Becoming a scientist: students' ethical judgments on the use of data (0217)

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Developing the ability to make professional judgments is an important element of higher education but one that is emphasised to different degrees in different disciplines. Science degrees have a strong emphasis on practice, consisting of laboratory and field work, but the way these activities are structured often provide very limited opportunities for students to use their own judgment and engage in the types of decision making that is required for the practice of science. As a result, students may develop two separate views of science; a proximal view, which encompasses the science they do and a distal view, reflecting their understanding of professional science (Hogan, 2000). Science degrees are often characterised by a focus on content mastery where foundational knowledge is seen as essential before students can progress to research-based experiences. Proximal views, therefore, may be characterised by a 'right answer orientation' (Hodson, 1999) where science learning consists of memorising facts and answers are either right or wrong. Students with this view focus on producing right answers, rather than engaging with science as a professional discipline.

While such a view of science may be productive in meeting assessment requirements (Elby and Hammer, 2001), it can inhibit the development of students' identities as scientists. If students are not given opportunities to make decisions, for example, in the way an experiment is designed or how data should be interpreted, they may not recognise that these judgments are crucial for the practice of science. Students need to see themselves as trainee scientists and to see scientists as fallible people like themselves. The former may be achieved through providing a variety of inquiry-learning and research experiences where students have some control over the project direction and outcome. This study focussed on the second approach, where students read about scientists, with opportunities to reflect on and discuss their actions. Both approaches aim to assist students better align their proximal and distal views of science.

The analysis and interpretation of data provides an excellent issue to prompt students to think about the need for judgment. Scientists make decisions about what and how much data to collect, appropriate statistical analysis, the level of acceptable error, and how data should be presented, for example. There are particular issues around decisions to remove outlying data points that students find challenging because there is a fine line between acceptable data manipulation and that which is fraudulent. In this study, such issues were included in a course on the nature of science that was offered to first year science students. Students read about several cases where famous scientists based their conclusions on only some of the data they actually collected. In these examples, data was difficult to collect and the experiments prone to technical errors. There was, therefore, a need for the scientists to make decisions about which data should be included in the final analysis. These situations challenge students to consider the role of professional judgment and to confront potential ethical issues in determining acceptable levels of data manipulation.

Student were assessed on reflective responses to each issue presented, including data manipulation and interpretation, as well as a final integrative reflection in which they were encouraged to reflect on their changing views of science and scientists. All reflections were de-identified and entered into NVivo to facilitate analysis of data and identification of material relevant to particular themes. Qualitative analysis of the reflections used a grounded theory approach (Strauss & Corbin, 2008) to identify emergent themes relating to students' perspectives on their learning and their understandings of the nature and practice of science. We also drew on phenomenographic approaches to characterize variation in student responses (Marton, 1981) to the chosen themes of data manipulation, fraud and the use of judgment in science. We were interested in the relationship between proximal and distal views of individual students, as well as in variation between students.

The reflections show that students apply different ethical standards to their own behavior in the laboratory from that of professional scientists. This emphasizes the proximal/distal split in that students see their own experiences as so different from professional science that different ethical standards can be applied. It is also evident that many students had not previously considered laboratory work as training for professional practice. Thus, they felt that it was acceptable to doctor results in their own laboratory experiments because this was seen as an effective strategy for gaining good marks. However, the same students condemned such behavior in professional scientists because honesty and objectivity were seen as essential to the practice of professional science.

Our data also show that although most students entered the class with this separation of proximal and distal views, the readings, discussion and reflection during the class could prompt change. Students contrasted their initial views with their new understanding of the need for scientists to make judgments. We observed a range of views from a naïve absolutism that remained unchanged by the class activities to an acceptance that data analysis and modification must be considered on a case by case basis, requiring professional and ethical judgments. Some students produced sophisticated and critical discussions of the pressures on both scientists and science students to modify data inappropriately.

The range of views observed shows some parallels with the intellectual and ethical development framework developed by Perry (1970). This suggests that discussion and reflection on the nature of science and what scientists do can be an effective strategy in promoting not only a better understanding of science but also more general intellectual development. It also raises questions about why the change was greater for some students than others. An implication of our study is that curricula should be designed with the specific intention and appropriate teaching and learning strategies to develop students' identities as scientists as well as covering content and laboratory skills.

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