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3-D Spatial Skills for Secondary Students (Part 1)

Sheryl Sorby, Ph.D. • November 2007

Topic: Encouraging Girls in Math and Science
Practice: Teaching Spatial Skills

Highlights

- Spatial skills enable you to visualize what something looks like if the perspective shifts.
- There are significant differences in the ability to visualize rotating objects between genders; all students improve through training and practice.
- Research shows strong links between spatial skills and math performance, spatial skills and success in different careers, and spatial skills training and university-level retention rates for female students.
- One of the biggest reasons to help girls develop spatial skills is the confidence this will give them when they get further on in technology and math course.

About the Interviewee

Dr. Sheryl Sorby is currently serving as a Program Director within the Division of Undergraduate Education at the National Science Foundation. She is a Professor of Civil and Environmental Engineering at

Michigan Technological University. Dr. Sorby is the former Associate Dean for Academic Programs and the former Department Chair of Engineering Fundamentals at Michigan Tech. Her research interests include graphics and visualization. She was the recipient of the Betty Vetter research award through the Women in Engineering Program Advocates Network (WEPAN) for her work in improving the success of women engineering students. She has also been a leader in developing first-year engineering and the Enterprise program at Michigan Tech. She is the author of numerous publications and several textbooks. Dr. Sorby currently serves as an Associate Editor for ASEE's new online journal, *Advances in Engineering Education*.

Full Transcript

My name is Sheryl Sorby. My title is Professor of Civil and Environmental Engineering at Michigan Technological University. Spatial skills are those parts of your brain that enable you to visualize what something looks like if you rotate it in space or, if you're standing someplace, what something looks like over there or imagine the path you're going to go down as you're traveling somewhere.

Spatial skills are part of your—what Gardner calls your "Intelligences" are your spatial skills, and they enable you to maneuver within your—the world around you, basically. The spatial skills are very important, but they're sometimes neglected in the education of the students as they come through.

Engineering is one of the fields where spatial skills are the most important, because engineers are typically designing things that have never been before. And so in order to design something, you have to think in your mind what this will look like. And if you don't have well-developed spatial skills, then you can't figure out what something should look like.

So, for example, a civil engineer is designing a bridge. Well, they have to be able to imagine how far this is going, what the approaches are going to look like so that you don't have a big bump when you go on and when you get off. And they have to imagine how much clearance you're going to need for trucks. All of those things are related to the space around that bridge, and the engineer has to think about all of those things.

There are a lot of studies out there that look at gender differences and spatial skills. And what we've found is that at the university level and certainly—maybe in the high school level, the gender differences on rotation are pronounced. The gender differences on tasks like imagining what something looks like as it's folded up is not as pronounced. And, in fact, in some cases, we've found that the female students outperform the male students.

So it's mostly in the area of rotation, mental rotation. And the reason that that's important is that mental rotation is also the most important skill for success in engineering and, say, technology. And so even though girls usually have well-developed spatial skills in some areas, they might not have well-developed rotational skill.

So mental rotation is the ability to imagine what something would look like if you rotate it in space. Or if you yourself rotated around it. So if I was going to stand at one angle of this chair and I would be able to imagine what it would look like if I was standing from another angle. Or if somebody were to take this chair and rotate it in space, I would image what it looks like from that direction.

Now, most students—and including women and men—can imagine very well what something looks like if it's an object they're familiar with. So if I asked you, "What does this chair look like if I rotate in space?" No one would have a problem with that, because they know what a chair is and they know what a chair looks like from all different vantage points. But if it's a part or a system that's unfamiliar to you, which is the case if you're designing something new in engineering, and you try to imagine rotating that in space, that's where you have difficulty—if it's an unfamiliar object.

The gender difference persists across several age levels. There are a lot of reasons why people think that the boys have better developed spatial skills than the girls, or rotational skills than the girls. Things that—playing with Legos and Tinkertoys and those kinds of activities have been shown to help people develop their spatial skills, and if you look at the— the girls tend to play with those toys less than the boys, and so they have less ability to develop their 3-D spatial skills.

If you've ever looked at the pattern for a Lego, it shows you. You need these pieces and they all fit together in this way. And just practicing that and doing that helps you develop your 3-D spatial skills. And if girls haven't done those kinds of things, they haven't then developed their 3-D rotational skills.

I think that this spatial skills training should be taking place in the middle school grades or in high school certainly, if not—I think it could even be started in the elementary grades, easily. And I think that students have responded. We've done some testing with students in middle school and high school, and they have been able to show significant improvements in their spatial skills through some training and practice.

Spatial skills is part of the math national standards. It's not always tested in the high-stakes tests in the states. It's not always tested on the ACT or SAT, but certainly it should be incorporated, perhaps in a high school geometry class or maybe even a high school algebra class.

Another area that you could use—another area in the K-12 curriculum that could benefit from some spatial skills training is in technology classes, because engineers and technologists typically communicate with one another through drawings. So if you can't communicate through drawings, then you're kind of at a disadvantage in talking to other people about your designs.

There's research out there that shows a strong link between well-developed spatial skills and math performance. So, for example, at my university we've found that students who have high spatial skills, typically have high ACT skills—ACT math scores. And so the link has been well established between math, I think, and spatial skills. And so if you help students improve their spatial skills, perhaps then you're helping them be more successful in their later on math courses.

At our university, we've also found though that there could be a link between the spatial skills and things like computer science, physics. Other people have found links between spatial skills and chemistry performance. And so there's a lot of other courses that could benefit from some spatial skills training. And most of those are science, math, technology, engineering, those kids of courses.

If we look at our university students for the girls—or the women, I should say—the retention rate is about 50 percent for the women who have weak spatial skills and did not develop them, versus about 80 percent for the girls who actually went through some spatial skills training and improved their spatial skills. And I'm not sure if it was all their spatial skills training or they felt more confident because when they got to their next classes, the next class, they understood what they were looking at. Again, engineering professors tend to communicate always by drawing pictures. If you don't understand the pictures, you're not going to understand what the professor's talking about. And so what we found is helping these students improve their spatial skills, improved their success rate in engineering. It didn't necessarily improve all their grades, but it improved their willingness to stick it out and become engineers and become successful in the technological field later on.

The biggest reason to help girls develop their spatial skills is just their feeling of confidence when they get into their follow on technology, math courses. I always tell the story about when I was a freshman at the university, majoring in engineering, you know. I had 97 percent on the chemistry test; I had 95 percent on the calculus test, and I took my first engineering graphics course, which is very spatially oriented, and it was the first time in my entire life I had struggled with a subject. I couldn't figure out why this line was there, why this line was dashed, this line was solid, and why was this—why did this look like this? It was very discouraging for me, especially because most of the male students in my class were like, "Oh, this is really easy. This is the easiest class I'm taking." And for me it was the most difficult.

And so I think just to feel confident that you can go out and do these problems, you need to have well-developed spatial skills. And that's part of the reason that I got into this area. When I was teaching graphics later in life, I noticed that a lot of the young women in my class would be very discouraged. They'd say, "I can't understand this." They were all excellent students in high school, and they got to their graphics class, and they couldn't understand it. And so their first response was always, "I need to change majors and drop out of engineering." And I was always working with them saying, "No, no, no, no—you can do this. I did it. You can do this." And so I think that, just from a self confidence point of view, having girls with well-developed spatial skills is really important to their success, especially in engineering and technology and the other science fields.

There have been a lot of studies through the years about spatial skills and their link to success in different careers. And there's a lot of, you know, medicine, dental work, computer science, engineering, technology, mathematics, physics—all of these fields require well-developed spatial skills, you know. I met with somebody doing research on—he was doing research on laparoscopic instruments. Those are the cameras

that the doctors put inside of you now so they don't have to do surgery and open you up. And if you think about it, you have to have very well-developed spatial skills to operate that, to know which way you're going to turn. If you get to the stomach, "Do I turn right or do I turn left to see what I want to see." And he found that he was trying to train doctors how to use this equipment, which is actually very advanced and it's helped medicine by leaps and bounds. And he found that the people with well-developed spatial skills learned how to use this equipment better than the people with poorly developed spatial skills. And so, even though maybe in a general case, a doctor doesn't need well-developed spatial skills, in some cases they do. And in fact, if they're looking at an xray, you want them to know what they're looking at. And so spatial skills are important, not just for engineering, but for all kinds of technical fields. And I think they've not been formally taught in a systematic way across the country. And that's, I think, one of the things that needs to change.