TEACHING HIGH SCHOOL LEARNERS THROUGH LABORATORY INVESTIGATIVE TASKS

ISRAEL KIBIRIGE

University of Limpopo, Department of Mathematics, Science & Technology Education (DMSTE), P/Bag X 1106, SOVENGA, South Africa, 0727, Tel: +2715 268 3431, israelk@ul.ac.za

Abstract

The study aimed at engaging high school learners in laboratory investigative tasks (LIT) that enhance positive attitudes towards science. The subjects included grades 11-12 learners. Results show that designed tasks reflecting learner's prior knowledge motivated every learner and that tasks helped learners to develop critical thinking skills. Learners also increased in positive attitudes towards science and consequently there was an improved achievement in grade 12 final external examinations.

INTRODUCTION

High school science courses in Africa and indeed the rest of the world include a laboratory component. Blosser (1988) states that science educators cannot provide convincing evident to support the inclusion of laboratory work in teaching. Review of published laboratory work concluded that science educators know very little about the functioning and effects of laboratory teaching (Gallagher 1987). Laboratory environments and their impact as science education tools are difficult and complex they because involve psychosocial variables that affect learner's achievement (McComas 1997). These variables include the nature of written instructions, the role of an educator in the laboratory, prior conception, attitudes of learners and the relationship of laboratory to theory component. This implies that it is almost impossible to separate content (theory) from laboratory (practical) work.

Tamir (1976) proposed five comprehensive broad categories that can be considered as learning outcomes in laboratory experiments and these include: manipulation of equipment; experience with processes of science; an understanding of the nature of science; knowledge development; and the formation of positive attitudes about science. With these categories, laboratory learning outcomes can be modificed to meet individual learner's needs. In most schools learners manipulate equipment in the laboratory without meaningful learning taking place. After the experiments, learners mundanely write laboratory reports. Such approaches result in learners loosing interest because they cannot link their prior knowledge to laboratory experience. There is a need therefore, to organize laboratory investigative tasks (LIT), which are defined in this study as authentic laboratory activities that stimulate meaningful science learning and critical thinking skills.

Critical thinking is defined as logical thought process that leads to praise or blame (Black 1952). Other authors have defined critical thinking as the process of analyzing, evaluating, and synthesizing information in order to increase our understanding and knowledge of reality (Siervers 2001), it is also considered purposeful involving the use of cognitive skills or strategies that increase the probability of a desirable outcome (Halpern, 1997). No wonder critical thinking skills should be applied to virtually all methods of inquiry practiced in the academic disciplines (Angelo and Cross 1993). Clearly, any laboratory task that does not include critical thinking skills can not claim to be doing science. As mentioned by Egege and Kutieleh (2004) that most learners from high schools, which are deficient of critical thinking in laboratory work find it difficult to achieve best marks at the University. The main focus of this study was to engage high school learners in LIT that enhance critical thinking skills. The study specifically aimed at using laboratory tasks that encourage learners to gain experience with science processes and at developing positive attitudes towards science.

THE CONTEXT OF THE STUDY

In 1992, Bethel High School learners were not interested in learning science and were not motivated to do any science tasks in the classroom as well as at home. In my own estimation, those learners were at least two years behind their then current academic level. Their competence in English language was low, scientific language was poor and there were major gaps in their knowledge of mathematics. Also, most learners did not have an opportunity to handle a single piece of laboratory apparatus. The nearest most of them had been to those pieces of apparatus was a mere look at such pieces through the display window of the physical science storeroom at the college section a few buildings away from the high school block. Although high school learners and teachers' college students shared the same campus, the former had no access to the college laboratory facilities. I made special arrangements to use the college laboratories in order to do LIT at high school level.

METHODOLOGY

The subject included 25 grade 11 and 12 learners from Bethel High School, South Africa. Bethel is a co-educational Mission School that catered for all races even during the apartheid era. LIT was used in Physics, Chemistry as well as Biology subjects and focused on the following scientific processes: observing and collecting data; classifying and ordering materials according to their attributes and properties; measuring, testing, analyzing; assessing the properties and composition of materials; predicting and controlling variables; designing and modifying structures or materials; interpreting data and communicating results. In addition to educator's designed tasks, learners designed extra tasks of their choice, experimented and reflected on them. Findings were reported either in tabular or graphic form and during reflection learners suggested alternative ways to perform similar experiments. Continuous assessments were done on all tasks by relevant subject educators.

The ability to comprehend primary literature improves critical thinking skills at undergraduate level (Janick-Buckner 1997, DebBurman 2002). Although these authors refer to undergraduates, it is also true of high school learners who need to improve in both comprehension and science content. While teaching at secondary school, I taught different subjects during remedial study periods and these subjects included: English Language to enhance learners' understanding of science literature; and mathematics literacy to help learners to manipulate calculations involved in science courses. I designed tasks that targeted competence(s) in familiar and realistic topics from learner's local environment. Thus, LIT was based on authentic tasks and within the learners' context. All learners analysed critically their investigations in order to link LIT to high school syllabus.

RESULTS AND DISCUSSION

Results show that many learners responded to investigative tasks intelligently. For example, in authentic case of solutions necessary to reduce expenses on petrol, learners' suggestions ranged from using cars with low engine capacity and using alcohol as an alternative source of energy to using bicycles that do not need petrol. Over 92% of the learners reported that LIT had improved their understanding of science concepts and that their attitudes towards science had improved tremendously. Also, learners commented that LIT improved the integration of science with other subjects namely: English Language; Mathematics; and Social Studies. This was indeed a break-through because the unmotivated learners were now highly motivated. After two years of this innovative teaching, results for grade 12 were amazing as 25% of the learners had admission to state Universities and 75% passed well enough to join colleges, and that none failed. This was the first time in over 20 years for this high school to have 100% pass rate. This positive trend has continued since 1994 making this

study worth reporting in this paper and that data collected in the subsequent years will be reported elsewhere.

The relationship between theory and practicals in science teaching has been void due to poor communication among researchers and educators (Hillage et al., 1998). Surprisingly, research based on professional experience offers little direct guidance to educators about how best to teach specific topics (Lijnse, 2000). Al Proffit (2003) says that many challenges face learners and demand our urgent attention. Miller (2003) argues that educators' responses to teaching materials available to them reflect their conceptions of teaching. Also, Driver et al. (1994), and Pfundt & Duit, (1994) contend that understanding learners' misconceptions is central to scientific understanding the learner's context. Thus, any inclusion of learners' prior knowledge particularly in laboratory tasks serves as a starting point to enhance positive attitudes towards science.

IMPLICATIONS

According to Ogunniyi (1996), Africa has been eager to develop its scientific human power to attain a measure of self-reliance. This would make any country internationally competitive in terms of human resources (Robottom & Hart, 1993). This belief is reflected in the South African White Paper on Science and Technology (1996), which states that science is considered to be among the requirements for creating wealth, and improving the quality of life. Furthermore, educators have to shift roles to address the learners' needs which include: learner mediator; curriculum developer and interpreter; leader and manager; scholar/researcher; pastoral role; assessor; and learning area specialist (Department of Education 2002).

CONCLUSIONS

It is clear that LIT created interest in high school learners. Acquired knowledge through LIT is most likely to be transferred to different situations and this conclusion concurs with contemporary science educators' findings (Wellington 1998, Johnstone and Su 1994; Johnstone, 1997). This implies that the role of educators is not only to teach using "hands-on", but also "minds-on" approach. Therefore, science educators should engage learners in LIT as a preferred way of learning science at high school.

BIBLIOGRAPHY

Angelo T.A. & Cross K.P. (1993). Classroom Assessment Techniques: A Handbook for College Teachers. *San Francisco: Jossey-Bass Inc.*

Black, M. (1952). Critical Thinking *(2nd Ed.). New Jersey: Prentice Hall.*

Blosser, P. E. (1988). Labs- Are they really as valuable as teacher think they are? The science Teacher, *55(5), 57-59.*

DebBurman, S.K. (2002). Learning How Scientists Work: Experiential Research Project to Promote Cell Biology Learning and Scientific Process Skills. Cell Biology Education, 1, *154-172.*

Driver, R. Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). Making Sense of Secondary Science: Research into children's ideas. *London: Routledge.*

Egege, S., & Kutieleh S., (2004). Critical Thinking: Teaching Foreign Notion to Foreign Students. International Education Journal 4(4) Online: http://iej.cjb.net Accessed November 12, 2005.

Gallagher, J.J. (1987). A summary of research in science education. Science Education, 71(3), *271-457.*

Halpern, D.H. (1997). Critical Thinking Across the Curriculum. *New Jersey: Lawrence Erlbaum Associates.*

Hillage, J., Pearson, R., Anderson, A. & Tamkin, P. (1998). Excellence in Research on Schools. *Research Report RR74 London: Department for Education and Employment.*

Janick-Buckner, D., (1997). Getting undergraduate really read and discuss primary literature. Journal of College Science Teaching 27, *29-32.*

Johnstone, A.H., (1997). "Using a model of learning to give direction to developments " in "Science Education in the 21st Century" (Editor D L Thompson), Aldershot, Arena.

Johnstone, A.H., & Su W.Y., (1994). "Lectures - a learning experience?" Education in Chemistry, 31(3), *75-97.*

Johnstone, A.H., & Letton K.M., (1988). "Is Practical Work Practicable?" Journal of College Science Teaching, 18 (3), *190-92.*

Lijnse, P. (2000). Didactics of science: The forgotten dimension in science education research? In R. Millar, J. Leach and J. Osborne (eds.) Improving Science Education: The Contribution of Research *(pp. 308-326). Buckingham: Open University Press.*

McComas, W.F. (1997). An ecological perspective of laboratory teaching environment. Science Education International 8(2), *12-16.*

Miller, R. (2003). Paper presented at the Annual Conference of the National Association for Research in Science Teaching (NARST), Philadelphia, 23-26 March 2003. www.york.ac.uk/depts/educ/projs/EPSE Accessed November 12, 2005

Ogunniyi, M. B. (1996). Science, technology: the problem of developing critical human capital in Africa. international journal of Science Education, 18(3), *267-284.*

Pfundt, H. & Duit, R. (1994). Bibliography: Students' Alternative Frameworks and Science Education (Fourth Edition). *Kiel: Institüt für die Pädagogik der Naturwissenschaften (IPN).*

Proffit, A. (2003). Maslow's Child. Mountainrise 1(1), *1-8 pp.*

Department of Education (2002). Revised Curriculum Statement Grades R-9 (Schools) Policy.

South African White Paper on Science and Technology (1996). http://www.info.gov.za/documents/whitepapers/index.htm Accesses June 9, 2004

Robottom, I. & Hart, P. (1993). Towards a meta-search agenda in science and environmental education. International Journal of Science education, 15(5), *591-605.*

Tamir, T. (1976). The role of the laboratory in science teaching. (Tech. Re. 10). Iowa City, IA: The University of Iowa, Science Education Center.

Siervers, K. (2001). How do you know that…? Critical reasoning Handbook, *Philosophy Department, Flinders University, Adelaide.*

Wellington, J. (1998). Practical work in school science: which way now*? Routledge, London.*

White paper on Science and Technology: preparing for the 21st century. (1996) Department of Arts, Culture, Science and Technology. (South Africa) http://www.dst.gov.za/legislation_policies/white_papers/Science_Technology_White_Paper.pdf, Accessed September 15, 2004.