Cornered by the Real World

A Defense of Mathematics

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> *Our answers to students' questions about the relevance of what we teach might paint mathematics into an undesirable corner.*

"When am I ever going to use this?"
"Why do we need to learn this?"

According to beginning mathematics teachers involved in a nationwide study of secondary school teacher induction (Putnam and Britton 2009), these questions, remarkably common in mathematics classrooms, are often difficult to handle. In all likelihood, providing suitable answers is a concern for experienced teachers as well. Students feel moved to ask these questions (repeatedly, in some cases), so we should carefully consider how to go about answering them. Some teachers have developed a repertoire of responses that they draw on as needed, and many instructional materials—posters, websites, extra sections in textbooks—have been designed and marketed to aid in answering such questions. One typical response is to cite a real-world context in which the mathematical content under question can be used or at least recognized. Indeed, some teachers may fear that the failure to produce such a real-world example will damage their students' motivation or perception of the relevance of mathematics.

Here I consider many of the common answers to the student question "When am I ever going to use this?" and point out ways in which students may be dissatisfied with these answers. I then suggest a change in perspective with respect to the handling of this and similar questions. In particular, I propose that, if we are not careful, the tendency to cite real-world contexts can itself be damaging to mathematics education if it traps our discipline in a corner where all learning must be justified by something in everyday life.

CATALOGUE AND CRITIQUE OF RESPONSES TO "WHEN AM I EVER GOING TO USE THIS?"

Citing a Real-World Situation

"You would use area functions like this if you were carpeting your floors."
"The ability to solve systems of equations is important when you're comparing different phone plans."

Responses of this type are perhaps the most common, but students may have several difficulties with them. First, the supplied example may be contrived and not a reflection of real life. Such a school-world disconnect is similar to the joke about scientists' attempting to help ranchers by positing a spherical cow in a frictionless field. Students are keenly aware of such detachment and may therefore consider the teacher's attempt at justification a failure.

Yet even if the example very much resembles real life, people may be unlikely to solve such problems in the "school mathematics" fashion. For example, millions of people have made decisions about phone plans, but very few, I suspect, wrote functions based on the number of minutes used per month and solved the resulting system of equations. As Lave (1988) and others have shown, people are quite capable of meeting the mathematical challenges of everyday life without appealing to techniques taught in school. Thus, by pointing to real world situations, a teacher may in fact be supplying daily evidence that people happily get by *without*

"YOU MISSED A SPOT"

using school mathematics.

Some of us take pride in our ability to generate real-life examples readily for different mathematical content, often exerting great creativity in the process. Students, however, are quite capable of matching this creativity pound for pound as they formulate ways to navigate the same situation without using the mathematical content in question. Engaging in this duel of wits and losing (even if it is only the student who thinks the teacher has lost) may result in the implication that the mathematics at hand is not useful and is merely a school formality. Such an interaction may also undercut the perception of the teacher as a legitimate guide to life outside the classroom.

Citing a Profession

"You can't become a nurse without a solid foundation in algebra."
"Engineers use this stuff all the time."

Statements of this type may be true in some sense but are nonetheless ineffectual responses to the student's question. A problem becomes apparent as soon as you place yourself in the student's shoes. Imagine that you ask, "When am I ever going to use this?" and the teacher responds by citing nursing or engineering. Now, imagine further that you are headed toward a career in business or cosmetology or anything other than nursing or engineering—the teacher's response has essentially given you an excuse to be disengaged and has implicitly communicated that the current mathematical topic is of little or no worth to you personally.

Let's consider the alternative case. Imagine that you do indeed have nursing or engineering aspirations. The fact that you asked the proverbial question, assuming you used the proverbial tone, seems to indicate that you view the current mathematical topic or activity in a negative light. The teacher's response now ties this unpleasant topic or activity directly to your desired profession, thus constructing a negative and disappointing (and, most likely, inaccurate) portrait of what a career in that field would entail.

Of course, there is a third possibility. The student asking the question may be interested in the cited profession and may also enjoy the mathematics at hand. Surely, under these circumstances, it is appropriate to link the mathematics and the career, right? We teachers must remember, however, that our communications to a student are rarely isolated—other students likely have the same question (aren't we always telling our students that others probably have the same question?). They, too, will be listening to the response, and case 1 or case 2 may apply.

Citing the Mathematics that Underlies Useful Technology

"Matrix algebra is a basis for Internet search engines."
"That cell phone you're using wouldn't exist without mathematics. Now put it away, please."

This (indirect) reasoning does imply that much of mathematics is used every day, but students will be quick to point out that they were using the Internet and cell phones before they encountered the mathematical content at hand and will be able to go on using them even if they do not learn the mathematics. At this point, we could try to turn toward an argument based on an appreciation of technological advances, but this still seems to tie the value of mathematics to something other than mathematics.

This response may also tie mathematics to such things as HTML or Latin, both of which can lead to various appreciations but need not be studied to go online successfully or to speak grammatically. Moreover, students may happily generalize from the fact that HTML and Latin are not required components of their education to the conclusion that mathematics is unnecessary as well.

Citing a Future Mathematics Class

"You'll need this stuff from algebra when you get to advanced algebra."
"This is one of the pieces that's building up to calculus."

The limitations of this category of responses are clear. In my mind, a student who is not engaged in the current mathematical activity is unlikely to change his or her outlook as a result of an appeal to more unengaging mathematics down the road. The resulting view that mathematics is just inanity building on frustrating inanity would seem to lead students, in both high school and college, to withdraw from mathematics as soon as possible.

Another logical limitation of this type of response is the question of what we tell students in their last mathematics class, on which rests the motivation and justification for prior classes.

Citing a Future Event in the Current Class

"You'll use these trig functions in the next chapter."
"This material will be on the upcoming exam."

These responses may have some power in the short term, but at what expense? Do we want mathematics to be a discipline that motivates through fear and intimidation? I hope not. I do, however, see one acceptable use of such an appeal to an upcoming event within the class, and it is an ironic one—to model to students the unacceptability of circular reasoning.

Other Responses

Often teachers respond to the question "When am I ever going to use this?" with a question of their own. For example, students could be asked whether they themselves can think of an application of the mathematics. But this response is risky, especially if some students are awaiting an opportunity to point out what they perceive to be the content's uselessness.

Alternatively, students could be asked whether they challenge other classes in a similar way (e.g., "When am I going to use Shakespeare's sonnets or the periodic table?"), but this strategy is also risky because students are just as likely to increase their skepticism of other subjects as they are to decrease their skepticism of mathematics—and I imagine that our colleagues in the other disciplines would not appreciate this increased scrutiny.

Ignoring the question is generally not a good idea. You may appear not to have an answer or, worse, not to be paying attention to the student. A final option is to state simply that the particular piece of mathematics will not be used in most people's everyday life. This (often honest) response may be appropriate, but it must be followed by some other form of justification. (This idea will be developed in the next section.)

You may have noted that, thus far, I have dealt only with the question "When am I ever going to use this?" and not the question "Why do we need to learn this?" If you had not noticed, then this oversight supports my conjecture that the two questions are often conflated. Students asking "When …" may actually be concerned with "Why …," and, when responding, teachers may assume that an answer to "Why …" must come in the form of a "When …."

This conflation is important because I believe that thinking and acting as if the justification for teaching and learning mathematics is found solely in everyday applications can be dangerous. Mathematics does not exist only to serve other professions, nor is it merely a collection of algorithms and procedures for dealing with real-world situations. Such a mind-set essentially paints our discipline into a weak and lonely corner and leaves undefended many of its greatest aspects.

WHAT IS THE ANSWER?

My purpose here is not to promote a set of definitive or "right" answers to these proverbial student questions. In fact, I am sure that such a thing does not exist—each situation in which the questions arise is unique. Rather, I hope to spur thought and reflection on an issue that is widespread in mathematics education and yet may often be below our collective consciousness. Such reflection on teachers' part is important because, as Wren (1931, 2006) wrote, "The teachers of mathematics are primarily the ones who should be able to 'sell' mathematics to the 'doubting public' " (p. 5). In this spirit of reflection, I provide some possible answers. My answers are partial and noncomprehensive, and I expect fellow colleagues to add to them.

One possible reply is to emphasize the mathematical processes that are occurring rather than the immediate content. The thought processes that characterize mathematics—problem solving, reasoning, justifying, representing, working in deductive systems, to name a few—are unavoidably useful in many aspects of life. As Kilpatrick (1983) stated, "The quality of the lives our citizens lead depends on whether they are equipped with mathematical tools for thinking about problems that confront them" (p. 306). Note that he identified the "tools for thinking," not the "problems," as mathematical. Countless benefits arise from the ability to recognize the crucial features of a problem, to uncover latent assumptions at play, to think carefully and without fallacy, to devise symbols and diagrams that aid such thinking, and to communicate clearly and precisely, all of which can be cultivated in mathematics classrooms.

This appeal to processes, however, seems to be predicated on a philosophy of instruction that incorporates reasoning and sense making (NCTM 2009). Indeed, one could argue that a conceptually focused classroom has more potential for justifying the mathematics being taught than a procedurally focused classroom, the latter being somewhat limited to the types of responses critiqued above.

In addition to the utility that mathematical thought processes have in life, Freudenthal (1991) wrote that they "have a value of their own" (p. 111). This recognition suggests a justification of mathematics via its profound beauty (to me, a beauty of the process as well as the products). Others have written extensively on this topic (e.g., Sinclair 2006), so I do not pursue it further here.

Some teachers and textbooks attempt to preempt the proverbial questions by beginning a lesson with a description of how the mathematics can be used in life or by concluding a lesson with an application to a real-life situation. Although such an anticipatory approach can work, it is subject to the same critiques that were applied to the reactionary answers, with the added concern that possible decreases in motivation could be occurring even earlier in the lesson.

A different type of preemptive approach is one built around a learning environment in which the question "When am I ever going to use this?" is not raised because (1) the students are happily engaged in learning mathematics and unlikely to challenge its purpose (e.g., students are finding intrinsic value in mathematical discovery and sense making) or (2) they have already supplied answers themselves. This approach is analogous to the notion of good lessons being an effective technique of classroom management, and, in my experience, process-oriented classrooms are more likely than content-oriented classrooms to yield these results. Unfortunately, a description of how to develop such an environment is beyond the scope of this article, although glimpses are constantly present in the pages of this journal.

Appealing to the history and mathematical achievements of humankind is another possible response, which comes to mind especially in certain situations, such as investigations involving π or introductions to calculus, and is most potent, I suspect, when the history is connected to students' own reinvention of the mathematics. This argument is distinct from the aforementioned technology-appreciation argument because, instead of focusing on mathematics appreciation as a prerequisite of certain activities, here we focus on appreciation of mathematics history as a characteristic of a responsible, respectful member of humanity. I admit, however, that this approach should be used carefully and in moderation lest our field take on the appearance of being devoid of novel discovery or merely in service of the past.

CONCLUSION

At this point, it may seem that, with respect to secondary school classrooms, I am opposed to incorporating the real world in mathematics classrooms or, worse yet, that I am a lofty mathematician up in the clouds of irrelevance. Both of these perceptions are untrue, and I can dispel the first right away (you will have to take my word on the second). I believe that the real world has an important role to play in mathematics classrooms, but the notion of teaching mathematical content followed by real-world applications is not the only possible ordering.

Instead, I believe, along with curriculum developers (e.g., Clarke, Breed, and Fraser 2004; Hirsch et al. 1995) and prominent mathematics educators (e.g., Freudenthal 1991), that the real world can be a source of rich contexts in which students engage in mathematical processes and from which mathematical ideas can grow. (This is not to say that the real world is the only source of rich contexts—sometimes mathematics itself can and should be the context.) The challenge for us is to guide students' activities so that the mathematical ends are actually attained. Otherwise, we start in the real world and never leave it, and when this happens, the power and beauty of mathematical abstraction has been lost.

Some mathematics educators may also rely on the real world because it offers a way to connect instruction to students' experiences (perhaps following Dewey [1938]). I too believe in the value of building on students' experiences, but rather than look for experience in the form of mathematical content appearing in their everyday lives, I look for experience in the form of mathematical thought processes—such as classifying, identifying patterns, and generalizing—and, most important, a desire to solve problems and make sense of the world. Students have natural abilities with respect to these mathematical ways of thinking and use them, as shown here, to point out the insufficiencies of our responses to the questions "When am I ever going to use this?" and "Why do we need to learn this?" Mathematics classrooms are an ideal place to cultivate and refine such thought processes, but we must allow our discipline the space and freedom to do so.

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