EFFECTS OF EXEMPLARY TEACHING AND LEARNING MATERIALS ON STUDENTS' PERFORMANCE IN BIOLOGY

by

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Dedication

To my three 'reasons for being'; my darling wife Hannah and our two precious gifts from God; Khumoyame and Aobakwe.

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[1]Song of Solomon, 2:2; [2]Proverbs, 31:29.

DECLARATION.

I declare that **Effects of Exemplary Teaching and Learning Materials on Students' Performance in Biology** is my own work and that all sources I have used or quoted have been indicated and acknowledged by means of complete reference.

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ABSTRACT.

This study sought to determine the effects of exemplary teaching and learning materials on students' participation and achievement in biology in Botswana science classrooms. In particular, it was concerned with examining the effects of student-teacher-material interactions on the students' participation and achievement in biology. The method adopted for this study was an eclectic approach in which both quantitative and qualitative approaches were used to complement each other. In order to understand the social processes and meaning that the participants in this study attach to phenomena, a qualitative approach based on social interactionism was adopted.

The role played by the researcher in this study was that of a participant-as-observer. To explore life in Botswana biology classrooms and to unravel the complex social aspects of teaching and learning, a holistic ethnography (used alongside a variety of micro-ethnographies) were adopted for the study.

Ten experienced biology teachers were involved in identifying the topic that could be developed for exemplary practice as well as in validating the materials that were produced. They also responded to the exploratory questionnaire on the traits of an exemplary biology teacher, which formed the basis for the development of the exemplary package.

An induction workshop was conducted for the exemplary teachers to help them explore and reflect on their practice with a view to create in them an appreciation for the exemplary approach to teaching and learning. The curriculum package consisted of the students' workbook, scheme of work, lesson plans and an achievement test.

A sample of seven schools was used in the study. Two schools were used for each of the co-operative, competitive and individualistic groups and the last school was the used as the true control group. To minimise the effects of contamination, the treatment groups were chosen from different areas of the country. A total of seven teachers and 446 students were involved in the study. A quasi-experimental research design modified from the Solomon-three-control group design was used. Also, qualitative methods were used to capture the data that were not easily amenable to quantification.

The findings of this study suggest differences in the interaction behaviours of conventional and exemplary teachers. The conventional teachers tend to out-talk their students while the exemplary students tend to out-talk their teachers. Also, the verbal and non-verbal interactions of the conventional teachers exceed those of their students. On the other hand, the students' verbal and non-verbal interactions exceed those of the teachers in the exemplary classes. Teachers in both the exemplary and conventional classes ask predominately factual questions compared to the exemplary teachers who ask more leading and probing questions.

Students in two treatment groups (co-operative and competitive experimental) performed significantly better than those in the true control group. However, performance in the two treatment groups with respect to achievement in the Biology Achievement Test is quite identical. No significant difference is observed between the performance of the students in the third treatment group (individualistic) and those in the true control group.

The use of exemplary teaching and learning materials seemed to have enhanced the achievement of the girls, low ability and average ability students in all the assesed variables while the conventional teaching strategies seemed to have enhanced only the achievement of the average ability students.

Students perceive an exemplary teacher as the one who; (i) encourages student participation irrespective of their gender and academic ability, (ii) gives homework and marks it, (iii) ensures that students are on task.

Students in exemplary classes describe their experiences in practical activities as enjoyable, providing opportunities to learn new things and providing specific episodes during bilogy lessons.

When the learning task is unfamiliar, students seem to ask more procedural questions in their small groups, while they tend to ask more thought-provoking questions if the learning task is familiar.

In group discussions, students seem to use a variety of strategies to improve the chances that the group accepts their ideas. These include among others, discrediting the source of the counter-argument, sarcasm, substantiating their arguments, lobbying for support and introducing new evidence.

CHAPTER ONE.

1.0.0 Introduction

1.0.1 Background to the study.

The curriculum innovations of the 1950's which started in the United States and Europe rapidly spread throughout the world and greatly changed the way science was to be taught (Okatch, 1980; Jenkins, 1994; Ogunniyi, 1995). At the international scene, funds were made available to develop courses that would allow students to work "like practising scientists". The new courses were to be based upon an inductive problem-solving philosophy (Jenkins, 1994) and the development of process skills. Inherent in these new curriculum models, was the emphasis on the child as an active participant in the learning process and on the inquiry modes of knowledge acquisition (Schwab and Brandwein, 1966; Jansen, 1989). An important feature of inquiry is to allow pupils to interact with the learning environment and perhaps this is one of the reasons why practical work has become a unique feature of science education today.

Just as scientists need laboratories to carry out their investigations, school science have come to be associated with special rooms that provide ample opportunities for students to carry out experiments. The school science laboratory provides an environment where students can test how valid their intuitions, hunches and ideas are with respect to the scientific viewpoints. According to Schwab and Brandwein (1966) school science before the 1950's was more or less a "rhetoric of conclusions" to be committed to memory or a body of knowledge to be verified in contrived laboratory experiments (Solomon, 1991; White, 1991; Roth, 1993).

Africa was quite susceptible to these exogenous curriculum models of the 1950's and the 1960's for several reasons. Of particular interest to this study was the faith that was placed on science and technology as the primary means to socio - economic growth especially in a setting lacking the indigenous frameworks with which relevant and appropriate science courses could be developed (Jansen, 1989). In that context the new curriculum packages became something the newly independent African states could hardly resist (Okatch, 1980; Jenkins, 1994). Of course, in view of capitalist interest, the former colonial powers saw investment in science by African states as a potential extension of their market.

It is apposite to clarify the term "inquiry" as used in relation to science teaching and learning as the extant literature does reveal more than one interpretation. For instance, Fish and Goldmark (1969) identified three types of inquiry. First, is the self directed module: a situation where the learner is allowed to direct and control his own learning. The teacher is seen as a facilitator of learning and is expected to provide a climate and conditions that would encourage the learner to progress in the inquiry. The teacher would also assist the learner to evaluate his progress and also provide the assistance the learner needs to achieve his objectives. Second, in inquiry into science teaching which involves a systematic analysis and evaluation of one's teaching behaviour in an attempt to reflect on the consequences of such behaviour on the learners. Third, is inquiry teaching as a method selection. This approach focuses on the decisions that the students make about which method to use in their science inquiry. In this case the learners make decisions about which method to use, experience the consequences of using that method and assess the consequences of the discrepancies they could be encountering.

Schwab (1969) also distinguishes between fluid and stable inquiry. According to Schwab, stable inquiry arises when the researchers regard conceptual principles supplied by others as a matter of fact. The status of the principles is taken as absolute and they are used as a means of enquiry and not questionable entities to be enquired into. In fluid inquiry, the main aim of the researcher is to establish the validity and reliability of the principles as research tools. The researcher is interested in the limitations of such principles as cognitive tools in advancing research in the stable inquiry.

The emphasis on inquiry stems from at least two needs: (i) enlargement of the scientific/ technological human power to encounter the challenges posed by the Sputnik (1957) and (ii) the change in the epistemology of Science itself from being a "rhetoric of conclusions" to a dubitable, revisionary human enterprise (Schwab and Brandwein, 1966; Kuhn, 1970).

Roth (1993) sees a science laboratory as a construction site. Inquiry from a constructivist perspective expects students to work more independently, choosing their own paths of investigation, determining their own research agendas and setting up and conducting their experiments to make discoveries for themselves in the laboratory. The students in this situation are not provided with 'cookbook recipes' for the experiment but rather are afforded a chance to discuss the meaning of the problem in question and the appropriate experimental design for it. In this case, different groups could possibly decide on different designs and of course, may get the same or even different results for the same problem. As the students reflect on their experimental designs, procedures and results collaboratively, they are actively involved in the process of constructing knowledge. From a social constructivist perspective, learning in collaborative groups is viewed to facilitate and accelerate the construction of new conceptual and procedural knowledge (Roth, 1993). A collaborative learning environment has cognitive benefits in that it provides for a discourse situation in which meaning could be negotiated in the process of solving a problem. It is this form of inquiry that this study embraces and adapts for Botswana conditions where the curriculum is overloaded and the national examinations overhang the curriculum.

1.1 Science as an inquiry.

For many decades now, science has been taught "as an inquiry". Schools have built laboratories as places where students learn their science by doing things. Practical work forms an important part of inquiry learning. It is assumed to provide concrete props to help pupils comprehend the complex and abstract concepts of science (Tamir, 1991). Practical work is used to clarify concepts, elucidate theory, illustrate phenomena, verify facts and principles and confirm theory. Kerr (1963) cited a chemist as asserting that, "learning chemistry without practical work is like learning to swim without water - merely impossible." According to Solomon (1980), it is by doing experiments and creating concepts at first hand in the laboratory that this understanding of science was to be achieved. It is also believed to have a salutary effect on the development of scientific skills among pupils. Of course, practical work has various interpretations since any learning method that requires the learner to be actively involved in the learning situation presupposes the belief that children learn best by direct experience (Hodson, 1988).

Practical work has a great potential to make phenomena real to the pupils. This is what Woolnough and Allsop (1985) refer to as getting the "feel" for the phenomena or what Hodson (1992) believes constitutes an important aspect of personalising science. Others claim that practical work serves as (i) an aid to conserve memory (Solomon, 1980; White, 1991); (ii) an opportunity to discuss things in science; (iii) a conceptual model for evaluating levels of understanding (Barnes, 1976); (iv) a tool for conceptual change as well as a means to explore, unravel and identify misconceptions (Solomon, 1991; Aho, Huopio and Huttunen, 1993; Wenham, 1993; Ramorogo, 1994; Ramorogo and Wood-Robinson, 1995).

In the recent past, the processes of science have been considered very important components of most science curricula. Some curricula were even developed based on the processes of science (Hodson, 1991). Process skills are assumed to be critical elements of scientific inquiry as they offer ample opportunities for students to make accurate observations, measurements, use scientific apparatus correctly, acquire and use standard techniques, read, understand and carry out instructions, record data and communicate their results with other people (Van Praagh, 1983; Solomon, 1991; Tamir, 1991; White, 1979,1991).

Critics of practical work, however, argue that using it to meet didactic aims is a very expensive way of teaching science (Woolnough and Allsop, 1985). It has been observed that most of the practical work is done as a matter of ritual and tends to become a mere confirmation of "rhetoric of conclusions" (Schwab, 1962; Schwab and Brandwein, 1966; White, 1979; Woolnough and Allsop, 1985; Solomon, 1991). Also, there is sufficient evidence to suggest that practical work fails to fulfil the purposes for which it is set up and as such, becomes an unproductive exercise (Driver and Millar, 1978; White, 1979; Solomon, 1980; Hofstein and Lunetta, 1982; Driver, 1983; Hodson, 1988). As a result, a reflective approach to learning and teaching could prove to be helpful in that practical work would cease to be regarded as a panacea to conceptual problems but rather as a pedagogical tool which could be used only if it is necessary and when it yields worthwhile cognitive benefits.

1.2 Conditions for teaching and learning science.

For nearly two decades now, especially since the first National Commission of Education in 1977, science has been made a compulsory subject in the school curriculum. There is also some evidence to show that the conditions of teaching and learning science have improved significantly within the period (Kann and Nganunu, 1992; Marope, 1992; Ogunniyi, 1995). Ogunniyi (1977) identifies the conditions under which science is taught as an important factor that could enhance or hamper the full achievement of the reward structures in science education. A review of research findings indicates that a considerable number of Botswana secondary schools have well equipped science laboratories and well trained science teachers though most of them are expatriates (Pendaeli, Ogunniyi and Mosothwane, 1993). This however, is not the same as saying that the teachers are adequate in number or are performing to expectation. In fact, the instructional styles of many a science teacher in Botswana leaves much to be desired. Perhaps, this explains why a considerable percentage of the students are under-achieving in science (Republic of Botswana, 1991; Kann and Nganunu, 1992; Motang, 1992; Ngueja, 1992; Pendaeli et.al., 1993; Prophet and Rowell, 1993; Ogunniyi, 1995).

There is a general feeling in Botswana that the products of the education system in general lack scientific knowledge, and tend to recede into scientific illiteracy (Kahn, 1990). It is also observed that even though the number of students enrolling in senior secondary schools is increasing, the same increase is not reflected in the performance of students. There seems to be a gradual decline in performance (Pendaeli, Ogunniyi, and Mosothwane, 1993). This decline can be explained in a number of ways. One of the reasons is related to the teaching strategies used by the teachers. Too often, teachers resort to chalk and talk, drill and practice and closed question and answer methods which place a lot of emphasis on memorisation of information instead of providing children with opportunities to construct their knowledge (Prophet, 1990; Prophet and Rowell 1990; Rammiki, 1991; Fuller and Snyder, 1991; Ogunniyi and

Ramorogo, 1994). Other reasons are not unrelated to the neglect of: (i) the effects of the pupils socio-cultural environment; (ii) the ideas pupils bring to the learning situation and (iii) the mismatch between instructional tasks and the ability levels of the students (Hilsdon, 1993; Prophet, 1990, 1995; Ogunniyi, 1995). There is also a growing concern that despite the tremendous growth in school enrolment, not much has been achieved in terms of quality (Republic of Botswana, 1993; Youngman, 1993). This is a serious concern particularly when it is viewed against a background of gradually declining economies of the developing countries including Botswana. Hence, research into what teachers are doing in school science classrooms, their professional background and their epistemological frameworks might provide some clues to the nature of their interaction behaviours.

1.3 Classroom or laboratory interactions.

According to Novak (1990) teaching does not necessarily result in learning. At its best, teaching probably helps the learner to organise his/her experience in such a way that it will promote meaningful learning. It is through interactions with the teachers, other students and learning materials that students construct meanings of the world around them (Driver, 1989; Ramorogo, 1992). However, not all classroom interactions contribute to the construction of scientific meaning (Shepardson, Moje, and Kennard-McClelland, 1994). Only those that resolve the disparity between the learner's cognitive structure and scientific knowledge tend to facilitate the construction of new meanings from pre-existing ideas (Vygotsky, 1986; Driver, 1989;