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Hands-On Activities for 3-D Spatial Skills (Part 2)

Sheryl Sorby, Ph.D. • November 2007

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

Highlights

- One important component of spatial skills is the ability to mentally rotate an object.
- Teachers can help students gain this ability by having them start by visualizing an object rotating around each of the three axes one at a time.
- To help students remember which direction of rotation is positive and which is negative, teachers can use the "right hand rule," explaining that direction their fingers curl relative to their thumb is positive.

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

Spatial skills that students should be developing is their ability to mentally rotate objects, and so we spent a lot of time talking about how to rotate an object, how to think about rotating an object in our spatial skills training class. And what we usually start out talking about is that you have an object here and you have to think—and you've got three coordinate axes listed here. And you want to think about rotating that object about each one of these axes, and as you rotate this object about the various axes, you're going to get different views of that object. So if you start with the object here and you rotate it about this axis right here—if you think about the way an object rotates, it rotates like this in space. And so for this particular object, if it rotates about the—what I'm going to call the X-axis, it kind of falls forward and it ends up looking like this.

If however, you start with the same—the original object and instead of rotating about this X-axis, you rotate it about the Y-axis—the vertical axis here—in this way, you'll end up with a view of it looking like this instead. And if you go back to the original object and you think about rotating about this axis here—the Z-axis, you think about—it kind of falls backwards that way, and this is, then, what you end up with as your view of that object.

So you can see that we started with the same object, and depending upon which axis we chose to rotate about, we got three entirely different views of that object. And that's what you want the students to understand is that they need to be able to think about what this would look like if I rotate it about one of these axes or about both of these axes.

Now, in order to make our lives easier—in math and in science and in engineering and in those kinds of fields, we talk about positive and negative rotations. So a positive rotation is if you think about it, if you were looking down the particular axis and it was counterclockwise, that would be a positive rotation. If it was clockwise, it would be a negative rotation.

So here we have an object that starts out looking like this, we're going to rotate—if we rotate it in a positive direction about this particular axis, you would end up with an object that looks like this one right here. Now if you think about looking down this axis, that is a counterclockwise rotation about that axis. If you think about a negative rotation, which is a clockwise rotation and you take this original object, it would end up looking like this. And now again, you're looking down that axis and it's going clockwise in this case, and that

is a negative rotation.

One of the things that we use in engineering and in science and math a lot is the right hand rule to describe rotations, rather than the clockwise and counterclockwise rotation I just talked about. A positive rotation—for a positive rotation, you imagine that you put your thumb down the axis of interest. And your fingers will curl in the direction of that positive turn. This is called the right hand rule. So you put the thumb of your right hand down the axis, your fingers curl in the direction of the rotation—that's the right hand rule. Notice that if you look at this—if you think about the axis coming straight out at you and you curl your fingers—that is, indeed, a counterclockwise rotation about the axis. But being able to use it with your right hand is sometimes easier for students to visualize what that looks like. And, of course, if it's negative, your hands are going to curl in the other—your fingers will curl in the other direction.

So I have a problem here that we're going to work on. We're going to do a couple rotation problems. Here we have an axis shown like this. We have our object built like this. And now we want to do a negative, 90 degree rotation about the axis that's shown. So if we want to do a negative, 90 degree rotation—again, we're going to point the thumb of our right hand down the negative part of that axis, curl our fingers in that direction, so this object is going to fall over this way when we do a negative, 90 degree rotation about that particular axis. So after I've rotated that in space, what does this object look like? Well, it's going to look like this. We sketch it…so that's what the object looks like after it has been rotated about this axis by a minus 90 degrees.

Here we have an object that we want to rotate a positive 180 degrees. Again, I have the object built out of blocks here. You can see I've got it lined up kind of along the axis. I'm going to point my thumb down the positive direction, now, of that axis, and I'm going to curl my fingers in this direction, and it's going to rotate 90 degrees and then 180 degrees. And so now I would have students sketch what this looks like after it's been rotated in space 180 degrees. Start with the back surface here…and so that would be the answer to that particular problem.

Then we have a number of problems that we work where students have to rotate first about one axis and then the other, but these are the simplest ones, and that's what we've started with.