IHEPI

# 7 – 9 September 2009

# Higher Education, Partnership, Innovation

# USING LABORATORY MANUAL WITH VISUAL INFORMATION PROCESSING AIDS TO FACILITATE BIOLOGY STUDENTS' ACQUISITION OF SCIENCE SKILLS

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**ABSTRACT**

*The study (which is part of a larger study) sought the effects of a laboratory manual incorporating Visual Information Processing Aids (VIPA) on Biology students' acquisition of manipulative skills during laboratory activities. Twenty-two out of the one hundred and ten senior secondary school two students were randomly selected and assigned to experimental(n=12)and control (n=10)groups. Treatment lasted for five weeks during which three concepts in Biology (Effects of saliva on starch, test for mineral salts in a sample of garden soil, and diffusion in liquids) were investigated. The experimental group carried out activities using VIPA-included laboratory manual while the control group utilized the zero VIPA manual for the same purpose. Data generated were analyzed using means, ANOVA and t-test. Results showed a significant difference in the manipulative skill exhibition of the experimental group over the control in virtually all the subscales of the manipulative skill checklist designed by Dechsri, Espinosa, Mui, and Nanji (1987) and used by Dechsri, Jone,s and Heikkinen (1997).*

*Keywords: Laboratory instruction, manual, information, processing, visual, science skill, innovation*

## 1. INTRODUCTION

It is obvious that Nigeria is in dire need of proven practical scientists to help move her forward in the search for Technological advancement. Jegede's (2002) call on science teachers and the Science Teachers Association of Nigeria (STAN) to invent more proactive and innovative pedagogical practices for improving science teaching in the classrooms is more than a clarion call for best practice in the field. He decried the static, skewed, and insensate nature of science teaching and learning in Nigeria in the past twenty years. The use of laboratory instruction as an important pedagogy capable of innovative infusions in science teaching and learning has become well-accepted for a long time now (Ausubel,1968; Tamir,1977; Abdulahi,1979; Dechsri, Jones & Heikkinen 1997). Efforts are being made in research circles to identify and test the variables that improve laboratory instruction, students' achievement, and manipulative skills. The nature, content and design of laboratory manuals or handbooks in use in schools have thus gained attention (Dechsri, Jones & Heikkinen 199 7). The use of diagrams and pictures 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 found to be effective for their high verbal counterparts (Winn, 1996).Knowlton(1996) showed that pictorial adjuncts fulfill a variety of functions in processing and storing verbal information especially when the verbal learning task involves understanding relationships. Noh and Scharmann (1997) used pictures with relevance to the target concept and found that instruction became more effective at improving students' conception of Chemistry concepts. This, however, depended on the efficiency of the treatment and the grade of the topics in question. Other researchers also have attested to the efficacy of pictures and diagrams in learning(Reid & Miller, 1980; Gun-Rosenblit,1988; Chandler &Sweller,1992).

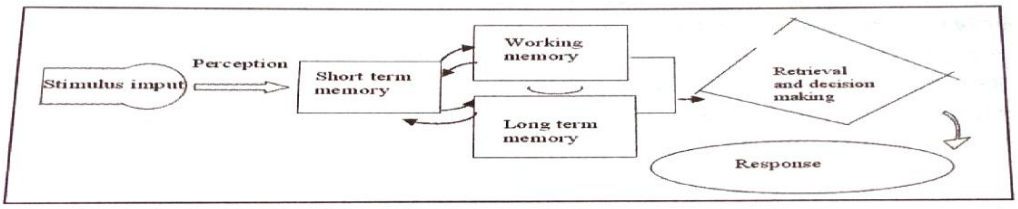
In Nigeria, efforts to improve science teaching took the form of improving laboratory facilities, training and supply of adequate manpower to handle facilities and equipment, curriculum review, and review of science textbooks in use in schools. Analysis shows that most laboratory manuals in use in schools list the steps for carrying out stipulated exercises without diagrams as aids. Where diagrams are included, they represent the final set-up of the apparatus but do not illustrate the equipment individually for identification and proper choice, sequence steps with diagrammatic illustrations, and show accurate handling of materials and equipment. The possibility of utilizing the additional attributes of manuals with visual information processing aids and the concomitant effect on the acquisition of manipulative skills is the focus of this study.

## 2. THEORETICAL AND CONCEPTUAL FRAMEWORK FOR THE STUDY

The study is based on the theory and concept of information processing (Gagne, 1985) and Schema Theory of learning (Anderson,1990). Gagne suggested that series of sequences of mental processes go on during any type of mental task. It begins when sense organs receive stimuli from the environment and generate patterns of neutral impulses. This is 'Receptance'. Selective perception is said to occur when the neutral impulses are sent to a sensory register, a mechanism in the brain that receives them and rejects those that are irrelevant at that time. Short-term storage is when the selected impulses are sent to the short-term memory and kept temporarily until they are transmitted for permanent encoding (semantic encoding) before it arrives in 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 action such as the introduction of an abrupt stimulus such as models, line diagrams, and colour pictures that will help students gain attention is needed. For selective perception also, a stimulus that can display content with distinctive features is needed. Fortifying laboratory manuals with VIPA as a means of illustrating proper handling of equipment and arresting of attention thus has some backing. Poorly equipped laboratories do not afford students ample opportunity to interact fully with materials hence the case for the inclusion of diagrams.

Anderson's schema theory of learning views organized knowledge as an elaborate network of abstract mental structures that 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.

*FIGURE 1. Shavelson (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/she 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.

## 3. STATEMENT OF THE PROBLEM

Science has remained an important subject in the Nigerian school curriculum. Biology in particular is a compulsory science subject in senior secondary school. Unfortunately, performance in the subject has not been as expected. Students are known not to have optimized scores in examinations (WAEC 1993,1994,1997), as they are not able to manipulate during practical examinations. Many students have reported inaccurate results and findings due to a lack of appropriate skills in manipulating equipment. This has often resulted in loss of marks. Egonwa (2009) has implicated the visual attributes of arts in the acquisition and utilization of science skills. It is therefore imperative for science teaching community to seek potent instructional devices to improve performance in these examinations and acquisition of important science outcomes. One such exploration is the effects of the inclusion of visual attributes of line diagrams into science laboratory manuals on students' acquisition of manipulative skills. This study thus asks the following question: Does the use of a laboratory manual incorporating visual information processing aids (VIPA) affect students' acquisition of manipulative skills? Perhaps helping students develop manipulative skills may provide the necessary incentives for raising practical scientists for Nigeria in this new millennium.

Student examination results show poor achievement. The WAEC examination which is the terminal examination for certification includes test of practical work in which the candidates are expected to carry out tests, perform activities and make reports of observations. These actions require the use of manipulative skills which only develop through practice. Poorly handled equipment and apparatuses are most likely to produce incorrect readings, and wrong reports and lead eventually to loss of marks. Also, poor textual ability of students to understand long instructions and process the information reasonably within the context of the examination time may also influence their performance in the examination. Efforts to improve achievement in this examination are very expedient since Biology is not just the only subject through which many Nigerian students experience science, but also a requirement for entry into many choice courses and professions. In this regard therefore attention to the nature of practical manuals used in schools has been drawn. There is a need to know whether biology students could utilize manual attributes for acquiring skills necessary for manipulating equipment and apparatuses as a requisite for accurate generation of results and clear reports.

## 4. RESEARCH QUESTIONS AND HYPOTHESES

The following research questions were raised for the study:

1. Is there a significant difference in manipulative skills development of students who used and those who did not use the laboratory manual with VIPA?
2. Are differences in manipulative skills based on the subscales?
3. Did the manipulative skill of the students differ with the activity?

To answer these questions, the following hypotheses were formulated and tested

1. There is no significant difference in manipulative skill development of students who used laboratory manuals with VIPA and those who used laboratory manuals without VIPA.
2. There is no significant difference in the acquisition of manipulative skills within the subscales by the students who used the VIPA manual and those who did not.
3. There is no significant difference in the experimental and control students' acquisition of manipulative skills in the different activities.

## 5. SIGNIFICANCE OF THE STUDY

This study is significant, as it will:

1. Provide students with information on laboratory manuals that will help them to overcome learning difficulties and acquire manipulative skills.
2. Give insight to authors of science texts and laboratory manuals on the effect of diagrams on acquisition of practical skills.
3. Assist the examining organizations in deciding what forms of laboratory manuals will improve the performance of students in practical examinations and be of immense help to the publishers.
4. Provide biology teachers with knowledge on the design of manuals that will enhance the development of manipulative skills during laboratory exercises.

## 6. METHOD OF THE STUDY

The study is part of a larger one in a randomly sampled urban co-educational senior secondary school in Delta state in which a quasi-experimental design was used. One hundred and ten (110) subjects consisting of sixty-three experimental and forty-seven control subjects with an average age of sixteen were involved in the study which lasted for five weeks. However, twenty-two students, made up of twelve experimental (9 males and 3 females) and ten control (6 males and 4 females) subjects were observed simultaneously while working in the front role benches of the laboratory during the activities. The seating arrangement was random as each subject selected a sitting position on the first day without prior knowledge of the observational strategy to be used. Subjects were instructed to maintain a chosen seating position throughout the five weeks that the study lasted. Two instruments were used in the study. They are:

1. Laboratory manual – an experimental manual and a conventional one. Both versions were similar in many but not respects. The conventional manual had a preliminary section showing clearly stated objectives, a summary of the activities, and the pattern of expected laboratory reports for the three topics (test of mineral salts in the soil, effect of saliva on starch, and diffusion of material through the liquid medium) selected for the study.

The manual is written in simple language to avoid confusion and verbal complications. The manual directs the students to practice the necessary skills before they are used in the activities. Finally, the laboratory procedures are sequenced into steps as a clue directing the order of actions. The experimental manual shares similar characteristics as the conventional version except for the inclusion of line diagrams. The diagrams introduced the new equipment, illustrated correct handling, and shows the procedural sequence. The laboratory manuals were developed by the investigator and the content was validated by experts.

2. Psychomotor skills observational checklist-The checklist was adapted from Dechsri, Espinosa, Mui, and Nanji (1987)as used by Dechsri Jones and Heikkinen (1997). The subscales of this instrument are methodical working, experimental techniques, manual dexterity, and orderliness. The skills were scored as shown in Table 1.

*TABLE 1. Scoring scale for Manipulative Skills Checklist*

| S/N | Components/ Subscales | 1 | 2 | 3 |
|---|---|---|---|---|
| 1 | Methodical working | A systematic plan for carrying out the experiment before starting on it; Close attention paid to the sequence of instruction | Plan is acceptable. Only a few mistakes in the sequence of task | Unplanned and incorrect; cannot follow instructions easily |
| 2 | Experimental Techniques | Correct choosing of appropriate equipment for task to be completed carefully and correct handling of chemicals and equipment; correct procedure | Mostly correct choosing of equipment but sometimes still incorrect handling; Takes less care in using apparatus or safety of chemicals, or makes mistakes in the procedures | Incorrect choosing of equipment for task to be completed; careless handling of apparatus and chemicals; incorrect procedures |
| 3 | Manual dexterity | Smooth working and confidence in execution of task; finish experiment before allotted time | Lack of confidence and slow execution; finish experiment but no time to recheck experiment or try something else | Confused execution; quite unsure of what has to be done; very slow task performance; thus takes beyond allotted time |
| 4 | Orderliness | Neat working space during the task; cleans up bench after work; puts materials and equipment away immediately after use | Takes less care about tidiness of space; equipment and materials are put away but not in very good order | Working space is messy during the task; leaves materials and equipment after use; does not clean up bench |

S/N, Components/,2,3,1, , Systematic plan for, Plan is acceptable only a few, Unplanned and incorrect; 2,

The checklist was used to rate the skill exhibition of the twenty-two subjects for three weeks that treatment lasted. Data were analyzed using ANOVA and t-test. The significance of difference was found at 0.05 level of significance.

## 7. RESULTS

TABLE 2. ANOVA summary of students' Manipulative skills score grouped by activity and component

| | **Experimental group** | | **Control Group** | | | |
|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **F** | **Sig.** |
| Activity 1 | | | | | | |
| Methodical working | 2.750 | .4532 | 1.800 | .6325 | 16.8298 | .0006* |
| Experimental techniques | 2.500 | .6742 | 1.600 | .6992 | 9.4004 | .0061* |
| Manual dexterity | 2.500 | .6742 | 1.500 | .7854 | 14.5455 | .0012* |
| Orderliness | 2.0833 | .9003 | 1.8182 | .7950 | 3.2515 | .0864 |
| Total for activity | 9.833 | 2.1672 | 6.4000 | 1.3499 | 18.9824 | .0003* |
| Activity | | | | | | |
| Methodical working | 2.5000 | .5222 | 1.800 | .4216 | 11.6206 | .0028* |
| Experimental techniques | 2.5000 | .6216 | 1.300 | .4830 | 15.5047 | .0008* |
| Manual dexterity | 2,0000 | .7385 | 1.300 | .4830 | 6.5993 | .0183* |
| Orderliness | 1.0000 | .7385 | 1.700 | .4830 | 1.2121 | .2840 |
| Total for activity | 8.7500 | 1.9598 | 6.1000 | 1.2867 | 13.4049 | .0016* |
| Activity 3 | | | | | | |
| Methodical working | 2.7500 | .4523 | 2.000 | .4714 | 14.4385 | .0011* |
| Experimental techniques | 2.2500 | .4523 | 1.500 | .6838 | 9.0909 | .0068* |
| Manual dexterity | 2.1667 | .8348 | 1.500 | .5270 | 4.7690 | .0411* |
| Orderliness | 2.0000 | .6030 | 1.300 | .4830 | 8.7630 | .0077* |
| Total for activity | 9.1667 | 1.3571 | 6.300 | 1.4944 | 22.5436 | .0001* |

*Note: Maximum score on each component is 3*

**Significant at P<0.05*

*TABLE 3. ANOVA Summary of Manipulative Skill scores grouped by components/subscales*

| | **Experimental group** | | **Control Group** | | | |
|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **F** | **Sig.** |
| Methodical working | 8.000 | 1.1281 | 5.6000 | 1.738 | 23.8017 | .0001* |
| Experimental techniques | 7.000 | 1.4142 | 4.4000 | 1.5776 | 16.6093 | .0006* |
| Manual dexterity | 6.6667 | 1.7233 | 4.3000 | .6740 | 4.7690 | .0411* |
| Orderliness | 6.0833 | 1.8320 | 4.5000 | 1.0801 | 5.7677 | .0262* |

**Significant at P<0.05*

*TABLE 4. Mean, Standard deviation and t-values of manipulative skill scores by component by group*

| | Mean | SD | N | df | Cal.t | tab.t | Sig. |
|---|---|---|---|---|---|---|---|
| Experimental techniques | | | | | | | |
| Experimental group | 7.000 | 1.414 | 12 | 20 | 1.08 | 2.086 | .000* |
| Control group | 4.400 | 1.578 | 10 | | | | |
| Methodical working | | | | | | | |
| Experimental group | 8.000 | 1.128 | 12 | 20 | 4.88 | 2.086 | .000* |
| Control group | 1.600 | 1.174 | 10 | | | | |
| Manual dexterity | | | | | | | |
| Experimental group | 6.667 | 1.723 | 12 | 20 | 4.08 | 2.086 | .001* |
| Control group | 4.300 | .675 | 10 | | | | |
| Orderliness | | | | | | | |
| Experimental group | 6.083 | 1.832 | 12 | 20 | 2.40 | 2.086 | .026* |
| Control group | 4.500 | 1.080 | 10 | | | | |
| Total | | | | | | | |
| Experimental group | 48.444 | 4.953 | 12 | 20 | 4.85 | 2.086 | .000* |
| Control group | 18.800 | 3.676 | 10 | | | | |

**Significant at P<0.05*

Table 2. above shows that apart from orderliness component in the first and second activities, the difference between the experimental and control groups in the other components was found to be significant. The difference between the experimental and control groups in respect of orderliness component was however found to be significant in the third activity. When these components were collapsed for the three activities, ANOVA showed a significant difference in all subscales (.0001, .0006,.0411 and.0262) at the 0.05 level of significance thus null hypothesis 1 which states that there is no significant difference in the manipulative skill of the students who used the VIPA manual and those who did not was rejected. The mean and standard deviation (Table 4) also reveal significant differences in all subscales (.0000,.0000,0001, and .0260) for experimental techniques, methodical working, manual dexterity, and orderliness between the experimental and control groups. Hypothesis 2 was therefore rejected.

## 8. DISCUSSION OF RESULTS

The no significant effect of the VIPA manual on the orderliness subscale in the first and second activities may be explained by the fact that the experimental group gained a better understanding of the VIPA manual with continued use thus users were able to save enough time to tidy up workbench and neatly putting away of apparatuses within the work time allotted to the activity. This is however not the case with the control group. The inclusion of the VIPA in the experimental manual may have also provided additional incentive to the users to focus on desirable experimental behaviours and skills necessary for the performance of the activities hence the significance of the difference noted in all the components of the manipulative checklist. This result is in line with that of Dechsri, Jones, and Heikkinen (1997).

The strategic importance of visualization in the development of science skills has become an important curriculum issue. Egonwa (2009) has stressed the relationship between visual arts and students' ability to exhibit some skills in Physical Sciences and advocated the pairing of Fine and Applied Arts and Science courses in the Faculties of Science and Engineering.

## 9. CONCLUSION

It is the view of the researcher that the difficulty which students of some cultures experience with the interpretation of lengthy instructions and verbalization can be reduced by the addition of line diagrams, not just to describe a phenomenon but also to sequence activities and stress key skills that a learner needs to note and utilize while undertaking practical science activities. This additional stress may not only benefit beginners but fortify skill acquisition in advanced learners too.

## 10. IMPLICATION OF FINDINGS

The interactive nature of science and utility has called for skill development in the products of the schools. School science could be an avenue for the teaching of vital skills which the learner requires for task performance in actual work environments outside the school. The adoption of appropriate instructional techniques such as use of the VIPA manual might just be one of the antidotes for skill acquisition during school science laboratory activities.

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