Cells and Understanding Water Movement

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Experiment Overview

The practical class is integral to the process of teaching and learning in the Sciences (Hodson, 1988; 1990; 1993). Traditionally, it is viewed as the place where students develop some of the expertise of professional scientists, such as manipulative skills, experience in designing experiments and conceptual understanding (Hodson, 1988, 1993; Dawson, 1994). Commonly, University educators structure the practical laboratory so that the students are directed to follow a series of specific steps, rather like the steps in a recipe or cookbook (Fraser and Deane, 1999). Although students may develop manipulative and technical skills this way, it is unlikely that they will develop a view that Science is a process of inquiry nor gain better understanding of concepts. Indeed, students can leave practical classes more confused about the concept under investigation than when they arrived (Beaver 1999). This is particularly the case when the 'noise-to-signal' level is high. ' Noise' here is defined as the multilayers of information that students need to assimilate at once in a practical laboratory , rather than the physical 'sound' in the practical laboratory which may also be high. Alternatively, the practical lesson could be based on macroscopic observations which require a microscopic or submicroscopic understanding (Hodson, 1993). To provide students with the experience of Science as a process, inquiry, investigations and problem-solving need to be a major part of learning and teaching in the sciences. Then there will be the potential to increase conceptual understanding, connecting doing and knowing, but moreover get students putting the information in a structure which is meaningful.

If this is to occur, then each practical laboratory needs to provide students with sufficient time to think, discuss, make plans, do experiments, reflect and discuss their results. Although the value of student investigations in the laboratory has been recognised for some time (e.g. Nuffield) and termed 'discovery' learning by some proponents (Schwab, 1962), in recent years this strategy has been used for only "some types" of biology investigations, most commonly with fieldwork exercises or for some laboratory experiments which can be easily reformulated. Antagonists of such 'inquiry" 'discovery' approaches argue they are fraudulent, requiring students to reveal the truth of theorems which had often taken scientists an entire life time to elucidate or were the result of centuries of work and thought e.g. such as some of the principals of motion, matter and energy, or the molecular nature of photosynthesis (Ross and Tronson 2007). They argued that the obsolete epistemology of inquiry was not only responsible for the shortfall in expectations of the major effort to improve science education in the 1950s and 1960s, but that inquiry-orientated science was the major barrier in the way of revolutionary improvement of science education (Novak, 1988). Novak (1988) lamented the lack of evidence of learning gained in laboratories where enquiry learning occurred. He stated that students gained little insight into either key science concepts or process in laboratories because of an instructional misconception that physical activity and cognitive gain were somehow equivalent (Hodson, 1990; 1993; 1998). Others agreed, and inquiry activities undertaken in laboratory work came under increasing scrutiny for their ineffectual influence for dealing with students misconceptions which left unchallenged scientifically unacceptable conceptual understandings (Novak, 1988; Solomon, 1988; Hart et al., 2000).

Although the arguments for moving away from 'discovery' learning are compelling, equally compelling arguments can be made for the value to students of decreasing the number of practical laboratories with a cook-book like approach. A cook-book approach may be time efficient and cater for students with limited laboratory skills, but the danger is that, if it is the only approach used in a whole practical course, it portrays a Science as a set of isolated, "correct" facts to be learnt If this is the only experience students have in the laboratory, they are allowed very little room to make mistakes and learn from these by needing to work out for themselves 'why' things 'went wrong'. Philosophically, treating students as passive vessels to be filled only serves to reinforce Science as static and deterministic. Educationally, it gives students little opportunity to engage in the learning process and develop skills in thinking. Students do require a fundamental base of biological knowledge, yet they also need be involved in the dynamic process which is Science, develop skills in thinking, develop confidence and be motivated by the process. The dilemma for the University educator is to design teaching and learning strategies in the laboratory which encourage students to be mentally active. Here I argue that many 'tried and true' practical exercises are tired and tortured and fall short of achieving the objectives to which they aspire because of their structural framework .

Learning Experience

The basis behind these two laboratories is to describe the re-structuring of some old favourite Biology practical exercises: osmosis (cells and understanding water movement) and the action of the enzyme amylase (A chemical in the mouth). Basically these two exercises exist in numerous laboratory textbooks as standards and have become tacit ritualised practice (Ross et al., 2010). The restructuring described in this paper was done to create process of inquiry within a two- three-hour time period in a University practical laboratory. This process and the rationale of the redesign has many applications to other practical laboratories, which have for far too long been accepted as a 'good' way to do Biology. In this paper, a model is suggested in several steps to assist in the rescuing of tired and tortured laboratories so that they through a process of inquiry they become motivating and engaging. These two examples have been used successfully in classes of up to 500 students and they have been purposely selected and altered because of their ubiquitous place in first year biology courses.

Aims and Objectives

In order to be free to concentrate on these conceptual, deep level thinking tasks, they need to be free from having to also think about performing technical tasks or concentrating unduly on background information. A series of 'technical notes' and 'background information' are provided to students to access separately when they are ready to go on to their self-determined next step. Demonstrators (teaching assistants) are also well- briefed in both the inquiry process and theory in a set of purposely written reference notes and during our regular staff meetings, where the process the students will undertake is modelled. There are several steps which will assist to structure a practical which is a process of inquiry. The first step is providing a period of exploration for the students, followed by a description of some technical information required for the student to perform the experiment and ensuring there is plenty of time for the students to complete the activity, while allowing them to make the mistakes from which they will learn. Finally, it is essential to provide time for reflection and group discussion about approaches, mistakes, re-design of experiments as well as the results obtained (which may be more meaningful when results from the whole group are pooled). This final step is best done on the same day, before the students leave the laboratory, but if this is not possible it should be done in some small group lesson such as a tutorial within the next few days.

Level of Experiment

First year laboratory

Keyword Descriptions of the Experiment

Domain
inquiry, biology

Specific Descriptors
problem based learning, amylase, osmosis,

Course Context

The cell is the basic unit of life and some basic processes, such as membrane function and protein synthesis, occur in the cells of all living organisms. This unit examines these processes and associated biological chemicals. The unit also examines phenomena such as cell replication, sex cell formation, inheritance, and cell metabolism in eukaryotes (animals, protists, fungi and plants). The biochemical capture of the sun's energy (photosynthesis) is also investigated. The evolutionary links between cellular processes and the origin of life forms the framework for the unit.

Prerequisite Knowledge and Skills

Students can complete these laboratories without specific knowledge and understandings. They must be briefed on occupational health and safety issues associated with the laboratory, but other than this these laboratories are purposely designed to allow entry of any beginning first year student.

Time Required to Complete

Prior to Lab: none
In Laboratory: 3 hours
After Laboratory: 1 hour

Experiment History

These two experiments have been run with first year biology at the University of Western Sydney for a ten year period. They use everyday equipment requiring low level manipulative skills to allow students to critically think about problem solving and concepts.