Helping Radiography Students Learn Spatial Resolution and Distortion

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Spatial resolution and distortion are important concepts for radiography students to learn. Spatial resolution refers to the accuracy and sharpness of anatomic structural lines.[1] It is measured in line pairs per millimeter (lp/mm) and is affected by several factors including focal spot size, source-to-image distance, and object-to-image distance.[1]

Distortion is a misrepresentation of the size and shape of an anatomic part. Magnification, also termed *size distortion*, refers to an increase in an object's image size compared with its actual size.[1] Some magnification is always present on radiographs.[1] Changes in source-to-image distance and object-to-image distance affect the degree of magnification. Shape distortion includes elongation and foreshortening.[1] Elongation occurs when an anatomic part appears longer than its actual size due to misalignment between the x-ray beam and the anatomic part. Foreshortening occurs when an anatomic part appears shorter than its actual size due to misalignment between the central ray and the anatomic part or the image receptor.

Spatial resolution and distortion can be challenging concepts in the radiography curriculum. Students must learn a substantial amount of content related to spatial resolution and distortion because multiple factors affect each. Students must understand these concepts to demonstrate clinical competencies and successfully complete their educational program. Research demonstrates many students prefer visual and kinesthetic learning methods.[2,3] A hands-on activity, such as a flashlight demonstration, is an effective tool for these students.[2,3]

Hands-On Activity

An assignment using 1 large and 1 small flashlight, a pad of sticky notes, and an image receptor (or another flat surface) can help students improve their understanding (see **Box**). The author incorporated the assignment into a first-year image evaluation and technical skills course. The instructional unit included content related to spatial resolution and distortion. During class, the instructor distributed the materials, reviewed the instructions, and paired students together. Each pair of students then worked through the assignment and answered the questions. The instructor was available to answer students' questions. Afterwards, students submitted the assignment to the course learning management system. When grading, the instructor provided correcting and clarifying explanations, as needed.

The assignment helped students demonstrate and learn these concepts[1]:

- as object-to-image distance increases, unsharpness (ie, blur) increases, magnification increases, and spatial resolution decreases (see **Figure 1**)
- as source-to-image distance decreases, unsharpness increases, magnification increases, and spatial resolution decreases

Box

Instructions for Hands-On Activity for Spatial Resolution and Distortion

Learning Goal:

Students will correctly demonstrate the effect of various factors on spatial resolution and magnification.

Activity A

1. Place the pad of sticky notes on the image receptor. Turn on the small or large flashlight and hold it approximately 12 inches above the image receptor. Note the sharpness of the pad's edges.
2. Slowly move the pad closer to the flashlight. Note the sharpness of the pad's edges. Also, note the size of the pad's shadow on the image receptor.
3. What did you learn regarding the effect of the object-to-image receptor distance on spatial resolution, unsharpness (ie, blur), and size distortion?

Activity B

1. Place the pad of sticky notes on the image receptor. Turn on the small or large flashlight and hold it approximately 12 inches above the image receptor. Note the sharpness of the pad's edges.
2. Slowly move the flashlight closer to the image receptor. Note the sharpness of the pad's edges.
3. What did you learn regarding the effect of source-to-image-receptor distance on spatial resolution and unsharpness (ie, blur)?

Activity C

1. Hold the pad of sticky notes approximately 1 inch above the tabletop. Turn on the large flashlight and hold it approximately 6 to 8 inches above the image receptor. Note the sharpness of the pad's edges.
2. Now turn on the small flashlight and hold it approximately 6 to 8 inches above the image receptor. Note the sharpness of the pad's edges.
3. What did you learn regarding the effect of focal spot size on spatial resolution and unsharpness?

Activity D

1. Hold the pad of sticky notes 1 to 2 inches above the tabletop. Turn on the small flashlight and hold it approximately 6 inches above the pad.
2. Tilt the pad at an angle. What do you observe? Which Unit 3 concept is demonstrated?

Activity E

1. Hold the pad of sticky notes 1 to 2 inches above the tabletop. Turn on the small flashlight and hold it approximately 6 inches above the pad.
2. Tilt the flashlight at an angle to the pad. What do you observe? Which Unit 3 concept is demonstrated?

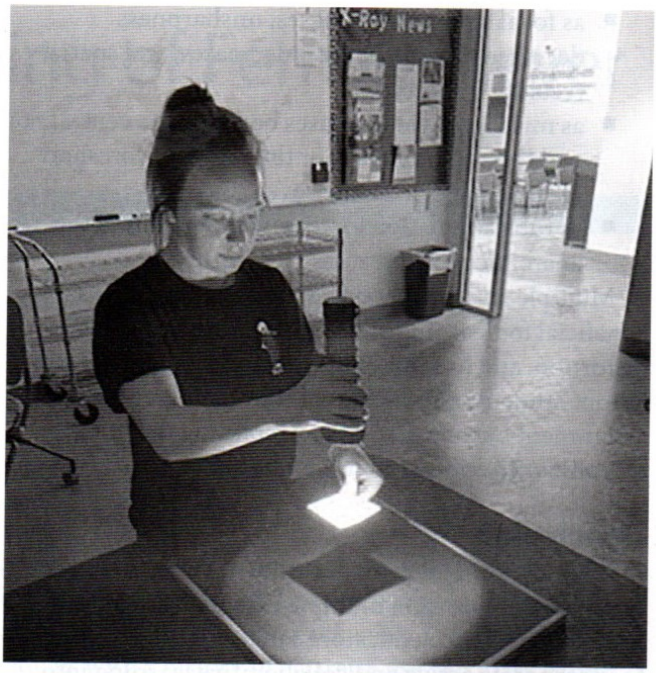

Figure 1. *A student investigates the effect of object-to-image distance on spatial resolution and distortion using a flashlight and note pad. Photograph courtesy of the author.*

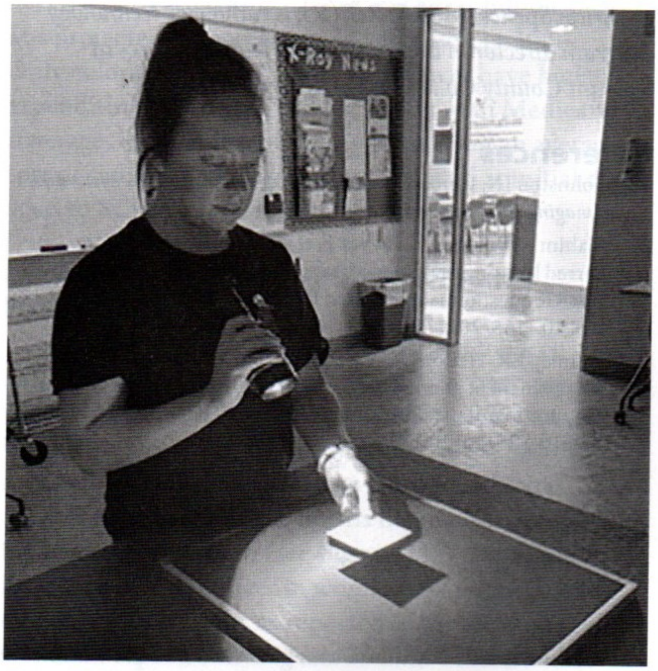

Figure 2. *A student investigates the effect of increasing tube angulation using a flashlight and note pad, demonstrating elongation of the object to be imaged. Photograph courtesy of the author.*

- as focal spot size decreases, unsharpness decreases, magnification decreases, and spatial resolution increases
- as misalignment increases between the central ray and the anatomic part or the receptor, foreshortening of the part increases
- as tube angulation increases, elongation of the anatomic part increases (see **Figure 2**)

Multiple students reported the assignment was beneficial for learning about spatial resolution and distortion, and how magnification affects spatial resolution. Students also liked that they could repeat the assignment outside of class (by replacing the image receptor with another item such as a table).

Conclusion

This assignment provides students with an opportunity to demonstrate multiple essential concepts. Radiologic science educators can use this assignment to incorporate active and collaborative learning into the curriculum.

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References

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