JOURNAL OF NIGERIAN EDUCATIONAL RESEARCH ASSOCIATION

2002/2003 VOLUME 16 & 17

ISSN: 0189 - 2321

EFFECTS OF VISUAL INFORMATION-PROCESSING AIDS ON STUDENTS ATTITUDE AND LEARNING OF BIOLOGY

Christiana Nkechi Omoifo and Clara Dumebi Moemeke

INTRODUCTION AND STUDENTS' THEORETICAL BACKGROUND

The world today could be rightly described as that of science and technology. For this reason, every country strives to develop resources in all directions. It is obvious that Nigeria is in dire need of proven and practical scientists to help her move forward in the search for technological advancement. The approaches employed in achieving this development and diversification may vary from country to country. However, appropriate science education stands out as an incontrovertible factor in this regard.

Reports have shown that the performance of students at the high school level is depressingly poor. Students' difficulties in biology practical in Nigeria have been diagnosed to include identification and classification of specimen, inability to observe parts identified and inability to label parts observed from specimens, (Ogunsola-Bandele and Lawan,1997; Nworgu, 1999). The persistent problem which science educators are now faced with is to develop strategies that could contribute to the improvement of student's performance in terms of achievement and attitude to science.

For many decades. Science Teachers Association of Nigeria (STAN) and the concerned citizens of Nigeria have been grappling with this problem of finding solution to the perennial problem of poor performance, low achievement and poor students' attitude towards science. The use of the laboratory as an important facility in the teaching of science to improve student achievement and interest has been variously reported (Dechsri, Jones and Heikkinen, 1997; Tamir, 1977). Several studies have emphasized other benefits of laboratory activities apart from giving students the opportunity to behave like scientists (Ango and Sila, 1986; Ehiemere,1978; Tamir and Lunetta, 1981). Despite these research reports that emphasize the use and value of the laboratory in pedagogy, the rates of failure and drop out from science classes in Nigeria still continue to be on the increase (Urevbu, 1997).A lot of effort has been made to find and identify the variables that will enhance and improve laboratory instruction and students achievement. Science educators have, therefore, directed their attention to the laboratory handbooks or manuals in use in secondary schools.

The use of diagrams in science teaching has been worked on extensively. Picture-word diagrams were found effective for low verbal learners (Holliday,1976) while block-diagrams containing no pictorial materials were effective for high verbal learners (Winn, 1981). Knowlton (1996) in an earlier study showed that pictorial adjuncts fulfill a variety of function in processing and storing verbal information, especially when the verbal learning task involves understanding of relationships. This is achieved through supplemental visual displays such as schematic diagrams in which all the relationships are structurally coordinated. Such visual displays help to overcome limitations in the capability of the learner to notice, encode, link and retain a sequence of ideas. Noh and Scharmann (1997) used pictures with relevance to the target concept and found that instruction became more effective at improving student conceptions of chemistry concepts.

However, this depends on the efficiency of the treatment and the grade of introduction of the topic in question. The authors, therefore, suggested that teachers increase their use of the topic in question. The authors therefore, suggested that teachers increase their use of pictorial materials, especially when introducing new concept that prove difficult to understand. Other researchers also attest to the efficacy of pictures and diagrams in learning (Chandler and Sweller, 1992; Guri-Rosenblit, 1988; Reid and Miller, 1980).

The laboratory is also a factor in the science-learning environment that is intrinsic to the development of positive student attitude toward science. In response to this awareness of attitudinal implication of laboratory instruction, many models that describe the relationship between instruction, attitude toward science and achievement have been put forward (Okebukola, 1986; Schibeci and Riley, 1986). These works are consistent in reporting that achievement in science does not influence attitude towards science but that the nature of science instruction (e.g. laboratory instruction) affects attitude toward science, which, in turn predict achievement, science learning and the amount of science, a student will choose to experience. Freedman (1997) in an experimental study of the use of laboratory instruction as a means of improving students attitude towards science and increasing students achievement level in science knowledge found that laboratory experiences have a positive influence on the student's attitude towards science and their achievement in science knowledge.

From the discussion above it is evident that several of these studies on improving students' learning of science are done outside Nigeria. Little effort has focused on Nigeria. Taking into account Nigeria's need for practical scientists with good orientation in laboratory activities, it becomes necessary to investigate any factor that will lead to the attainment of this goal. This study therefore, developed instruments which included a biology manual with Visual Information Processing Aids (VIPA), assessment instruments for attitude achievement and investigated the effects of the laboratory manual on students’ attitude and learning in biology. The study is based on the theory and concept of information processing (Gagne, 1962) and schema theory of learning (Anderson, 1990).

Gagne suggested that mental processes go on in learning or in any type of memory task. Receptance is when sense organs receive stimuli from the environment and generate patterns of neutral impulses. Selective perception is when the neutral impulses are sent to a sensory register, a mechanism in the brain, which receives them and rejects those that are irrelevant. Short-term storage is when the selected impulses are sent to the short-term memory and kept temporarily. Semantic encoding is when the information is encoded for permanent storage and long-term storage is when the item is placed in the long-term memory. When the information is needed again, a retrieval process is initiated. Considering these processes, Gagne suggested certain instructional events and actions necessary for each process. For receptance of the stimuli, an instructional event that will help students gain attention is necessary. This is possible by the use of an abrupt stimulus. For selective perception also, a stimulus which can display content with distinctive features is necessary. In a poor laboratory where equipment is not available in sufficient amounts and in situations where students had not had the opportunities to interact with the science materials, one way of making students gain attention is by presenting the stimuli in the form of pictures or diagrams. Such pictures or diagrams of the apparatus or procedures will help display the content of the activities.

Anderson's schema theory of learning views organized knowledge as an elaborate network of abstract mental structures, which represents one's understanding of the world. Anderson (1990) noted that this process of visual information processing begins when light from the object (stimulus) enters the visual organs (eye). It is registered by the visual receptors, which can only store a small amount of the information for a short time before transferring or committing it to the memory storage organs. This stored information can then be recalled and matched with that from long-term memory to form the working memory. It follows, therefore, that where a student's mental capacity is found inadequate for processing a large amount of information, presenting it in the form of pictures, diagrams, models and concrete objects might ease this task of conceptualization and remembering. Shavelson (1974) illustrated this human model of information processing diagrammatically as shown in figure 1:

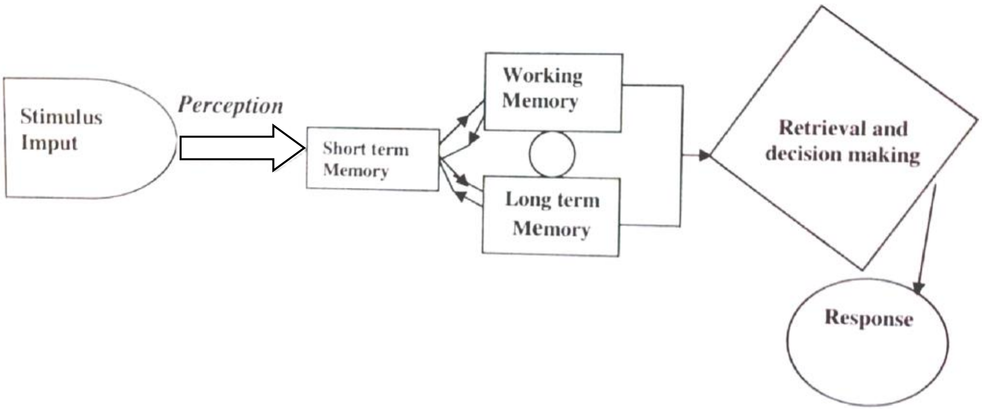

Fig. 1: Shavelson's (1974) Human Model of Information Processing

In any laboratory activity in which the student is unaware of the relevant prior knowledge or background information subsumed in the memory or cognitive structures, he is likely to go through the exercise or activity without any substantial gain and without understanding the learning inherent in the laboratory activity. Any manual which could help the student process the new information by tapping from the stored knowledge, will make such laboratory activity more meaningful. This study therefore is an attempt to use this conception and theory to explore the interaction of the design of laboratory manuals and their possible effects on students' attitude.
Based on the problem of the study, the following hypotheses were formulated and tested:

1. There is no significant difference in biology achievement of students who used laboratory manual with VIPA and those who used laboratory manual without VIPA.
2. Achievement scores of students who used the VIPA manual are not significantly different from those who did not use the manual based on sex.
3. Achievement scores of male and female students who used the VIPA manual are not significantly different from those who did not use the manual based on their attitude towards biology.

METHODOLOGY

The study is a quasi-experimental design. Intact classes were used for the experimental and control groups. Senior secondary class II biology students from a school in Boji-Boji Owa, Delta State, Nigeria, participated in the study. The school is co- educational and located in an urban area. A total of 110 students (sixty-three in the experimental group and forty-seven in the control group) participated in the study. There were forty experimental males and twenty- eight control males. There were also twenty- three experimental females and nineteen control females. The mean age of the students is sixteen years with an age range of fourteen to nineteen.
Three major instruments were used in this study:

1. **Laboratory manuals** – an experimental manual with diagrams and a conventional one that contained no diagrams. Both were similar in content. The conventional manual had a preliminary section showing clearly stated objectives, summary of the activities and the pattern of expected laboratory reports for three topics (test of mineral salts in the soil, effect of saliva on starch, and diffusion), selected for the study. The content of the manual is written in a simplified language to avoid contradictions and verbal complications. The manual is written in such a way as to direct students to practice necessary skills before they are used in the activities. Finally, the laboratory procedures are sequenced into steps. The experimental manual shared similar characteristics as the conventional manual except for the inclusion of line diagrams. The diagrams introduced the new equipment, illustrated correct handling and also showed procedural sequence.
2. **An attitude scale** – this included a five-point Likert scale with responses ranging from strongly agree to strongly disagree, and was adapted from Hofstein, Ben-Zvi and Samuel (1976) attitudinal scale pattern. The items were nineteen in all and were positively or negatively worded.
3. **The achievement test** – this consisted of fourteen multiple-choice items and was developed from the three laboratory activities for the study.

The laboratory manuals were content validated while reliability of the attitudinal scale and the achievement tests were calculated. Using Cronbach alpha, the internal consistency of the attitudinal scale was found to be 0.86, while kuder-Richardson 21 reliability score for the achievement test was 0.67.

Treatment lasted for a period of five weeks. The first week involved introduction and orientation, and a pre-test administration of the achievement test. Laboratory sessions and activities using the manuals were administered during the following weeks. Post-test and the attitudinal scale were administered during the last week.

Responses on the two assessment instruments were scored. For the achievement test a correct answer scored one point while a wrong answer scored no point. For the attitude scale, a positively worded item scored five points for strongly agreed and one point for strongly disagree; and vice versa for negatively worded items. Since there were 14 items on the achievement test, the maximum score for a student was 14.The attitudinal scale had nineteen items and the maximum score was 95 while the minimum was 19.Significant differences were determined using analysis of covariate. All decisions to accept or reject a hypothesis were made at the 0.05 level of significance.

RESULTS

The results on table 1 are used to investigate the hypothesis on differences in achievement between experimental and control groups.

Table 1: Mean Scores on Achievement Pretest and Posttest

	Experimental Group (n = 63)		Control Group (n = 47)	
	Mean	**Std. Deviation**	**Mean**	**Std. Division**
Achievement Pretest	8.81	1.76	7.40	1.74
Achievement Posttest	9.24	2.00	7.89	1.55

In general, there is a higher mean score on the posttest than the pre-test. On the significance of the differences, an Analysis of Covariance (ANCOVA) was carried out and the results are presented on table 2

Table 2: Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent Parameter	Observed Power [a]
Corrected Model	156.427[b]	2	78.213	33.458	.000	66.916	1.000
Intercept	74.708	1	74.708	31.959	.000	31.959	1.000
PRET	107.769	1	107.769	46.101	.000	46.101	1.000
GROUP	6.830	1	6.830	2.922	.090	2.922	.395
Error	250.128	107	2.338				
Total	8663.000	110					
Corrected Total	406.555	109					

a. Computed using alpha=.05
b. R Squared = .385 (Adjusted R Squared = .373)

Results reveal that in general the experimental group demonstrated significant higher achievement than the control group at an alpha level of 0.09 and not 0.05.

The extent to which the manual affected the performance of male and female students in the experimental group as against the control group was also sort. The summary of the analysis is presented on tables 3 and 4.

Table 3: Means Score Achievement of Experimental and Control Males and Females

Sex	Groups	Mean	Std. Deviation	N
Male	Experimental Group	9.38	2.07	40
	Control Group	7.57	1.79	28
	Toal	8.63	2.14	68
Female	Experimental Group	9.00	1.88	23
	Control Group	8.37	.96	19
	Toal	8.71	1.55	42

Although on table 3 indicate a higher mean achievement for both experimental males and females than for the control group, an indication that students who used the visual information processing and manual performed better than those who did not use the manual. The extent to which the difference are significant was tested using analysis of covariance and the result is presented in table 4.

Table 4: Tests of Between-Subjects Effects for Males and Females
Dependent Variable: Post-test Scores

Sex	Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Male	Corrected Model	139.066[a]	2	69.533	26.784	.000
	Intercept	23.828	1	23.828	9.179	.004
	PRET	85.489	1	85.489	32.930	.000
	GROUP	.955	1	.955	.368	.546
	Error	168.743	65	2.596		
	Total	5375.000	68			
	Corrected Total	307.809	67			
Female	Corrected Model	24.342[b]	2	12.171	6.394	.004
	Intercept	48.817	1	48.817	25.648	.000
	PRET	20.191	1	20.191	10.608	.002
	GROUP	2.935	1	2.935	1.542	.222
	Error	74.230	39	1.903		
	Total	3288.000	42			
	Corrected Total	98.571	41			

a. R Squared = .452 (Adjusted R Squared=.435)
b. R Squared = .247 (Adjusted R Squared=.208)

Although there are differences in the mean posttest achievements scores for males and females in the two groups, the differences were not statistically significant as shown on table 4.

Attempt was also made to find out the effect of the manual on male and female students with different attitudes to biology. Students attitude were categorized as positive for at least agreeing with the items or negative for not at least agreeing. Results of students' achievements are presented on tables 5 and 6.

Table 5: Mean Score of Experimental and Control Students with Different Attitudes

Dependent Variable: Post-test Scores

Sex	Attitudinal Category	Groups	Mean	Std. Deviation	N
Male	Positive	Experimental Group	9.42	2.11	38
		Control Group	7.83	1.74	24
		Total	8.81	2.11	62
	Negative	Experimental Group	8.50	.71	2
		Control Group	6.00	1.41	4
		Total	6.83	1.72	6
Female	Positive	Experimental Group	9.14	1.85	21
		Control Group	8.24	.90	17
		Total	8.74	1.55	38
	Negative	Experimental Group	7.50	2.12	2
		Control Group	9.50	.71	2
		Total	8.50	1.73	4

Results on table 5 are indication of higher posttest mean achievement of experimental positive males and females over the control group. However, a striking difference is observed for negative female students, where the control group females with negative attitude scored higher in the posttest. The significance of the differences was also carried out using analysis of covariance as shown on table 6.

Table 6: Analysis of Covariance for Experimental Males and Females with Different Attitudes

Sex	Attitudinal Category	Source	Type III Sum of Square	df	Mean Square	F	Sig.
Male	Positive	Corrected Model	126.726	2	63.363	25.791	.000
		Intercept	20.068	1	20.068	8.168	.006
		PRET	89.645	1	89.645	36.489	.000
		GROUP	7.095E-02	1	7.095E-02	.029	.866
		Error	144.951	59	2.457		
		Total	5080.000	62			
		Corrected Total	271.677	61			
	Negative	Corrected Model	9.195[b]	2	4.598	2.446	.234
		Intercept	11.361	1	11.361	6.045	.091
		PRET	.862	1	.862	.459	.547
		GROUP	5.940	1	5.940	3.161	.173
		Error	5.638	3	1.879		
		Total	295.000	6			
		Corrected Total	14.833	5			
Female	Positive	Corrected Model	35.111[c]	2	17.557	11.327	.000
		Intercept	33.032	1	33.032	21.310	.000
		PRET	27.377	1	27.377	17.661	.000
		GROUP	7.398	1	7.398	4.772	.036
		Error	54.253	35	1.550		
		Total	2990.000	38			
		Corrected Total	89.368	37			
	Negative	Corrected Model	8.000[d]	2	4.000	4.000	.333
		Intercept	9.774	1	9.774	9.774	.197
		PRET	4.000	1	4.000	4.000	.295
		GROUP	800	1	.800	.800	.535
		Error	1.000	1	1.000		
		Total	298.000	4			
		Corrected Total	9.000	3			

a. R Squared = .466 (Adjusted R Squared = .448)
b. R Squared = 620 (Adjusted R Squared = .367)
c. R Square R Squared = .358) Squared =.393 (Adjusted
d. R Squared (Adjusted R Squared = .667)

In all cases there were also no significant difference in achievement except for the female students with positive attitude. Consequently, it may be stated that female students with positive attitude who used the manual with visual information processing aid performed better than females with positive attitude who did not use the manual.

DISCUSSIONS AND CONCLUSIONS

The result of this study is similar to that of Thomas (1978) which did not find any evidence to support that pictures influence comprehension of science textbooks. He however did not report any adverse effect of such pictures and illustrations. These results may be justified by the fact that cognition involves concept understanding and intellectual reproduction of facts, as well as their utility in problem situations. The subjects may not have effectively utilized the presence of diagrams in the experimental manual. This may probably be due to lack of necessary background knowledge on the concepts. Noh and Scharmann (1997) had reported that such diagrams would only directly influence achievement if they were with relevance to targeted concepts. Since this experimental manual aimed only at the introduction of apparatus and sequencing of steps, a difficult task of abstracting meanings cognitively from the diagrams might have arisen. This may be overcome overtime with a more frequent application and concept teaching prior to treatment. Higher mean post scores of the experimental groups and a significant difference between experimental females with positive attitude is worth noting. Schibeci and Riley (1986), Hagarty-Hazel (1990) and Simpson and Oliver (1990) have unanimously reported the influence of attitude towards science on achievement. They explained that attitude towards science predict achievement. It means therefore that with a continuous use of the laboratory manual with diagrams, learners' attitude to science is likely to increase positively and in turn induce higher achievement.

CONCLUSION AND RECOMMENDATION

The results of this study led to the conclusion that a laboratory manual with visual information processing aid may help students perform better in cognitive and affective domain. It is evident that the manual had effect on achievement (although not quite significant) as well as increased attitude to biology of females. Therefore, the need to incorporate such aids into the curriculum reforms is necessary. Using such manuals, students will be able to process information, develop their intellectual abilities, as well as become scientifically literate. Nigerian researchers and educators should see it as of great importance to develop such manuals by participating in textbook writing and analyses.

REFERENCES

Ango, M. L. & Sila, M.D.(1986).Teaching and learning of biology practical: The experience of some Nigerian secondary schools. Journal of Science

Teachers Association of Nigeria 24 (1& 2) 33-47.

Anderson, R. C. (1970). Control of student mediating processes during verbal learning and instruction, Review of Educational Research,40,349-369.

Anderson, J.R. (1990). Cognitive psychology and its implications (3rd ed). New York: Freeman.

Chandler, P., & Sweller, J. (1992). Cognitive load theory and the format of instruction. Cognition and Instruction 8,293-332.

Dechsri, P., Jones, L.L., & Heikkinen, H. W. (1997). Effects of a laboratory manual design incorporating visual information - processing aids on Student learning and attitudes. *Journal of Research in Science Teaching*, 34(9),891- 904.

Ehiemere, M. E. (1978). Science activity in the lower forms of secondary schools in Lagos State. Journal of Science Teachers Association of Nigeria, 16 (2). 109 - 121.

Freedman, M. P., (1997). Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge Journal of Research in Science Teaching, 34(4)343-357.

Gagne. R. M. (1962).The acquisition of knowledge. Psychological Review,69,355- 365.

Guri-Rozenblit, S. (1988). The interrelations between diagrammatic Representation and verbal explanations in learning from social science texts. Instructional Science, 17,219-234.

Holliday, W. G. (1976). Conceptualizing and evaluating learner aptitudes related to instructional stimuli in science education. Journal of Research in Science Teaching, 13.101-111.

Hofstein, A., Ben-Zvi, R., & Samuel, D. (1976). The measurement of the interest in and attitude to laboratory work amongst Israeli high school chemistry students Science Education, 60 (3), 401-411.

Knowlton, J. (1966). On the definition of "picture." AV Communication Review, 14,157-183.

Ogunsola-Bandele, M. F. & Lawan, F.K. (1997). Innovations into biology students' practical work through error analysis, Science Teachers Association of Nigeria 1997 Annual Conference Proceeding,130-134

Okebukola, P. A.(1986).An investigation of some factors affecting students' attitude toward laboratory chemistry. Journal of Chemistry Education, 63, 531-532.

Noh, T., & Scharmann, L. C. (1997).Instructional influence of a molecular-level pictorial presentation of matter on student's conceptions and problem-solving ability Journal of Research in Science Teaching.34(2),199-217.

Nworgu, L. N. (1999). “Diagnosis of students' difficulties in biology practical”, Science Teachers Association of Nigeria 1999 Annual Conference Proceeding. 97-100

Reid, J. R., & Miller, G. J. (1980). Pupils' perception of biological pictures and

Its implications for readability studies of biology text books. Journal of Biological Education.14(1), 59-69.

Schibeci, R. A., & Riley, J.P. Jr. (1986). Influence of students background and perceptions on science attitudes and achievement. Journal of Research in Science Teaching 23, 177-187.

Shavelson, R. J. (1974). Methods for examining representations of a subject-Matter structure in a students' memory. *Journal of Research in Science Teaching*, 11(3)231 – 249.

Tamir, P.(1977).How are the Laboratories used? Journal of Research in Science Teaching, 14(4),311-316

Tamir, P., & Lunetta, V. N (1981). Inquiry-related tasks in high school science laboratory Handbooks. *Science Education* 65,477-484.

Thomas,J.C.(1978).The influence of pictorial Illustrations with written text and previous achievement on the reading comprehension of fourth grade science students. *Journal of Research in Science Teaching*, 15 (5), 401405.

Urevbu, A. O. (1997). Creating the school we deserve: Reflections on education, pedagogy and curriculum. Inaugural Lecture Series 49, University of Benin, Benin City.

Winn, W. (1981). Effect of attribute highlighting and diagrammatic organization on identification and classification. Journal of Research in Science Teaching,18 (1),23-32.