Assessment needs to match the nature of the problem, so might well be a product or a performance. Formative, as well as summative, assessment will be used, and this should include self-assessment (e.g., rubric or journal writing) which might increase as students become more familiar with the process. Journal writing should include evidence of contributions made by every group member.

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Critical Constructivism, Neo-Relativism, and the Place of Values in Science Education

Gary Simpson
Woodleigh School, Victoria, Australia
simpg@woodleigh.vic.edu.au

Abstract

In this paper, the author considers the role of teaching values in science education as part of a move from teacher-centred pedagogy to student-centred pedagogy. Taking a constructivist-inspired position, he argues that, as part of their study of the use of scientific knowledge by society, students need to be given opportunities to make value judgements. A practice of teaching and learning that is centred on the unique individual needs of each student is outlined as a manner in which this vision for the future can be achieved.

Introduction

Does the teaching of values have a place in science education? If so, whose values? Which ethics? Many philosophers of science and of science education would argue that humans have constructed the body of knowledge we call science and used it to explain the natural world. This is certainly so of indigenous peoples and their constructions of science. If we accept that knowledge is constructed (a relativist position[1]) and we accept that the role of science is to serve the needs of the society, then we must ask about values and ethics (which has not been an explicit relativist concern, as to make a choice between two or more values is to privilege one over the others--something relativists are loath to do). How do we want the knowledge and technologies that result from the scientific endeavour to be utilized by our society? Who should benefit from this knowledge? When are some ideas just too dangerous and unpalatable? Why?

As for education, the educational philosopher Henri Giroux (1987) stated:

> Teachers are asked once again to promote character development in

> students, to teach them a clear sense of right and wrong, to promote skills of individual achievement, which translates into the virtues of hard work, self-discipline, perseverance, industry, respect for family, for learning and for country. (p. 113)

Giroux suggested four theoretical considerations for developing what he calls "pedagogy of critical citizenship" (p. 119). The first is a curriculum that challenges the issues of whose knowledge, history, language, visions, culture, and authority prevail as legitimate objects of learning and analysis? The second is a classroom that allows different student voices to be heard and legitimated. Third, the teacher must provide students with the opportunity to investigate a diversity of discourse about a subject from as many different sources as possible. Finally, Giroux argues for the teaching of values. Students need to be assisted to learn how to critique the information they receive and to evaluate that information and make their own decisions about it. I argue that this must be done through moral and ethical filters.

In this paper, I would like to consider a pedagogical approach to science education that attempts to answer these questions. It applies Critical Constructivism[2] (Lewin, 2000; Taylor, 1998), which by extension suggests Neo-Relativism, to the teaching and learning of science. Neo-Relativism is a term I use to describe a new form of Relativism that is concerned with valuing in the more pragmatic field of education. Using a Neo-Relativistic viewpoint, one is able to accept a variety of constructions of reality, but lead students to the position valued by society (such as a concept like the cellular basis of life) or question the position valued by society (such as globalisation) and suggest a new solution. This way, one is able to accept each student's construction of the concept, but teach them about the concept valued by society and assist them to reconstruct their own knowledge and understanding. It is a highly pragmatic application of relativism to the teaching and learning of science by adolescents.

Student-Centred Teaching and Learning

Radical Constructivism developed as an epistemological[3] response to standard transmissionist epistemologies for science and mathematics education. Ernst von Glasersfeld (1995) suggested that there are two basic tenets of constructivism:

> a) Knowledge is not passively received but built up by the cognising subject.
> b) The function of cognition is adaptive and serves the organisation of the experiential world, not the discovery of ontological reality. (p. 18)

This means that a learner will actively build knowledge to explain his or her experiences with the natural and social world of which the learner is a part. These two basic tenets of constructivism can be expanded to four general characteristics:

1. All knowledge is constructed.
2. There exist cognitive structures that are activated in the process of construction.
3. Cognitive structures are under development that can be transformed through purposive activity or from environmental or social pressure.
4. Acknowledgement of constructivism as a cognitive position leads to the adoption of a constructivist methodology.

Von Glasersfeld did not envisage that Radical Constructivism would deal with the issue of values (von Glasersfeld, 2000), particularly as it took a relativist position in relation to ontology[4] that does not privilege or value one knowledge claim over another. This neutral ontology led to many critical attacks upon the practice of Radical Constructivism and the development of many other versions of constructivism to answer those critics.

Critical Constructivism accepts the general tenets as outlined by von Glasersfeld above, but suggests that the knowledge claims most appropriate to the society are those that are privileged over others. With the move toward Critical Constructivism, this has become an important concern (Lewin, 2000). This suggests a new position for relativism (Neo-Relativism) that develops an axiological[5] approach to answer the question of what is taught? Which knowledge claims are valued? For practicing teachers this is an important development, for we must pragmatically deal with the students in our care. We must privilege western constructions of knowledge, in my case science, but need to do so in a way that is sensitive to "others." Thus I have developed a student-centred approach to teaching and learning science that accepts von Glasersfeld's basic characteristics, but also accepts that students must make judgements about the value of different knowledge claims.

My approach comprises three main features:

1. Discovering what the students already know, and what they feel, about a topic.
2. Having discovered what the students know and feel about the topic, and what (mis)conceptions they have, I negotiate meaningful tasks to address the identified needs of the students. That is, we find ways together to (re)inform their knowledge and understanding of phenomena so that they are either accultured (Aikenhead, 2000) or encultured (Driver, Asoko, Leach, Mortimer, & Scott, 1994) to the western tradition of science.
3. Sharing. An obligation of student-centred approaches to teaching that I place on learners is the need to share what they have learnt.

To achieve these three features, I developed six pedagogical characteristics of a critical constructivist epistemology. They are:

1. the measurement of prior knowledge and understanding,
2. the intervention by the teacher to mediate the learning of students with purposive activity,
3. establishing social situations in which students can make sense of experiences in terms of what is already known, and discuss issues of which knowledge claims should be privileged,
4. a diversity of opportunities for students to represent their knowledge,
5. constant monitoring of student activity to recognise signs of difficulty, disengagement, and depth of understanding, and
6. reporting that recognises the learner as a unique individual.

I believe that students enter my classroom with prior conceptions that explain phenomena. These prior conceptions are deeply held by the student because they have developed over time in response to various experiences and the student's unique enculturation that reflects the values of their family and community. To reframe these (mis)conceptions[6] requires the student to actively question what they believe to be true.

A student-centred approach shares the knowledge and power of the teacher with the student, and has the potential to empower all students. Having been empowered to share in the learning process, the students invest personal energy in exploring phenomena, are caused to question their prior conceptions, explain their beliefs to their peers, renegotiate what they believe to be true, and value knowledge claims over other knowledge claims. The requirement to share these new constructions of knowledge with a larger audience causes the learners to prepare these new constructions carefully. Students also need to be prepared to have their knowledge claims challenged by the audience. As learning is a life-long process, this approach recognises that learners need to revisit and revise their understanding frequently in order to enrich and deepen their understanding from their new experiences. Therefore, the ability to describe what knowledge and understanding students in one's class have when a unit of study begins, and then compare that level of knowledge and understanding for each student when the unit of study has been completed, is very important. It is then possible to assess growth in knowledge and understanding and to report success for all learners. However, a cautionary note should be made. One needs to develop this new way of approaching teaching and learning slowly and with sensitivity, understanding that the students' construction of pedagogy is also being challenged.

Having a classroom that is operating under student-centred pedagogy is not an easier way of teaching. It requires the teacher to act as:

- a facilitator, finding information or resources,

- a critical friend, questioning and assessing work in progress in a positive and meaningful manner, and asking questions to cause students to reflect on the values implicit in their knowledge claims,
- a referee, settling squabbles within and between groups of students over who did what, etc.,
- a police officer, maintaining good patterns of student and work behaviours, and
- a seer. The teacher still needs to have a strong knowledge of their subject area in order that they be able to ask the right questions of the students, suggest appropriate lines of inquiry, and construct successful investigations with the students.

Reflection

The WebQuest approach (Simpson, 2003b) published previously in this journal is one example of this approach to teaching and learning. Essentially, I attempt to create a classroom environment that accepts my learners as unique individuals. Like most teachers, I have tasks prepared for my classes. I will plot a sequence of lessons with my learning outcomes in mind, but rather than doggedly demanding all my students to complete it in the way that I had in my mind, I allow students to negotiate all aspects of each activity. The outcome is a diverse set of products responding to the same stimuli. By having the students share these products with the rest of the class, the experience is enriched for all students. Interestingly, the majority of students are usually happy to work with the materials supplied to them, making only minor alterations. In my experience, it is generally the higher achievers who are able to negotiate and radically alter tasks to suit their own needs (Simpson, 2003a). For those students with learning difficulties, I am able to collaboratively create structured tasks that are meaningful and achievable for them. This approach to teaching values each individual, applies an ethic of care to my students (Taylor, 1998), and assists me to build rich relationships with my students.

This approach has important ramifications for assessment and reporting of student success. I wish to report on student growth, so I first need to assess student knowledge, understanding, and scientific literacy prior to the study of a unit. During, and following, the unit of study, I am to assess how students' knowledge and understanding of important concepts have changed. I can therefore report on those changes in a descriptive manner. But I also use rubrics for my individual tasks. These are written to address issues of scientific literacy, practical skill, and knowledge outcomes (Simpson, 2003b), and are given and explained to students with their task. In this way, the purpose of the task is clear, the manner in which it will be assessed is clear, and students are free to negotiate the various parameters of the task within that framework. With students regularly presenting their work to other students, peer assessment is also a common feature of my assessment.

Teaching in this way is often exhausting, sometimes frustrating, often exhilarating and, as a partner in learning, personally educative. A student-centred classroom looks the same as any other classroom, but there is a great deal of difference in how it operates. The students move freely about the classroom, and the whiteboard is often bare--or at least has half a dozen different notes to different groups, notes the students may have written themselves. The teacher moves freely about the classroom, engaging with students. There can be a significant amount of noise, and often very few students are in the classroom proper. They have moved to other parts of the school that have the equipment or expertise required for the work they have negotiated.

Notes

[1] Relativism holds that all knowledge is constructed by cognition and then various forms of relativism argue about the manner in which social pressures mediate that knowledge and its application. The search for an absolute truth by western science is therefore viewed, by relativism, as futile.
[2] Critical Constructivism is a later form of Radical Constructivism. It does not apply the strongly held relativist position of Radical Constructivism, but accepts that choices between knowledge claims need to be made within the social setting of the individuals (Ernst, 1995).
[3] Epistemology is the study of the way we come to know things.
[4] Ontology is the study of ways of being or ways of becoming, and has to do with what we believe to be true.
[5] Axiology is the study of ways of valuing, or how we establish truths.
[6] I use this term here to acknowledge that my students will all have conceptions, but that some are not as sophisticated as others, or in line with current western scientific thinking. The purpose of science education is therefore to acculture (Aikenhead, 2000) or enculture (Driver et al., 1994) our students into the western tradition of science.

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