When Will I Ever Use This?
An Essay for Students Who Have Ever Asked This Question in Math Class

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The most-asked question in math class is some variation of "When am I ever going to use this?" In fact, I began typing this question into a search engine, and every one of the 10 popular completions for "when am I ever going to use . . ." dealt with school mathematics. Now, as a student, I know this question is a compelling one. Of course, some students ask it as a challenge to the teacher, using it to mean "Prove to me that I need this in my life." However, some students ask it sincerely, honestly wanting to know how it might be used in the future.

In either case, teachers most often do one of the following. One, they respond with some trite response about how you will need it next week on the exam or next year in another class. Not very compelling. Two, they give the quick reply that "if you don't know it, you will never use it" or a similar comment that, although true, is not much more satisfying than the first. Three, which is traditionally about the best a teacher can do in this situation, they try to give the students what they think students want. Either the teacher tries to tie the mathematics to some field of employment (there is a popular poster on the Internet that helps teachers with this), or they present an application of the mathematics to some area that might be interesting to the student or will at least justify the mathematical topic. If you have been in a class where this happens, you know it is rarely satisfying.

This has become a paradox that I have spent time thinking about—math is certainly useful, yet why is it so hard to explain to or show students how it can be useful to them? In this essay I analyze this paradox, and I give my response to the student question, "When am I ever going to use this?"

To start off with, let's do a thought experiment. Take a moment and think about the last time you used multiplication outside of a school environment. It might be hard, but try to remember. If you can't remember the last time, try to recall at least some time recently where you used multiplication. Think . . . Think . . . Think. Do you have situation yet? It doesn't have to be a time that you wrote down a multiplication problem or worked it out on paper. You could have done it in your head or on a calculator. If you are like me, you are having a hard time remembering a specific situation. I had a difficult time recalling a time, yet I use multiplication all the time. It is so ingrained in my thought process, I don't usually notice it. I bet that is true for most of you. I am sure that you use the idea of multiplication with its closely related mathematical cousins of finding areas, counting things in groups or arrays, scaling things up or down, or working with proportions. It has become such a natural a part of our thinking that we don't consciously think, "OK, this is a multiplication problem. How was I taught to do this in school?"

This may be the first piece of understanding this paradox. Math is useful, but the large majority of the use is done mentally and subconsciously. When you look at a graph, a number, a formula, a chart, an algorithm, a quantitative situation, or anything of the sort, you draw upon myriad mathematical connections made during the many hours spent in math classes and doing your math homework (and in other situations) to immediately make meaning (or begin making meaning) of what you are experiencing (seeing, reading, and so on). Rarely could you go back and figure out when you learned the skills, even one skill, you are using in the moment of making sense of something. It is nearly impossible to pinpoint the moments that you learned specific skills, especially those that create the schema we use to make sense of the world. The consequence is often a loss of credit to the teachers who helped students learn, simply because finding the source of the knowledge becomes nearly intractable.

Let's get back to our thought experiment. I hope by now you have a situation in which you used multiplication. When I first conducted this experiment, I thought of two instances. I used multiplication to calculate the area of a raspberry patch I was putting in my backyard so I could compare the area to some information about raspberry patches online. I also used multiplication to quickly figure out if I had picked up enough cans of cream of mushroom soup at the grocery store; I needed 24 cans, so I organized them in a four-by-six array.

Yesterday I asked a couple other people the same question. The two situations they mentioned were figuring out if a box of diapers would last through the month and seeing if a favorite baseball player would end the season with 100 RBIs if he continues at the current rate. Your situation may or may not be as idiosyncratic as these.

Now, suppose a young student asked us, "When will I ever use multiplication?" And we responded with one, or maybe even a few of these examples to justify his effort in learning multiplication. The conversation might go like this:

Student: When will I ever use multiplication?

Teacher: I used it just the other day to calculate the area of my raspberry patch.

Student: Yeah, like I am ever going to do that in my lifetime.

Teacher: Well, I had a friend who told me yesterday that he used multiplication to figure out if his favorite baseball player might get 100 RBIs by the end of the season.

Student: What the heck is an RBI? I don't even like baseball.

Teacher: You can use it when you are shopping. You could use it to figure out if the package of diapers you are considering buying will last you until your next paycheck.

Student: Diapers? Are you serious? If having kids means I will be using math, then I am not going to have kids.

Teacher: (under his breath) I knew I should have been a doctor.

OK, I am kidding about that last line, but you can see how frustrating it might be trying to convince a student by such a technique, and remember, this is about a mathematical operation that is used extensively every day by real people. Your example may have been better, but I doubt it would motivate an elementary school student to dive into his homework.

Clearly this is not the way to convince students that math is useful. I would argue that application problems do a lot more to convince students that math is NOT useful rather than the alternative. I saw this time and time again teaching college algebra as a graduate student. I would do what I thought was a reasonable job of teaching a topic, and then I would illustrate with some interesting applications. Students seemed to be with me through the first part, but when I started doing applications, I could see them saying to themselves, "Well, it looked like this might be an important topic, but if this is where it is used (biology, psychology, history, physics, and so on), I know I will never use it!" Any application problem that a teacher picks will likely be outside the interest and field of almost all students, thus providing one more piece of evidence that they will never use that mathematical topic.

I call this the *paradox of application.* This becomes the second insight into the larger paradox we are trying to understand: Applications so often involve such specific contexts that they miss the reality of almost all students.

This puts math teachers in a bind. Doing the alternative—giving no application problems—is a worse strategy for convincing students that math is useful. Teachers are forced to do the very hard work of finding or creating application problems that are general enough and compelling enough to interest all students. If you are not convinced this is difficult, try coming up with an application problem for a common topic (like solving linear equations) that would convince most students in a class that the topic is awesome and worth studying.

Connecting the Dots

In truth, the when-will-I-use-this question is unfair for the teacher. She doesn't know when *you* will (or even might) use it (except on the exam and in the next course in the sequence). She might explain how other people have used it, but, as we saw above, that response is not convincing. The difficulty in answering this question lies with an implicit assumption hidden beneath the question. The student has an idea of the kinds of situations that she will encounter in her life, and when the response from the teacher doesn't apply to any of these situations, the mathematics seems useless. But it is fraudulent to assume that we know at a moment of reflection the kinds of situations in which we might use something. Why? Because we typically don't know what we don't know.

Viewing learning from the I-KNOW-what-I-don't-know perspective is fine for certain kinds of knowledge. Trades, for example. If you want to fix air conditioners, then the things you learn in your "how to fix ACs" classes seem pertinent. You can picture yourself taking off a panel of an air conditioner and looking at components that look a lot like the pictures in your textbook. You know that you don't know how to diagnose and fix those components in the air conditioner (and moreover, you would like to learn).

But these situations are few compared with all the other instances in which we could use knowledge. In most cases, we don't know what we don't know. This makes it very hard to predict what kind of knowledge we will need at some distant time. It also makes it very hard to see how we could use knowledge that we don't have. Here are a few stories to illustrate this point.

This is a segment from Steve Job's commencement address at Stanford University [1].

> I did go to college. But I naively chose a college that was almost as expensive as Stanford, and all of my working-class parents' savings were being spent on my college tuition. After six months, I couldn't see the value in it. I had no idea what I wanted to do with my life and no idea how college was going to help me figure it out. And here I was spending all of the money my parents had saved their entire life. So I decided to drop out and trust that it would all work out OK. It was pretty scary at the time, but looking back it was one of the best decisions I ever made. The minute I dropped out I could stop taking the required classes that didn't interest me, and begin dropping in on the ones that looked interesting.
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> It wasn't all romantic. I didn't have a dorm room, so I slept on the floor in friends' rooms, I returned coke bottles for the 5¢ deposits to buy food with, and I would walk the 7 miles across town every Sunday night to get one good meal a week at the Hare Krishna temple. I loved it. And much of what I stumbled into by following my curiosity and intuition turned out to be priceless later on. Let me give you one example:
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> Reed College at that time offered perhaps the best calligraphy instruction in the country. Throughout the campus every poster, every label on every drawer, was beautifully hand calligraphed. Because I had

> dropped out and didn't have to take the normal classes, I decided to take a calligraphy class to learn how to do this. I learned about serif and san serif typefaces, about varying the amount of space between different letter combinations, about what makes great typography great. It was beautiful, historical, artistically subtle in a way that science can't capture, and I found it fascinating.
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> None of this had even a hope of any practical application in my life. But ten years later, when we were designing the first Macintosh computer, it all came back to me. And we designed it all into the Mac. It was the first computer with beautiful typography. If I had never dropped in on that single course in college, the Mac would have never had multiple typefaces or proportionally spaced fonts. And since Windows just copied the Mac, it's likely that no personal computer would have them. If I had never dropped out, I would have never dropped in on this calligraphy class, and personal computers might not have the wonderful typography that they do. Of course it was impossible to connect the dots looking forward when I was in college. But it was very, very clear looking backwards ten years later.
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> Again, you can't connect the dots looking forward; you can only connect them looking backwards. So you have to trust that the dots will somehow connect in your future. You have to trust in something — your gut, destiny, life, karma, whatever. This approach has never let me down, and it has made all the difference in my life.

A colleague of mine attended a national conference for technology teachers—those who teach courses such as cabinetmaking, auto repair, welding, multimedia production, computer animation, and so on. The keynote speaker was a medical doctor who had created the artificial lung [2]. As part of his talk, he told the teachers something he hadn't told people before. He told them the most important experience he had had that allowed him to develop the artificial lung. The teachers were amazed when he confessed that the key experience was rebuilding an old car when he was 16 years old. During that experience, he learned how the components of a car worked and how they worked together. The artificial lung, he admitted, is really just a fancy radiator.

What I find most interesting about this story is that if any of us were faced with the task of developing an artificial lung we would not think, "I know what I need to do; I need to rebuild an old car!" Similarly, if it had been you and Apple cofounder Steve Wozniak creating a computer in your parents' garage, you would not have turned to him and said, "Steve, I think one thing that we really need is for one of us to take a calligraphy class. That will really help us make our computers stand out." You cannot connect the dots forward, or, in other words, you don't (usually) know what you don't know.

What we learn—what we really learn and understand—affects our lives in ways that we don't fully realize. All of our previous knowledge, previous experience, and previous thoughts affect what we currently think. Consider this statement by the teacher S. W. Kimball, which agrees with an important point made by modern cognitive science: "Every thought that one permits through his mind leaves its trace. Thoughts are things. Our lives are governed a great deal by our thoughts."

What is learning but the gradual molding of our mind, heart, and hands by these thoughts and experiences that leave their impression and make us something better and more capable than we were before?

The Eye of the Mind

Although this happens in many ways, our current knowledge might affect us the most through what we are able to "see." What we are able to "see" has far-reaching effects on our experience in life.

I have a colleague who had a friend who was a mathematics professor. This professor had a tropical fish aquarium. The aquarium must be kept at a certain temperature for the fish to survive; so special light bulbs are used to heat the water. His light burned out, and he needed to travel to a nearby town to get a new one. During the 15-minute drive, he set up a differential equation based on the size of his aquarium to calculate the correct wattage bulb to maintain proper water temperature. He solved the differential equation by the time he got to the store, so he was able to get the right one. I could not do that, and you could probably not do that. But we didn't know enough mathematics to recognize that it is possible to find the wattage in this way. Most of us would not have seen the mathematics problem.

I know a doctor who that has a strong background in mathematics. He did not major or minor in mathematics in college, but he took a couple of calculus classes and understood the material well. He said that as a practicing physician he uses the ideas of limit, derivative, and integral every day in his work. He uses them to make sense of readings over time on patient's charts, to analyze drug concentration in the blood stream over time, and in myriad other tasks that often come up. The uses of these ideas is not the same every day, but time and time again, new situations arise in which he uses them to make sense of what is going on and to help him decide about diagnoses and treatments. These core concepts of calculus are invaluable to his work. This is not unique to this doctor. I met another doctor with a strong mathematical background, and he said a similar thing about the frequent use of the ideas of calculus in his work.

Doctors who are not fluent in these ideas do not use these valuable tools. They cannot use them, for the tools are not theirs to use. Yet, according to my doctor friend, many doctors think that taking calculus was a waste of time. When he tells them that calculus would help them to overcome some of the struggles they are having, they don't believe him because they don't see any calculus problems in their work.

Seeing isn't restricted to seeing math problems. What coaches see in a basketball game is far different than what the fans do. They see why a play does or does not work, which players' execution was most instrumental in helping the play develop, and which players are playing above or below what could reasonably be expected. Even my limited experience with basketball has raised some interesting insights, like seeing a coach cheer for a player on a two-on-one fast break—for a player who *did not* touch the ball during play. He just ran down the court. No one passed to him. He never touched the defender. His teammate with the ball dribbled past the defender and made the layup.

The coach's explanation? "My forward is not fast enough to beat that defender one-on-one; he would have had to take a bad shot, a long shot, or pulled up—I would rather have a layup than any of those. But with our other player there, the defender is in a spot. He can't just stop my forward, or he gives up the pass and an easy shot. The second player was the most important player on that play."

Of course, fans don't see this. They only see the forward make a good move on a defender (when in fact the defender was put in a very difficult position by player number two) and make a layup. No thought at all about the player who made it a two-on-one instead of a one-on-one.

When one of my sons puts on his shirt inside out and backwards, I think of the symmetry group generated by the actions on his shirt. I think of solving systems of equations and linear programming when looking at the dietary information on food packages. When I am playing on the trampoline with my kids, and we have balls on the trampoline, I think of how the paths of the balls could be modeled by hyperbolic geometry and how the model is also used in the general theory of relativity to describe the paths of light across long distances.

It doesn't go the other way. People don't stand on the trampoline and ask themselves what connections it has to hyperbolic geometry. They don't see a ball roll across a trampoline and ask if it has anything to do with the way that light travels through the universe. They don't usually think about studying concepts from abstract algebra when they see a shirt turned inside out. They can't see these connections, so the connections don't exist. Yet these are the same people who say that advanced math has no connection to real life. Well, in one way they are right: It has no connection for them because they do not know enough to see these connections.

Some of the most successful people succeeded because they worked hard, but they also spent some of their time learning. Larry H. Miller was a multimillionaire who opened multiple car dealerships in Utah, but he is mostly known as the (now-deceased) owner of the Utah Jazz NBA team. On his weekly radio interview about six years ago, as the economy was in the dumps, he started sharing facts about the United States from the time of the Revolutionary War to help set the economic downturn in perspective. This was a surprising thing coming from an NBA team owner, but it illustrates two things. First, Miller was very well read on many subjects. Second, because of this, he understood the current situation in a different manner than most people. He saw it differently because of the knowledge that he had.

Just Look It Up

This point is related to another comment (usually a complaint) in mathematics class. Math teachers (just like other teachers and professors) require students to memorize information: formulas, definitions, theorems, proofs, and so on. The common response by students is that this is a waste of time because they can look up these things. Well, they certainly can. That isn't the point I am debating. The problem is that you look up things that you know you don't know—and on top of that, you need to know fairly specifically what you don't know. This is where the problem comes—you have got to know the subject well enough that you know when you might use the item that you could look up. Without that knowledge, you won't know that there is a formula, proof, strategy, result, analysis, and so on, that can help.

This quickly leads to a great fallacy in knowledge: You don't need to learn things that you can look up. But now we can look up about anything online or in a research library like the ones on many college campuses. This leads to the quick conclusion that you don't have to learn anything. What, then, becomes of the knowledge that forms our everyday thoughts? We can think only with ideas that are already formed in our minds. That is how we make sense of what we have experienced. With those ideas only in books, websites, videos, and so on, they are not available for us to think with—not until we have digested them and made them a part of us.

Here is an experiment. Take the time to memorize a quote. Here is one I have always liked by Thomas Edison: "We often miss opportunity because it is dressed in overalls and looks like work." Memorize it by repeating it every morning and evening. Do this for two weeks, and pay attention to how many times that quote comes mind throughout the day. For the vast majority of you, it will happen multiple times. Here is the interesting part. You could have looked up the quote at any time and read it. But without memorizing it, you would have not stopped at those same occasions and thought, "I wonder if there is a quote that I could use right now." It would have never occurred to you. The quote will have come to mind because something you experienced would have connected with it. This experiment readily illustrates the fallacy of relying on the ability to look things up. Our thoughts come from what we know—not what we could know. We make sense of the world with the knowledge and beliefs in our mind, not with what we can look up on a smartphone.

Conclusion

When will you use what you are learning in your classes? I don't know. No one does. Is it worth learning even if we don't see an immediate application to something you are interested in? Probably, because most knowledge gets applied to situations we never anticipated or to situations in which we don't even realize what knowledge we are using. This is a situation in which we ask that you have a little faith in those who have gone before you and are teaching you. The ideas in this essay do not get your teachers off the hook for doing the best they can at helping you understand how the applied fields of mathematics are used. They still have a great responsibility to do that. But if they are doing their best and you are not completely satisfied, then you can use the ideas in this essay to better understand why.

It pays to learn all you can about all you can. Of course, you can't learn everything, but the more you learn, the better judge you can be of what is worth learning. Exactly how you benefit from what you learn will best be seen by connecting the dots backwards.

References

[1] Steve Jobs, Stanford University Commencement Address, Palo Alto, CA (June 2005). Text retrieved from http://news.stanford.edu/news/2005/june15/jobs-061505.html.

[2] J. Zwischenberger, Teacher-Excellence General Session Keynote, presentation given at the International Technology and Engineering Educators Association Conference, Minneapolis, MN (March 2011).