
Category C Schools	.37	.57	.008	.35	.38	.00	1.00
Total	.49	.51	.003	.48	.49	.00	1.00

The mean difference of (M = .51; SD = .23) for basic science process skills and (M = .45; SD = .28) for integrated science process skill (Table 3) is significant at [F (1,7230) = 110.91, p < .01] (Table 4).

Table 4: Analysis of variance for the various variables of students' test scores (N = 904)

Variable		Sum of Squares	df	Mean Square	F	Sig.
SPS (H ₀₁)	Between	7.16	1	7.16	110.91	<.01
	Within	466.88	7230	.065		
Gender (H ₀₂)	Between	3.08	1	3.08	11.63	.01
	Within	7366.80	27781	.26		
Schools A, B & C (H ₀₃)	Between	90.63	2	45.31	172.93	<.01
	Within	7279.25	27780	.26		

The analysis of the result indicates that the null hypothesis is rejected. The mean difference between scores for basic science process skills and integrated science process skills is significant.

H₀₂: The mean scores of boys will not be significantly different from that of girls.

The analysis in the study indicates that the mean difference (M = .48; SD = .52) for girls and (M = .50; SD = .50) for boys (Table 3) is significant at [F (1, 27781) = 11.63, p = 0.01] (Table 4). The null hypothesis is rejected. The gender of the students significantly influenced their development of the process skills.

H₀₃: The mean scores of students from different category of schools will not be significantly different.

Table 4 shows that at p < .05 level, the category of schools had significant effect at [F (2, 27780) = 172.93, p < .01]. However, Table 5 which contains the Post hoc comparison using Tukey HSD Test indicated that all the mean scores for the three categories of schools were significantly different.

Table 5: Post Hoc analysis of the mean scores on science process skills among the category of schools

(I) CAT	(J) CAT	Mean Diff. (I-J)	SE	Sig.	95% CI	
					LB	UB
Category A	Category B	.03	.007	<.01	.015	.047
	Category C	.16	.009	<.01	.14	.180
Category B	Category A	-.03	.007	<.01	-.05	-.015
	Category C	.13	.008	<.01	.11	.15
Category C	Category A	-.16	.009	<.01	-.18	-.14
	Category B	-.13	.009	<.01	-.15	-.11

The mean difference for (M = .53; SD = .50) for Category A Schools and (M = .50; SD = .50) for Category B Schools (Table 3) is significant at p < 0.01 (Table 5). The mean difference for (M = .53; SD = .5) for Category A Schools and (M = .37; SD = .57) for Category C Schools (Table 3) is significant at p < 0.01 (Table 5). The mean difference for (M = .50; SD = .5) for Category B Schools and (M = .37; SD = .57) for Category C Schools (Table 3) is significant at p < 0.01 (Table 5). The null hypothesis is therefore rejected. The category of schools influenced the development of science process skills.

DISCUSSION

The findings in the study show that science process skills like data interpreting (69.0%), observing (64.1%), communicating (59.3%), measuring (55.2%), were fairly developed but science process skills like predicting/infering (43.4%), experimenting (37.4%), controlling variables (36.6%), hypothesizing (35.6%) and classifying (34.0%) were underdeveloped. The basic science process skills ($M = 51.1$, $SD = .23$) are significantly developed at the expense of integrated science process skills ($M = .45$; $SD = .28$) at $[F(1,7230) = 110.91, p < .01]$. Judging from the average acquisition of the overall skills of about 47.9%, it can be inferred fairly that the findings is consistent with Jack (2018) who found that students find these skills difficult to acquire. The differences lie in observing, communicating and data interpreting which Jack (2018) found difficult to acquire, but the subjects in this study seem to have mastered. The process skills acquired by students also seems to correlate with process skills emphasized by examining bodies in the region. The WAEC physics practical papers and Kenyan biology examining body (Akinbobola & Afolashade, 2010; Ongowo, & Indoshi, 2013) all put emphasis in assessing basic science process skills. Koomson's (2019) report that the process skill of classifying (0.3%) is hardly used in WAEC chemistry examinations is also consistent with the finding in the study that classifying (34%), is the least acquired skill in this study. The implication for the findings is that Ghanaian SHS students can use their observational skills to observe data, differentiate the measuring variables and able to give explanation/interpretation of data and communicate scientific data using either tables, graphs or verbal means. What perhaps, is lacking to some extent is the ability to infer or predict from observations and to order variables into meaningful groups or categories. However, developing inferring, predicting, and classifying process skills are key to developing the integrated science process skills which enable identification and formulation of solutions to scientific problems (Rambuda & Fraser, 2004). The under development of the latter process skills therefore had implication on the acquisition of the integrated science skills as observed by the study.

The study depicts linear interaction between the categories of schools into A, B and C in Ghana and acquisition of science process skills. The categorization of schools into A, B and C (GES, 2016) partitions schools into socio-cultural environments with decreasing endowments in the order of Category A schools > category B schools > category C schools. The study indicates that category A schools ($M = .53$; $SD = .50$) acquires science process skills better than category B schools ($M = .50$; $SD = .50$) at $p < 0.01$ with category B schools also acquiring science process skills better than category C schools ($M = .37$; $SD = .57$) at $p < 0$. Self-efficacy that drives engagement in cognitive tasks is known to interact with motivation and social supports derived from socio-cultural environment of the individual (Adey, 1997; Pajares, 2003). The study suggests that the socio-cultural inequalities enjoy by these categories of schools are influencing their development and acquisition of science process skills. Efforts therefore need to be made by stakeholders to improve and close the gaps among these categories of senior high schools in Ghana. On the issue of gender, Song and Black (1991) found that boys significantly outperformed girls in the skill of application in everyday contexts, Zeidan and Jayosi (2015) indicated gender effect in favour of girls and Jack (2018) found no gender effect. This study indicates that the mean difference ($M = .48$; $SD = .52$) for girls and ($M = .50$; $SD = .50$) for boys is significant at $(F(1, 27781) = 11.63, p = 0.01)$. This shows that gender interaction with science process skills may be complex and may depend on specific context. It can also be said that the school categories may confound the present study. Perhaps, gender effect should have been

measured with respect to single sex schools in specific category of schools and mixed sex schools in specific category of schools.

CONCLUSION

The discussion of the findings in the study has demonstrated that development and acquisition of science process skills are necessary for scientific understanding and offering of solutions to scientific problems. However, the observed lack of development and acquisition of skills like inferring, predicting, classifying and integrated skills among students should be rectified through provision of opportunities to develop and acquire those skills if the curriculum aspiration of equipping students to identify and contribute toward solving scientific problems are to be achieved. The findings that development and acquisition has significant interaction with contexts and the socio-culture environment of the learner implies that categorization in the Ghanaian senior high schools creates and harbors inequity with respect to the development and acquisition of the skills. Attempts should be made by stakeholders to bridge such gap. The complexity of the science process skills and gender effect means that method of sampling should be done in a way to eliminate confounding of school categories to make gender effect emphatic.

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