Learning mathematics for an environmentally sustainable future

Karl Bushnell shares resources he has designed to teach for an environmentally sustainable future.

My students often ask me, “Why do we have to learn this?” There was a time when, without hesitation, I would have responded with a statement along the lines of:

We learn mathematics to appreciate its beautiful and elegant essence. Mathematics reveals to us the fundamental truths that govern our universe in a way that no other discipline can.

However, having experienced the profound impression that education can have on a student’s life, I have now persuaded myself that this romantic purpose for learning mathematics, if adopted exclusively, is not beneficial to students. I cannot expect to make a positive difference to my students’ lives if my educational philosophy ignores the challenges that they will face in the future. Indeed, my response to the question, “Why do we have to learn this?” now reflects my belief that learning mathematics is an important tool to support us in becoming reflective, active members of a democratic society, prepared for the difficulties that we will encounter. In my opinion, one of the greatest challenges that we currently face is that of environmental sustainability. The sustenance of the global population is threatened. We have to balance our human activities resulting in environmental pollution with their consequences, be it extreme weather events, ocean acidification or the damaging of ecosystems due to climate change. Mathematical concepts are central to exploring such problems and I feel a responsibility to investigate some of them with my students.

On a wider scale, the integration of environmental sustainability and mathematics education is a movement that remains in its infancy. In 2003, an internet search conducted by Petocz and Reid, using the words “mathematics” and “sustainability”, yielded a small number of research-related documents. Of course, research was not as widely publicised on the internet in 2003 as it is today. However, a similar search over a decade later produced comparable results (Coles, 2016, p. 1), which suggests a limited interest in exploring environmental sustainability within

Figure 1: Melting ice sheets.
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These circumstances have motivated me to create resources of my own (see figures 1, 2 and 3) and I would like to offer the reader an insight into their design, alongside an account of how one was used during a lesson. I hope that the ideas contained within this article make a meaningful addition to the developing dialogue between educators about learning mathematics for an environmentally sustainable future.

Creating a resource

Each activity is concerned with a mathematical question related to a particular environmental issue. For example, Disappearing forests (figure 3) investigates the number of years it will be before the Earth’s forests are completely cut down, as part of a wider exploration into deforestation. As I planned the activities, I was mindful of how overwhelming the questions might be for some of my students. I decided it would be appropriate to break the question down into a sequence of questions. For example, “What will the mass of atmospheric carbon dioxide be in the year 2050?”, can be broken down into enquiries about trends, statistical interpolation and rates of change. I planned each section to build upon the previous until I was confident that my students would be able to answer the main question. I thought that this approach would not only give my students access to the activity, but would also demonstrate that with some direction, they are capable of engaging mathematically with environmental issues. However, I thought that there was something more valuable in adopting this structure; it serves as a meta-comment to my students about how mathematicians often break down a challenging problem by tackling smaller, more manageable, problems first.

Yet, I was worried that this would still not allow independent learning as I recognised that some of my students might not be able to identify the mathematics in each of the sections. For example, in section three of Melting ice sheets (figure 1), I did not believe that it would be clear to some of my students that the density of water connects its volume to its mass. So, in most cases, I partitioned each section into two parts, the first of which contained standard, mathematical problems, whilst the second extended these problems into the context of the overarching environmental issue (See figure 4).

I believed that the presence of standard, mathematical problems would help my students refine their understanding of a concept in preparation for working with it in an unfamiliar context. I believed that this would not only offer direction but would anchor the activity in a setting that my students were already familiar with and improve their confidence when attempting it.
a way, I thought that this would help to sensitize my students to some of the mathematical complexities contained within these environmental issues. In turn, I believed that my students would realize for themselves how their developing mathematical understanding can be applied to the world beyond the classroom. However, a question that I am left thinking about is whether the mathematical skills should come first so that they support students working in context, or whether the context should come first so that students are motivated to learn the mathematical skills and perhaps apply them outside of the classroom.

Whilst working on the activities, I was keen for my students to develop some of the skills that they will need to navigate the complex, global issues surrounding us. For example, I believe that my students will need to be collaborative; to understand different perspectives and solutions; and be confident to ask for assistance from those who have more expertise. Communication is important for all of this and in order to promote it within my classroom, I made the standard, mathematical questions in each section relatively challenging and increasingly difficult.

You can see that I included a space on each worksheet for my students to reflect on their immediate thoughts, having completed the activity. For me, this is the most important part of the activity as I believe it helps students make sense of what they have discovered and what it means to them. I expect that some of my students will be galvanized by these environmental issues whilst some will be unmoved. However, I suspect that for many of my students, their feelings towards taking independent action will be tentative and will alternate between action and inaction. Should there be any possibility of them taking action, this exercise may help them capture that. They will remember what they had learned more effectively, and this might encourage them to spread the message.

As a teacher, I am conscious of my role as an authority within the classroom and I want to avoid coercing my students into adopting a specific attitude towards environmental issues. Indeed, when I designed these activities, it was particularly important to me that they remained objective so that my students could explore the issues for themselves. As I said earlier, I used real data from reliable sources (see note at the end of this article) and I hope that working on the activities enables students to form their own conclusions.

**Tensions and reflections**

Having designed the activities, I decided to use *Melting ice sheets* (figure 1) with a class of 11-12-year-old students. We first discussed the environmental issues facing us in the world today and how mathematics...
might be able to help us address them. I reproduce part of this discussion below:

**Teacher:** Can anybody think of problems in the world today that mathematics might be able to help us with?

**Student 1:** Pollution.

**Student 2:** Global warming.

**Student 3:** Financial problems.

**Teacher:** Yes, mathematics might help us with all of these by analysing data and making predictions thereby helping us to find solutions. Anything else?

**Student 4:** Obesity.

**Teacher:** We could investigate the mathematics within that and calculate how much food might be left in a given year.

**Student 5:** Terrorism.

**Teacher:** This is a global issue we have to face. There may be some areas of mathematics that intelligence agencies use to fight crime.

**Pause.**

**Teacher:** Today, we’re looking at melting ice sheets.

After our brief discussion, I experienced an immediate tension. Although I was pleased to hear my students share their awareness of global issues, I cannot help but wonder if I inadvertently hindered their natural inquiry into them. By dictating the issue that is to be investigated during a lesson, I suspect that some students would feel discouraged that their ideas are seemingly dismissed and might therefore feel unworthy of acting on an issue that troubled them. Moreover, the topic of melting ice sheets might not be one that appeals to some students. In such a moment, I believe that one needs to think carefully about how prescribing topics can dissuade students from acting on environmental issues at all. Perhaps next time, I will adopt a more democratic approach and allow my students to explore issues that are important to them. Indeed, I have observed many instances where students have taken the most from a lesson when they are given the freedom to inquire about that which concerns them, excites them and interests them.

On the other hand, not all students possess the confidence to independently explore such issues from a mathematical perspective and might not have the mathematical skills they need to work on the problems. In this case, more guidance and structure may be important and the issue to be investigated may need to be prescribed. Certainly, for these students it was the first time I had offered an activity of this kind and so it felt appropriate to choose the issue myself. Perhaps, having seen how these activities work, they could explore their own questions afterwards. Perhaps my students could have voted on an environmental issue and I could have created an activity around that issue. I am left reflecting on what scope there is in these activities for my students to explore their own questions.

Interestingly, the most tension I experienced during the lesson was whether I should have scaffolded the activity more. In particular, I had not anticipated the number of students who would struggle with the concept of the volume of a prism. Many students required my support and, in some cases, this support was insufficient to allow them to proceed.

Admittedly, the volume of a prism was a topic that I had not yet taught but its inclusion in the activity...
was deliberate as I wanted my students to collaborate with each other, sharing their current understandings to develop their missing knowledge. I felt conflicted when I realised that I had to provide my students some detailed and structured exposition about volumes of cuboids. I wanted my students to feel as though they had discovered solutions for themselves. I wanted my students to assume ownership of the problem and therefore feel as though the need to act had been generated by themselves. I wanted my students to work as if they were outside the classroom.

Although my exposition seemed to help, it left me wondering if it was unreasonable to expect my students to engage in independent modes of learning without guidance and without instruction. Should these skills be built up first? I suppose that in some ways, my students did work in the manner I wanted them to, they sought information from a subject specialist. In summary, I believe that the role of the teacher in working with these students needs to be carefully considered. For me, it is about pointing students in the right direction in terms of resources to generate knowledge and letting my students choose whether they want me to teach specific skills.

Using exposition also forced me to contemplate whether it is more important for my students to understand why the formula for volume of prisms is what it is, or do I just want them to be able to use it so that they can communicate ideas about a real-world context? Is it the learning of mathematics or getting students to act on environmental issues that is more important? I suppose that my students were able to recognise the consequences of melting ice sheets without necessarily developing the conceptual understanding of volume and so perhaps the learning of mathematics is not as important as one might think.

On the other hand, a deeper understanding of volume might have afforded my students an insight into a potential solution and therefore inspired them to act.

**Conclusion**

I would like to share some of the students’ reflections with you. These comments reflect the tensions that I have described above:

- It didn’t really make me feel anything but I enjoyed the maths.
- Doing this activity makes me feel that we should look after the earth.
- I enjoyed doing maths with real-life problems and it makes you think about what happens in the real-world.
  - I found it fun to do an activity more practically which is linked to the wider world. The maths was challenging but I found it really interesting and it really pushed me.
  - It made me feel that this activity wants me to change the way I act, but the maths itself is very difficult.
  - It made me think of how mathematics can help in the wider world. It also made me think of how ice melting can affect the next generation.

I had hoped that more of my students felt compelled to take action. I wonder how that can be achieved? Should we have investigated an issue more relevant to their lives? I am also left reflecting on my wider responsibilities. Where does my role as a teacher end in trying to get my students to act? Is raising awareness enough? And, if I create a desire in my students to act, am I responsible to support them in taking action?

**References**


Notes: I drew on the following websites to support me in the design of the activities:


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