Interpreting Skills of Senior Secondary School Students in Elective Biology in the Central Region of Ghana.

Christian Anthony-Krueger.

University of Cape Coast, Ghana.

Abstract

Investigation was made into students' proficiency at interpreting biological diagrams, an important component of senior secondary school certificate examination (SSSCE) in Biology Paper 2. In all 303 elective biology students, aged between 15 and 24 years made up of 159 males and 144 females in urban and rural senior secondary schools were randomly selected for the study. A performance task was the instrument used to determine the interpreting skills of the students. Majority of the students seem not able to interpret biological diagrams. Sex, age and the type of school the students attended were found not to be related to their performance at interpreting biological diagrams. Nevertheless, a greater proportion of females than males exhibited the same level of performance in interpreting biological diagrams. The major implication of the results for science education is that a lot of data interpretation exercises should be included in the teaching of biology.

The basic purpose of instruction is not to cause students to memorize facts but to participate actively in the processes that lead to the creation of new knowledge (Brunner, 1966). Knowing, according to Brunner (1966), is a process not a product. Knowledge–getting processes in science and for that matter in Biology are full of skills in which the student needs to be proficient. Akinmade (1992) reported that process skills are the foundation of scientific enquiry and are required for learning facts, concepts and principles necessary for making valid interpretation of biological data. For Finlay (1983), once science process skills are acquired they become very powerful means for mastering content. Shaw (1983) pointed out that process skills that scientist use for practising and understanding science can be put into two categories: basic and integrated process skills. Skills needed to interpret scientific data fall under the integrated process skills.

Students demonstrating the process of interpreting are required to determine a pattern or put meaning into scientific (biological) data presented in any form. They are also expected to justify any meaning put into or taken out of their experiences at the time. Akinmade (1992) reiterated that for a student to exhibit competency in the use of interpreting skills in science and for that matter in biology, the student must be able to:

1. make generalization from a set of biological data or information;
2. identify cause and effect relationships from biological data;
3. recognize which biological data lend support to an inference; and to
4. draw as many plausible inferences as the data may allow.

Biology is one of the science elective subjects taught at the senior secondary school (SSS) level in Ghana. The assessment in biology takes many forms including grading of students' performance during practical activities. For example, if the dissection of a mammal is done the student might be required to draw the displayed internal organs in situ and the drawing and skill of dissection are assessed based on the dissected mammal exhibited. Another form of assessment is to provide performance tasks and investigative projects for the students to work at. Other tasks are multiple choice, short-answer and essay tests. Both internal and external examinations in biology are comprehensive and call for one to demonstrate one's proficiency in the process skills rather than mere recall of facts only. In order to be able to perform well in the West African Examinations Council's (WAEC's) Senior Secondary School Certificate Examination (SSSCE) Biology Paper 2, one needs to demonstrate adequate competence in the process skill of interpreting biological data. It is revealing, after a considerable number of years of experience as a biology teacher, that biology students are unable to interpret biological data satisfactorily. The result is that most of the students score low marks at the SSSCE in Biology Paper 2. This situation has been observed by Rounning and McCurdy (1982) and Lassa and Akpan (1988) who commented that secondary school students perform poorly on tasks involving the use of integrated processes.

Padilla, Okey and Dillashaw cited by Akinmade (1992) agree with Baird and Borich (1987) that some amount of overlap exists between integrated process skills and formal operational thought. This suggests that the two constructs are interdependent. By implication it follows that some level of reasoning is a prerequisite for students to be able to interpret biological data that are either in the form of a table, a chart, a diagram or graph. According to Berg and Smith (1994) students with deficient logical thinking abilities such as spatial thinking and proportional reasoning have great difficulty in interpreting or constructing graphs. The reason given by Berg and Smith (1994) is that many students do not have the mental tools to engage in a high level interpretation of graphs. When students were asked to interpret the concepts conveyed by graphs in a research conducted by Beichner (1990), they performed poorly and the reason was traced to cognitive inability of the students to construct and interpret the graphs. The reason of Beichner (1990) is corroborated by Roth and McGinn (1997) that the lack of competence on the part of students in interpreting data is explained in terms of their experience and the degree of their participation in activities involving interpreting data rather than, exclusively, in terms of their cognitive ability.

Analyses of assessment in science by the British Assessment of Performance Unit (APU) have established that at ages 11 and 13 years, irrespective of criteria being assessed, there are sex differences in achievement (Johnson, 1987; Murphy, 1988). The differences reflect areas in which each sex had prior experience. For example, girls scored better on items relating to health, reproduction, nutrition and domestic situations, whereas boys did better on items concerning building sites, race trucks, spare parts, electricity and many others. Linn and Hyde (1989) have shown that sex differences for science processes are not as great as for science knowledge. They contended that differences appear to be related to learning opportunities both inside and outside school. Simpson and Oliver (1985) have revealed that female attitude toward science becomes more related to their concept of male dominance in science. It has been found out by Weinburgh (1995) that boys show more positive attitude toward science than girls. Ossei-Anto (1996) confirmed that finding when he reported that boys showed more positive attitude towards science than girls in a physics (refraction) task he administered on selected students at Buffalo. However, it was not always the case, because Schibeci (1984) and Al-Hajji (1983) have found out that girls show more positive attitude toward science than boys. The foregoing findings appear to point to the fact that, there is a controversy as to which sex exhibits process skills better in science than the other.

This study was therefore carried out to find out if SSS biology students in senior secondary schools in Cape Coast can interpret biological diagram. It was also to find out if the students' ability to interpret the diagram depended on sex, age and the type of school they attended.

Method

Sample

The sample consisted of 303 final year elective biology students from both single sex and co-educational senior secondary schools in the Central Region of Ghana. It is a region with the highest number of senior secondary schools including the first secondary school in Ghana – Mfantsipim. It has two Universities that run mostly education-based courses.

The 303 participants were made up of 159 males and 144 females whose ages ranged between 15 and 24 years. They came from various home backgrounds ranging from elite to illiterate parents. It is also noteworthy that they came from both endowed and less endowed schools. (An endowed school in this study is one that has adequate number of teachers and teaching-learning materials, while the less endowed has inadequate number of teachers and poor teaching-learning facilities).

In selecting the sample, a list of only the 24 senior secondary schools in the Region that offer elective biology was compiled alphabetically by name on pieces of paper and 15 schools were selected at random using the lottery approach.

A visit was made to all the 15 schools to collect a list of names of all students offering elective biology. All the names on the lists were put together and arranged alphabetically by family name. Serial numbers were assigned to the names and a table of random numbers was used to select the 303 out of a total of 1215 students

Instrument

The instrument was a biological diagram shown as Figure 1 depicting the concept of irritability with a two-item questionnaire developed by the researcher. The task shows four boxes of equal size initially filled with dry sawdust and 10 worms put at the centre of each. The sawdust in boxes I, II and IV had portions wet with water while the sawdust in box II still remained dry. A source of light was placed equidistant from each box Figure 1 shows the different positions taken by the worms in the boxes after one hour. The diagram was based on irritability in animals. The choice of the concept of irritability was co-incidental, it had no special significance.

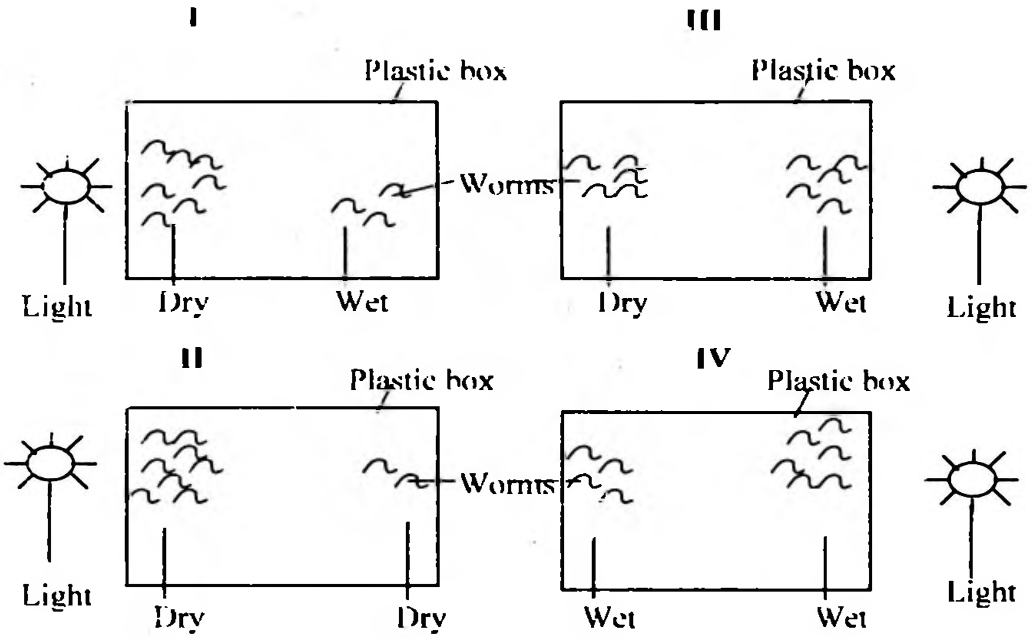

Figure 1. Worms in boxes of sawdust

The questionnaire had two items as shown below. Tick the box of the appropriate response and write where spaces have been provided.

1. How often have you practised interpreting biological data?

Often	[ ]	Very often	[ ]
Seldom	[ ]	Not at all	[ ]

2. Write your comments about the task.......................................

....

....

The task developed for this research was dubbed: Process Skills Assessment Task in Biology (PSATB) which is an adaptation of Physics Laboratory Assessment Scheme (PLAS) used by Ossei-Anto (1996). Defending the suitability of an instrument for assessing science process skills, Ossei-Anto (1996) asserted that a valid instrument does not automatically make another instrument valid, even if both are correlated to each other. Hence, it is suggestive that in assessing any science process skills, an assessment instrument that is valid must be developed. Such an instrument should be unique, complete, independent and unbiased.

Procedure

The schools selected by random sampling were visited and the students concerned were isolated and kept in the classroom or science laboratory. They were given serial numbers, which were preceded by either the letters MS or SS for identification purposes (MS indicated mixed school and SS, single sex school). The task sheets were distributed and read to them in case they were unable to comprehend the task. The students were allowed 30 minutes to complete the task.

The scores were categorized into levels of performance. All those whose level of performance was1 and 2 or gave wrong or partial interpretation of the diagram in Figure 1 were classified as not having the skill while those who performed at level 3 or gave full and accurate responses were classified as having the skill.

Results and Discussion

Students' Performance in Interpreting Biological Diagram

A scheme for assessing the performance of the students has been shown as Figure 2

Figure 2

Level of Performance	**Rubric**
0	**No response**
1	*Wrong interpretation*
	Partially correct interpretation:

2	• Using single variable e.g. worms respond positively to light. Or worms respond negatively to moisture • .Interpretation that is partially correct.
3	**Accurate interpretation:** • Complete / full response combining two or more variables quoting correct numbers or ratios and giving reason(s) for the observations **Correct interpretation:** (Worms respond to light but not moisture because where there is light and no moisture, the number of worms increases).

Figure 2: Scoring Rubric for Interpreting the Diagrams

The performance of the students has been presented in Table 1.

Table 1
Performance of Students in Interpreting Biological Diagram

Level of Performance	Frequency	Percent
0 – No response	5	1.7
1 – Wrong interpretation	161	53.1
2 – Partial interpretation	108	35.6
3 – Accurate interpretation	29	9.6
Total	303	100.0

Table 1 shows that the total percentage of students, who made partially correct and accurate interpretation was, 137(45.2%). As many as 161 (53.1%) of the students made the wrong interpretation. It means that a little more than half the number of students appeared not able to interpret the biological data presented in diagrams. Students who have the skill should be able to interpret the diagrams correctly, but since a relatively large number 108 (35.6%) of students could make partial interpretation, it suggests that their score for that performance is likely to be low. In a biology examination like the SSSCE, a low score for interpreting data will affect the overall score in the paper. It is highly probable that the seemingly poor performance that characterizes biology results could be partly the cause of the low grades in the subject.

In order to find out if the students had any experience in interpreting data, the students were to indicate on a two-item questionnaire incorporated in the biological diagram in Figure 1, the regularity at which they practised. The distribution of their responses has been shown in Table 2.

Table 2
The Frequency at which Students Practise Interpreting Biological Diagram.

Response	Frequency	Percent
No response	6	2.0
Often	110	36.3
Very often	43	14.2
Seldom	119	39.3
Not at all	25	8.3
Total	303	100.0

From Table 2 it is seen that about half the number 153 (50.5%) of the students indicated that they often or very often practised interpreting while the remaining half 150 (49.5%) did not practice interpreting biological data. Definitely, since practice leads to perfection, non practice by almost 50% of the students implied that the students are likely not to develop the skill of interpreting biological data and therefore they were likely to perform poorly in biology. The revelation in Table 2 is in consonance with the reason assigned by Beichner (1990) and Roth and McGinn (1997) that the lack of competence in interpreting data is the result of limited experience and degree of participation in activities involving interpreting data.

The performance of the students in interpreting the biological diagrams was examined to see if any relationship existed either between sex, age, or type of school they attended and their performance. Pearson's X^2 -test values for sex, age and type of school against their performance have been presented in Table 3.

Table 3

Pearson's X^2-test Values for Sex, Age and School Type; and Students' Performance in Interpreting Biological Diagrams. N=303

Variable	X^2-test Values	df	Critical Values of X^2 at $\alpha = 0.05$
Sex	2.27	3	7.82
Age	18.22	12	21.03
School type	17.93	15	25.00

With reference to Table 3 none of the X^2-test values is significant at 0.05 alpha level as far as interpreting the biological diagram was concerned. This meant that sex, age and school type were independent of the performance of the students in the interpretation of the diagrams.

Comparison of the numbers of females and males interpreting the biological diagram has been shown in Table 4.

Table 4
Sex of Students and their Performance in Interpreting Biological Diagram.

Performance Level	Sex	
	Female [a]	Male [b]
0 – no response	3(2.1)	2(1.3)
1 – wrong interpretation	72(50.0)	89(56.0)
2 – partial interpretation	52(36.1)	56(35.2)
3 – accurate interpretation	17(11.8)	12(7.5)

Note: Figures in parentheses are percentages while those without parentheses are frequencies.

[a]Total number (n) of females = 144; [b]Total number (n) of males = 159

From Table 4, it is apparent that more females 17 (11.8%) than males 12 (7.5%) appeared to have made accurate interpretation of the biological diagrams. This observation is in line with the findings of Schibeci (1984) and Al-Hajji (1983), but it disagrees with the finding of Weinburgh (1995). This apparent difference was subjected to a t-test at a significance level of 0.05. The t-test values for the mean performance of female and male students on the interpretation of the diagrams shows that the females' performance was not significantly better than that of the males ($\underline{m}$ = 1.58, SD = 0.72), t (301) = 1.083, p> 0.05.

The age levels of the students and their level of performance in interpreting the biological diagram have been presented in Table 5.

Table 5

Age of Students and their Level of Performance in Interpreting Biological Diagram.

Level of Performance	Age [a] in Years				
	15	16	17	18	19⁺
0 – no response	-	-	1(1.6)	-	4(5.6)
1 – wrong	1(100.0)	2(33.3)	26(42.6)	96(58.5)	36(50.7)
interpretation	-	4(66.7)	25(41.0)	54(32.9)	25(35.2)
2 – partial	-	-	9(14.8)	14(8.5)	6(8.5)
interpretation					
3 – accurate interpretation					

Note. Dashes indicate that no values were obtained. Figures in parentheses are percentages while those without are frequencies.

[a] Number (n) of various ages in the research sample were:

15 years 1; 16 years 6; 17 years 61; 18 years 164; 19^+ years 71.

The 15 and 16-year olds seem not able to make accurate interpretation of the diagrams as shown in Table 5. However, only a handful of 17, 18 and 19^+-year olds appeared to make accurate interpretation in the following percentages: 9(14.8%), 14(8.5%) and 6(8.5%) respectively (see Table 5). It appears that small numbers of students in their late teens seem to interpret the diagram more accurately than those in their early and mid teens even though about half the number seldom practised biological data interpretation as indicated in Table 2. The difference in performance is, however, not statistically significant at 0.05 alpha level.

It was of interest to find out if the type of school attended by th students had any influence on or relationship with their performance. Th finding has been presented in Table 6.

Table 6
Type of School and Students' Performance in Interpreting Biological Diagrams.

Level of Performance	Type of School [a]					
	USSF	USSM	UM	RSSF	RSSM	RM
0– no response	2(3.9)	2(2.4)	1(1.1)	-	-	-
1– wrong interpretation	20(39.2)	48(57.1)	45(51.1)	14(58.3)	5(51.4)	29(59.2)
2– partial interpretation	18(35.3)	28(33.3)	33(37.5)	9(37.5)	2(28.6)	18(36.7)
3– accurate interpretation	11(21.6)	6(7.1)	9(10.2)	1(4.2)	-	2(4.1)

Note. Dashes indicate that no values were obtained. Figures in parentheses are percentages and those without parentheses are frequencies.

[a]Type of school and the number (n) in each school that took part in the research: USSF = urban single sex females 51; USSM = urban single sex males 84; UM = urban mixed 88; RSSF = rural single sex females 24; RSSM = rural single sex males 7; RM = rural mixed 49.

It is shown in Table 6 that only small numbers of students from the various types of schools except RSSM seem to make accurate interpretation of the diagrams. Comparatively, more students from urban schools than students from rural schools made accurate interpretations of the diagrams. This suggests that students in urban schools might be predisposed to facilities that enable them practice data interpretation.

Although sex, age and school type appeared to be independent of the performance of the students in interpreting the diagram, the findings showed that more females than males appeared to have made accurate interpretation of the diagrams. The implication being that more females seem to exhibit interpreting skills than the males but the difference is not statistically significant.

Similarly, students from the age of 17 years and above in selected SSS in the Central Region appeared to interpret the biological diagrams accurately, while those below 17 years appeared unable to interpret them. In the same vein this apparent difference was not statistically significant. The results with the school type and students' performance showed that more students from urban schools than rural schools were able to make accurate interpretation of the diagram. The difference in performance, however, between urban and rural school students was also not statistically significant at alpha level 0.05.

Conclusions

The results show that, almost all the SS 3 biology students from selected SSS in the Central Region of Ghana seem not able to interpret the biological diagrams. Additionally, a good number of the students had no practice at interpreting biological data. Of the few that appeared able to interpret the diagrams accurately a large number of them were females. Similarly, more students from urban schools than rural schools made accurate interpretation of the diagrams. Considering the ages of the students, only 9 (14.8%) of those who were 17 and above years were able to make accurate interpretations of the diagrams and those below 17 years could not.

Although a larger number of females than males appeared to have made accurate interpretation of the diagram, it is not statistically significant. the striking thing about the study was that the males outnumbered the females in the ratio 159:144 respectively, but more of the females than males seemed to make partially correct interpretations of the diagrams. It pre supposes that more girls are likely to pass the biology examinations in Paper 2 at SSSCE than boys even though their grades might be low. The revelation in Table 4 that relatively more girls than boys made accurate interpretation of the biological diagrams, is likely to point to the fact that more girls might make good quality grades in biology at the SSSCE than the boys because accurate interpretation of biological data will likely boost the quality of the grade one makes at the SSSCE.

If some reasoning is a prerequisite for interpreting biological data as contended by Akinmade (1992); Baird and Borich (1987); and Berg and Smith (1994), then one wonders whether the students who were 17 years and above but made accurate interpretations of the biological diagrams exhibited some level of reasoning over those with younger age. The answer to this concern is beyond the scope of this study.

Implication for Educational Practice

The limitations of the study notwithstanding the findings have some implication for educational practice. Since most of the students did not practice interpreting biological data, biology teachers should infuse their lessons with data interpretation sessions. Biology textbook writers ought to revise their books or write new ones and include a lot of varying exercises on interpreting biological data. It is noteworthy that the data must be provided in different forms for them to develop versatility in handling data in different forms.

Furthermore, rural schools need to be well equipped with material and human resources so that students in those schools will have comparable learning experience as their counterparts in urban schools. It is only then that students from both types of schools can be perceived to be equivalent.

REFERENCES

Akinmade, C.T.O. (1992). Developing basic and integrated science process skills in elementary school students. In O.E. Akpan (Ed.), *Towards Creative Science Teaching and Learning in West African Schools* (pp. 50 – 62). Cape Coast: Catholic Mission Press.

Al-Hajji, Y.Y. (1993). Attitudes of Students and Science Teachers Toward Science Laboratory Work in the Middle Schools of Kuwait (Doctoral Dissertation, Boston University, School of Education. *Dissertation Abstracts International, 43, 12A.*

Baird, W.E. & Borich, G.D. (1987). Validity considerations for research on integrated science process skills and formal reasoning ability. *Science Education. 71(2), 259 – 269.*

Beichner, R.J. (1990). The Effect of simultaneous motion presentation and graphgeneration in kinematics laboratory. *Journal of Research in Science Teaching, 27, 803 – 815.*

Berg, C.A & Smith, P. (1994). Assessing students' abilities to construct and interpret line graphs: Disparities between multiple-choice and free-reponse instruments. *Science Education. 78,* 527 – 554.

Best, J.W. & Kahn, J.V. (1995). *Research in education* (7^{th} ed.). New Delhi:Prentice Hall.

Booman, J.M. (1991). The development and testing of laboratory performance tasks for the assessment of achievement in high school physics. (Doctoral Dissertation, State University of New York at Buffalo, 1991). *Dissertation Abstracts International 52(2),* p.490A.

Brunner, J.S. (1996). *Toward a theory of instruction.* Cambridge: Belknap.

Finlay, F.N. (1983). Science processes. *Journal Research in Science Teaching. 1(20), 47 – 54.*

Johnson, S. (1987). Gender differences in science: Parallels in interest, experience and performance. *International Journal of Science Education. 9, 467 – 481.*

Lassa, P.N. & Akpan, O.E. (1998). A Comparison of science students'

performances on SAT, SAI and WSPI in selected Nigerian secondary schools: A preliminary report. *Journal of Educational Studies. 1(2), 19.*

Linn, M.C. & Hyde, J.S. (1989). Gender, mathematics and science. *Educational Researcher* 18, 17 – 19, 22 – 27.

Murphy, P. (1988). Gender and assessment. *Curriculum. 9,* 165 – 171.

Nwana, O.C. (1992). *Introduction to educational research.* Ibadan: Heinemann Educational Books.

Ossei-Anto, T.A (1996). *Assessing laboratory skills of students in selected high school physics topics in optics.* Michigan: A Bell and Howell.

Roth, W.M. & McGinn, M.K. (1997). Graphing: Cognitive ability or practice. *Science Education. 81(1).*

Rounning, R.R. & McCurdy, R.W. (1982). The role of instruction in the development of problem solving skills in science. *What Research Says to the Science Teacher. 4, 31 – 41.*

Schibeci, R.A. (1984). Attitudes to Science: An update. *Studies in Scie Education, 11, 26 – 59.*

Shaw, J.J. (1983). The effect of a process–oriented science curriculum u problem solving ability. *Science Education 67*(5), 615 – 624.

Simpson, R.D. & Oliver, J.S. (1985). Attitude towards science achievem motivation profiles of male and female science students in grades through ten. *Science Education,* 69, 511 – 526.

Weinburgh, M. (1995). Gender differences in student attitudes towa science: A meta–analysis of the literature from 1970 to 199 *Journal of Research in Science Teaching, 32(4), 387 – 398.*