

Making mathematics and science relevant through story

Linda Darby

Deakin University

[l<darby@deakin.edu.au>](mailto:ldarby@deakin.edu.au)

Inquiries into the state of mathematics and science education in Australia express the need to make the curriculum more relevant and meaningful to students' lives. However, such a vision requires that teachers understand how relevance can enter mathematics and science classrooms in meaningful and appropriate ways. This paper asks: how is relevance thought of in mathematics as compared with science and what problems might this pose for teachers moving between mathematics and science?

Background, aims and framework

Despite reform in Australia in science and mathematics education, the disparity between the science and mathematics education being offered and the needs and interests of students continue to be of growing concern. A number of inquiries into the state of school science and mathematics in Australia in the past six years (Department of Education Science and Training, 2003; Education Training Committee, 2006; Goodrum, Hackling, & Rennie, 2001) report on falling enrolments in post-compulsory science and mathematics, and student disenchantment with curriculum that they often consider to be irrelevant. For example, the Education Training Committee (2006) found that one of the major factors contributing to student disengagement in secondary mathematics is the lack of connectivity between students' lives and mathematical problems. Similarly in science, the Committee recognised a need for curriculum approaches that focus on, among other things, relevance to students' lives, as well as those that make strong links between future education and career pathways.

As a discourse operating in both mathematics and science, relevance by relating the curriculum to students' lives is well established as being important in making the curriculum accessible and meaningful for students (Education Training Committee, 2006). For instance, the curriculum documents of the Victorian Essential Learning Standards (VELS) for mathematics and science recognise relevance as one of the bases of the discipline-based learning strand: "students develop deeper understanding of discipline-based concepts when they are encouraged to reflect on their

learning, take personal responsibility for it and relate it to their own world” (VCAA, 2005, p. 3). However, such a focus will depend on teachers understanding how relevance can enter mathematics and science classrooms in a meaningful and appropriate way.

This paper uses snippets from classroom practice to explore how six mathematics and/or science teachers attempted to make the subject matter meaningful for their students by presenting a humanised and relevant subject. The paper asks the questions:

- how is relevance thought of in mathematics as compared with science?
- what problems might this pose for teachers moving between mathematics and science?

The attempts of the teachers are referred to as “stories” or “narratives” because it was through discussions about stories that many of these ideas emerged from the teachers. As “stories” they “help students organise their knowledge into explanatory frameworks which serve them as interpretive lenses through which to comprehend their experiences” (Milne, 1998, p.178).

Methods

This comparative study aimed to explore:

- how teachers of mathematics and science in lower secondary school experienced the subject cultures of mathematics and science;
- identification of those pedagogies that appeared to be representative of the subject cultures; and,
- ways in which pedagogy was shaped by teachers’ experiences with the subject cultures.

Various qualitative methods were used over eighteen months to periodically observe, video-record and interview six secondary science and/or mathematics teachers: Donna, Pauline, Rose, Simon, Ian and James. I observed teachers’ classroom practice during a sequence of teaching in mathematics and/or science, and two of these lessons were video-recorded for each teacher. A reflective interview (Darby, 2004) with each teacher followed a private viewing of video footage taken in the classrooms—a modified video-stimulated recall process (cf. Clarke, 2001; Senger, 1998). For the first four teachers, a focus group discussion and a second round of observing, video-recording and interviewing followed. The use of stories to make links between students’ lives and subject matter emerged during a preliminary analysis of first round classroom and interview data, and was seen to be more prevalent in science than in mathematics classes (see Darby, 2005). A subsequent thematic analysis of the interview transcripts explored the various ways that teachers explicitly or implicitly made these links.

Results

All teachers believed it was important to relate the content matter to students’ lives. However, they seemed to approach this issue of relevance differently, both in practice and in their stated beliefs about what it means to teach effectively. For example, Pauline, a science teacher who also teaches mathematics, used stories in science to show how science relates to students’ lives, but

struggled to find and use stories in mathematics. Donna emphasised the need for students to develop their own stories as contexts in which students could explore phenomena in both subjects. Rose's use of stories in mathematics often modelled the use of mathematics in everyday life.

Four types of pedagogical approaches were found to be representative of how the teachers recognised what needed to be made meaningful and relevant and how this could be portrayed for students. These were labelled as categories of meaning making. Mathematics and science are presented differently in each category, and the stories serve to focus on different aspects of both the subject matter and the place that this has in students' lives.

Category 1: Illustrations of relevance

The first category includes illustrations of relevance. These were often referred to by teachers in the interviews as examples of stories they would use to relate the subject matter to students' lives — examples that gave shape, meaning, relevance and sensibility to explanations given in class. To successfully assist students to make abstract concepts concrete, teachers must also be aware of what interests students, and relate their subject matter to those phenomena.

In mathematics, the examples illustrate how the subject matter provides a tool to represent patterns recognisable in society, particular ways of thinking that students might carry out or encounter in their lives, and thinking processes that they might have experienced or where they can see the application. For example, in the context of real life applications of algebra at Year 9, Simon tries to incorporate "worded questions that are world use sort of questions" that apply, contextualise, and illustrate where this thinking might occur in real life, "questions that they would come across in actual life rather than just 'do the left hand side.'" Rose tries to make mathematics more understandable by illustrating an operation using recognisable objects, such as the sharing of chocolate to illustrate fractions, and the "fruit bowl" analogy for algebra, such as a and b "standing for something" like apples and bananas, thereby illustrating reasons for adding and subtracting like terms only. In these cases, the familiar objects (apples and bananas) are used as representations of abstract symbols (a and b), rather than helping students understand the actual objects themselves, as is usually the case for science. The object or phenomenon, therefore, stands in a different relation to the concept in mathematics than it does in science. In science, the object or phenomenon is the object under study and the meaning of the object for the person is bound up in the explanation. There is a natural relation between the explanation and the object.

In science, they are illustrative of how science explains natural phenomena. The illustrations emanate more naturally from students' experiences. The illustrations target examples of phenomena, such as discussing familiar examples of translucent, transparent and opaque materials, corrective lenses as an application of lenses, and the melting of chocolate and ice-cream as visual examples of physical change. These illustrations were usually visual, required little personal engagement with the concepts, were offered by teacher and students, and were selected based on the teachers' understanding of what the students would "recognise," "relate to," "provide links that were relevant to students' lives," and that students would "have an interest in."

Category 2: Explorations of contexts

The second category includes those instances where contexts were used to challenge students to think more deeply about the subject matter. These contexts were built around the students' interests, or were generative of new interests. The power of this category lies in the way a complex series of ideas are pulled together and given meaning through an application. Connections are made between the subject matter and ideas or phenomena that are already understood by the student or that hold intrigue. The result is a coherent and deeper understanding of the subject matter.

In mathematics, such stories can be used to develop "problem solving activities" or "open-ended tasks". For example, Donna's students investigated fractions using a context that was of interest to them, such as sewing, sales or football. In an attempt to generate new interest, James explained an investigation that he gave students that incorporated the mathematical skills required to build a house and design a vineyard.

In science, "regurgitating questions" can be replaced by student-generated questions, for example, exploring refraction by investigating lighthouses. Lighthouses are a prominent part of the lives of these coastal students, therefore, the use of light and the optical properties of mirrors and lenses is both relevant and intriguing. Donna refers to such stories as "favourites."

Category 3: Humanising stories of historical and contemporary "heroes"

The third category includes stories that were used either implicitly or explicitly to humanise the subject. I observed these stories in science, but not in mathematics. The stories focused on the discipline of science, and included stories about historical and contemporary "heroes" that contributed to the development of scientific knowledge. These stories have the potential to demonstrate the development of science and mathematics ideas over time.

In science, Pauline shared with her students the story of Benjamin Franklin's discovery of static electricity in an attempt to engage students in the stories surrounding the discovery of static electricity. The story is intriguing because Franklin went to such extremes in his search for understanding electricity. James told a story of spontaneous creation that he used during a Year 10 genetics unit. This story portrayed a scientist using scientific experimentation to falsify the previously accepted idea that life was created in a spontaneous manner.

Category 4: Representations of the human endeavour

The fourth category also humanises the subject, but these stories relate to the ways teachers modelled or emphasised in their teaching the human endeavour of science and mathematics. These stories included:

- how mathematics and science provide the means by which we can live our lives as functioning and empowered human beings;
- stories about teachers' personal encounters with mathematics or science; and,
- what it means to be passionate and committed.

Their inclusion depended on the extent and quality of teachers' experiences with, and knowledge about, the discipline.

The human side of mathematics was demonstrated in a number of ways. Simon wanted students to understand how to work with numbers and appreciate significance in mathematics, such as the significance of one of four members of an Olympic team winning a medal. Rose emphasised mathematics as “making you think,” and Pauline liked to model this thinking process as she toiled to find the answer to a problem. Rose modelled an enjoyment and love of mathematics by being enthusiastic in her approach to mathematics: “I tell them I love mathematics.”

Teachers demonstrated science as a human endeavour in different ways. Pauline emphasised the explanatory power of science in understanding our world, such as why televisions get dusty. Pauline implicitly demonstrated the place of phenomena in the human search for explanation as she explained how rainbows are formed when students were intrigued by a colour spectrum that they observed while playing with lenses. Donna was explicit with her students about why scientists do a number of trials during a controlled experiment and why scientists use chemical symbols as shorthand for chemicals. Pauline emphasised science as being embedded in our lives and that being scientifically literate “informs everything that we do personally, and the way we interact with the world and being more responsible.”

Discussion

Some of the “stories” mentioned above do not technically have a recognisable narrative structure but they do retain particular cultural or human values. They suggest for students that these illustrations or ways of thinking are worthy of attention because of their scientific or mathematical importance within their world. The use of stories was a common strategy used by teachers to make links between the subject and students’ lives. Stories about the discipline and about the concepts in context provide a mode of representing this relevance.

All teachers felt that it was important to relate the subject matter to students’ lives in some way, so relevance could be considered a fundamental and powerful discourse. However, the fact that different teachers emphasised relevance in different ways by using different strategies suggests that a teacher’s decision about what to tell and why they tell it is very much dependent on a teacher’s beliefs, knowledge, experiences and commitments in relation to mathematics and science. It also reflects the multi-faceted nature of relevance. Consequently, teaching across subjects requires an understanding of not just the stories that can be told, but also an understanding of what is appropriate for making the subject matter relevant to students’ lives.

Understanding how teachers of mathematics and science conceptualise relevance and how they connect subject matter to real life can inform teaching practice in three ways.

Firstly, comparing the role of relevance in mathematics and science illustrates various meanings that relevance can have for teachers. For example, the absence of historical stories in mathematics demonstrates a silencing and lack of appreciation for the historical development of mathematical ideas, and how this can inform the learning process. Emphasising this historical development has the potential to depict mathematics as a search for ideas, and not just a utilitarian subject that is only relevant when there is direct application to students’ current or future lives.

Secondly, it demonstrates that expecting teachers to make the curriculum relevant is not necessarily unproblematic because the meaning of relevance is not collectively understood, nor is it the same for mathematics and science. For teachers moving between mathematics and science teaching, especially when moving into a subject for which they have limited appreciation or experience, understanding how the subject can be made relevant for their students, and themselves, is valuable information.

Thirdly, Elbaz-Luwisch (2002) describes the practice of teaching as being constructed when teachers tell and live out particular stories. Teachers having stories to tell is important, not only in terms of sharing anecdotes in the classroom that reveal the teacher's view of the subject in an effort to draw students into the subject, but it fundamentally reflects back on the teacher as part of their personal response to the subject. In this way, stories have a reflexive character as they have the potential to give the teacher a confidence and level of commitment that may be evident as a passion for teaching the subject to students.

References

- Clarke, D. (2001). Complementary accounts methodology. In D. Clarke (Ed.), *Perspectives on Practice and Meaning in Mathematics and Science Classrooms*. Dordrecht: Kluwer Academic Publishers.
- Darby, L. (2004, December). *The inner and outer teacher: Constructing stories of subject, classroom and identity*. Paper presented at the Symposium on Contemporary Approaches to Research in Mathematics, Science and Environmental Education, Deakin University, Burwood.
- Darby, L. (2005, July). *Having stories to tell: Negotiating subject boundaries in mathematics and science*. Paper presented at the Australasian Association for Research in Science Education, Hamilton, NZ.
- Department of Education Science and Training. (2003). *Australia's Teachers: Australia's Future. Advancing Innovation, Science, Technology and Mathematics. Agenda for Action*. Canberra: Commonwealth of Australia.
- Education Training Committee. (2006). *Inquiry into the Promotion of Mathematics and Science Education*. Melbourne: Parliament of Victoria.
- Elbaz-Luwisch, F. (2002). Writing as inquiry: Storying the teaching self in writing workshops. *Curriculum Inquiry*, 32, 403–428.
- Goodrum, D., Hackling, M. & Rennie, L. (2001). *The Status and Quality of Teaching and Learning of Science in Australian Schools*. Canberra: Department of Education, Training and Youth Affairs.
- Milne, C. (1998). Philosophically correct stories? Examining the implications of heroic science stories for school science. *Journal of Research in Science Teaching*, 35, 175–187.
- Senger, E. S. (1998). Beyond classroom description: Methods of understanding reflection and beliefs in mathematics teaching. *Educational Research Quarterly*, 21(3), 21–39.
- VCAA. (2005). *Victorian Essential Learning Standards: Discipline-Based Learning Strand Science*. Melbourne: Victorian Curriculum and Assessment Authority.

From Helen Prochazka's **Scrapbook**

I have always hated machinery, and the only machine I ever understood was a wheelbarrow, and that but imperfectly. (Eric Temple Bell, 1883–1960)
In H. Eves, 1977, "Mathematical Circles Adieu", Boston: Prindle, Weber and Schmidt.

There is no branch of mathematics, however abstract, which may not some day be applied to phenomena of the real world.
(Nikolai Lobatchevsky)
In N. Rose, 1988, "Mathematical Maxims and Minims", Raleigh NC: Rome Press.