negative quantities. To grow more powerful in mathematical thinking requires a focus on the essentials that operate in a more general manner.

The historical allusions to Norse mythology make fascinating reading and I would not be without such a vision. Yet, at higher levels, mathematics must operate in a wide range of situations where particular embodiments give meanings that may not be applicable in other contexts. Consider, for example, the interpretation of a function as distance given in terms of time, and all the meanings and allusions involved as its derivative is called velocity, with velocity having a derivative called acceleration, and its derivative often called “jerk” because a sudden change in acceleration is felt as a jerk. But this meaning does not fit well with simple harmonic motion, such as the case where the distance is \( s\), the velocity is \( c\), the acceleration is \( -s\), and the jerk is \(-c\).

In what sense is the smooth function \(-c\) a “jerk”? While some embodiments may be supportive in many ways, they may also have particular characteristics that are problematic and impede generalization.

While mathematics should have meaning, such meanings should be flexible to take account of other situations where the mathematics may be applicable. Embodied representations are powerful in giving fundamental meanings but they usually lack the power of symbolism to formulate ideas precisely and to find exact solutions to complex problems. They may also involve problematic met-befores that impede understanding in new contexts.

Mathematics must harness gesture and embodiment in enactive and visual representations, but it must also develop a flexibility in the use of symbolism and, where appropriate, the later development of mathematical formalism and proof. Mathematics needs to be related to real world situations but it also needs a symbolic fluency and power of its own that sets it free to move on to previously unimaginable ideas.

We therefore need to look at our own theories in more humble ways, to seek simple ways of expressing practical insights into teaching and learning. There are huge problems to address. There is much for us still to do to understand the nature of mathematical thinking with its crystalline structure and longer-term supportive and problematic met-befores. We should also apply our analysis not only to the learning of students but also to the supportive and problematic aspects of our own theories.

References


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Modeling for life

WALTER WHITELEY

Almost all of us grew up mathematically with an assumption of the certainty of mathematical reasoning. Given certain input, we have certain output. However, problems like climate change, the degrading changes in the sea, and health treatment decisions have an unavoidable level of uncertainty in the input, as well as some complex connections. What is causal in a multi-variable set of complex connections? (See [1] for reflections on such a fundamental shift). It is a basic characteristic of modeling in situations such as climate change, or health outcomes, that the input and the conclusions are stochastic (subject in essential ways to uncertainty) but still have an appropriate form of reliability. This characteristic leads into probabilistic reasoning, a new topic not yet well supported in the curriculum or in the preparation of teachers.

As Renert (2011) notes, transforming action on such topics (and on others), also requires essential learning about modeling. Students need to practice a form of problem-based learning and simulation with multiple variables. In this approach, students and teachers search for mathematics sufficient to run a simulation of changes and then make some sense of why or why not to consider information from models as reliable. As Renert notes, this will require the use of modeling software, often in a black box form. This focus on modeling represents a shift from Platonist, deterministic, deductive, proof-based reasoning, towards modeling-based and stochastic-based reasoning. This shift positions applied mathematics as a key defining experience of current mathematics, in place of an approach to mathematics education which takes pure mathematics as the ideal to be emulated by classrooms full of students, few of whom would become users of formal proofs.

Modeling will require the essential use of technology, and data for which we do not have even a good approximating formula. This work can be supported by information presented and reasoned about visually, rather than by being immediately transferred to algebra. A move towards qualitative reasoning.

Figure 1. Simplified representation of a temperature distribution (vertical height represents number of days at a given temperature).
which key people have worked to prevent any form of regulation on all of these issues, in part by questioning the science (and mathematics) of predictions based on modeling and by contesting any decisions made under these stochastic characteristics (uncertainty).

The development of the capacity to assess information emerging from modeling, with a described range of uncertainty, and to still make decisions within this context is a task that cannot happen without effective mathematics education. Developing this capacity is also essential in a culture that often interprets “likely” as a synonym for “do I want it to happen!” I look forward to richer examples and more pointed discussion within the mathematics education community.

Notes
[1] AAKKOZZLI: chance, statistics and a new paradigm: www.aakkozzi.com Note the pronunciation of the site name is ‘acausal’.
[2] These images are simplified and adapted from Weaver (2008, p 8).

References

Now it concerns us! A reaction to Sustainable Mathematics Education

UWE GELLERT

The third millennium has come with a remarkably increased awareness of ecological dynamics triggered by the way we live on earth. Sustainability appears as a new key concept for thinking and acting. Do we need a Sustainable Mathematics Education? If so, what could Sustainable Mathematics Education look like? I will briefly comment on the not-so-altruistic nature of the sudden concern for sustainability before arguing that the political and sociological dimensions of the relationship between mathematics, technology and society are fundamental to an “ethic of mathematics for life” (Renert, 2011, p 25).

The catastrophic side effects of industrial production and increasing consumption have always been part and parcel of economic growth during the last century. The catastrophes have been more visible when abrupt, e.g. the disasters of Bhopal or Chernobyl of Fukushima, although the pollution caused continuously by major and minor raw material plants in Latin America, Africa and Asia may have caused even more damage to individuals and the environment. This destruction of life and lifeforms has not directly affected all those who have profited most from the outsourcing of the