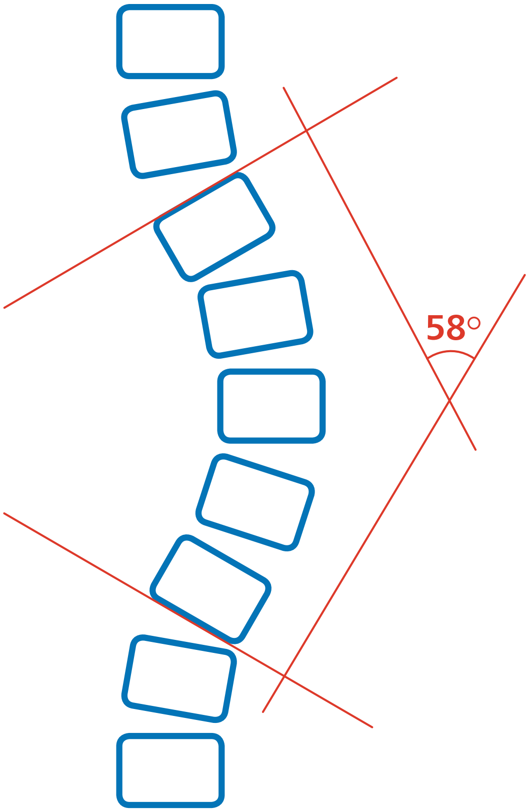
Terri L. Kurz, H. Bahadir Yanik, and Mi Yeon Lee

The geometry of scoliosis



Science and mathematics often go hand-in-hand. Using scoliosis as a context, intermediate elementary school students can explore how geometry, specifically angle measurement, plays an important role in recognizing the extent of a person's spine curvature. According to Hresko (2013), scoliosis is a medical condition caused by the curvature of the spine; it is the most common spine deformity. Few (1.6 percent) of high school students have a spine that does *not* curve and is completely symmetrical; curvature is actually common. Because most people have some curvature of the spine, scoliosis is specifically defined as "a lateral curvature of the spine that is 10 degrees or greater on a coronal radiographic image while the patient is in a standing position" (p. 834).

In the United States, schools often screen for scoliosis starting in elementary school and sometimes continuing through high school. Children are asked to bend over with their arms hanging down and palms together as their backs are examined for curvatures. If a curvature is suspected, children are referred to a medical doctor for further tests. Scoliosis is relatively common and affects about 1–3 percent of children who are age 10–16 (Weinstein et al. 2008).

With the frequency of scoliosis screenings in schools and its recognition as the most common kind of spine deformity, the topic is familiar enough to integrate into a STEM lesson. In this lesson, intermediate elementary school students will devise a strategy to measure the curvature of the spine of people who are diagnosed with the condition. Students will play the role of a scientist and examine x-rays of patients with scoliosis to try to determine a systematic way of measuring the curvature.

Measuring idiopathic scoliosis

To begin the lesson, the teacher might explain what scoliosis is and review data on the commonality of the deformity. Most cases of scoliosis are idiopathic (i.e., the cause is unknown). Different types of curves exist, for example, a C-shape curve or an S-shape curve. The website http://www.orthopediatrics.com/docs/Guides/scoloisis.html provides a nice overview to share with students. Other images of spines could also be shown to the whole class.

Explain to students that they will play the role of medical scientists and try to develop a method to measure the curvature of the spine. Supply the class with various x-ray printouts of spine curvatures. (A Google Images search of *scoliosis x-ray pictures or images* yields various curvatures. Do not print any images with the curvature measured or marked, as it would influence students' techniques.) Students should have protractors and straightedges too.

Be sure to remind students that they are acting

as a medical scientist would act and should remain professional. Students should be considerate of others, making sure that they stay courteous and respectful of the spinal conditions they will see. A doctor will always treat his or her patients' lab work with civility. Teachers should be aware of the possibility that a student in the classroom has scoliosis. This behavioral review may be necessary to prevent students from using inappropriate terms in describing the spine curvatures.

Group work

How can doctors measure someone's spine so that the severity of its curve can be determined? We suggest having your students, working in groups of about three, try to develop a method for measuring spine curvature using a protractor and straightedge. A variety of approaches could measure spine curvatures. The important aspect of this part of the lesson is that students develop a procedure that will work all the time and can be taught easily to others. It may be helpful to supply all groups with about five images of C-shape curves; S-shape curves may be too difficult to measure because they have two different angles to the curvature. To support future discussions, label the images (image 1, image 2, image 3, etc.) and supply all the groups with the same images. Students should develop a step-by-step procedure for determining the curvature of the spine.

Discussion

Have groups share their methods for measuring curvature with the whole class and explain their steps for determining spine curvature. Ask questions:

- Did any of the groups have similar methods?
- Which group has a different method to share?
- What did you find out?
- Which method is the most effective to measure spines that are more curved?
- Did the spines that looked as if the curvature was large actually measure to have a large curvature?

Connecting to science

Next, have students investigate the Cobb method online. First coined by John Cobb, this method is the most commonly used way of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Find a detailed explanation of the Cobb method at the University of Washington's Department of Radiology: http://www.rad.washington.edu/academics/academic-sections/msk/teaching-materials/online-musculoskeletal-radiology-book /scoliosis

measuring spine curvature (Tanure et al. 2010) and uses a protractor and pencil. When measuring with the Cobb method, the upper and lower limits of the curve—based on the vertebra—are extended to form lines. Then the perpendiculars of those lines are drawn. The angle formed by the perpendiculars defines the degree of curvature for the scoliosis patient. How does the radiographic assessment method described on the website compare to the Cobb method?

Using the Cobb method, students should then remeasure the images that you provided during group work. You could also supply some S-shape curves and have students use the Cobb method to determine the angle measurement for both curves. Some discussion questions could include the following:

- When you used the Cobb method, did the calculated angle measure across the groups have uniformity? Explain.
- When trained orthopedic surgeons manually evaluated spinal curvature using the Cobb method, the range of variation was 3.5 degrees to 7.2 degrees (Wu et al. 2014). So, even trained surgeons have discrepancies in their evaluation of spines. Were your discrepancies across groups similar? Explain.

As an extension, have student groups discuss measurement discrepancies and why mathematical precision is crucial to an accurate medical diagnosis.

(Wu et al. 2014 is available online if students or teachers are interested in reading the findings; see the reference list.)

- What might account for discrepancies if some exist? For example, potential exists for human error, or the perceived start and end points of the curve may be open to interpretation.
- In the medical profession, why is uniformity so important when developing procedures for diagnosis? Will some error always exist, for instance, even when a computer program does the evaluation? Explain.
- Computer software (called SurgimapSpine) evaluated the same spinal curvatures as the orthopedic surgeons. The variation was 3.2 degrees to 6.1 degrees (Wu et al. 2014). Does this surprise you? Explain what these data mean.
- When would it be economically sound to purchase the computer software? Explain your reasoning.

The angle of curvature is important; it determines how a doctor will treat the patient. For example, a curvature measuring greater than 45 degrees probably requires surgery (no uniformity exists in deciding when surgery is the best option), and curvatures measuring 25–45 degrees require a brace (Hresko 2013). Curvatures of lesser degrees may require monitoring only.

Evaluating measurement uniformity and discrepancies

This lesson offers students a chance to explore geometry within the context of science with an emphasis on scoliosis. Through engaging in the activity, students find opportunities to identify and draw angles to explore the curvature of a spine using tools like a straightedge and protractor. The activity encourages students to develop a variety of ways to draw angles and compare the angles they find with the Cobb method to check the range of variation. It also provides a fruitful learning environment in which students find opportunities to discuss possible sources of discrepancies in their angle measures. Through this activity, students may come to understand that measurements may have some discrepancies. However, evaluating how discrepancies would affect medical professionals' decisions is important, and measurement uniformity is necessary. For example, in measuring angles, if people use different scales (nonstandard units) to measure angles, they cannot communicate effectively with one another. Also, using an inaccurate method (e.g., failing to place the protractor so that the vertex of the angle is at a zero point of the protractor, failing to align the protractor so that the vertex of the angle is at a zero point or one side of the angle goes through a zero point on the scale) to measure the angles could produce measurement errors that would influence a doctor's diagnosis and treatment.

This hands-on experience presents students with an opportunity to see how mathematics is embedded in medical science and how important it is for enabling doctors to make appropriate medical diagnoses. Participating in such an activity would also help students realize that geometry is not only a course that they encounter in school but also a useful tool to inform people about their health.

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Terri L. Kurz, **terri.kurz@asu.edu**, an associate professor at Arizona State University at the Polytechnic campus in Mesa, Arizona, is interested in using tools and technology to support learning in mathematics. **H. Bahadir Yanik**, **hbyanik@anadolu.edu.tr**, an associate professor in the mathematics education program in the Department of Elementary Education at Anadolu University in Eskisehir, Turkey, is interested in modeling and STEM education. **Mi Yeon Lee**, **mlee115@asu.edu**, an assistant professor of mathematics education at Arizona State University, teaches mathematics content and elementary mathematics methods courses. She is interested in preservice elementary teacher education, algebraic reasoning, project-based learning, and the use of technology in math education. Edited by **Jorge Garcia**, **Jorge.garcia@csuci.edu**, who teaches at California State University Channel Islands.
