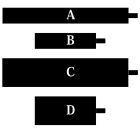




Student Difficulties with Understanding the Relationship Between Aperture and Resolution

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ABSTRACT: As part of the NITARP program, students and educators routinely make use of a wide range of observational instruments at various wavelengths. A critical concept required to make full use of the data provided by a telescope is the qualitative relationship between aperture and resolution. Informal evidence suggests a number of misconceptions related to a functional understanding of this relationship. These misconceptions were identified through the administration of a pre-test and addressed through a tutorial-type intervention. Following the tutorial students were more likely to attribute differences in telescope resolution in terms of the apertures of the telescopes.

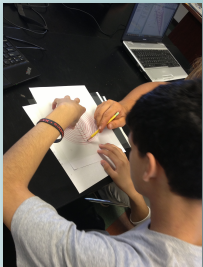
Telescope Resolution - Pretest
 Circle the letter of the telescope in the figure on the right that has the greatest resolution. Explain your reasoning.

 1. Which telescope will provide the highest angular resolution? Explain how you can tell. If you cannot determine, state so explicitly.
 2. Circle the telescope in which the greatest distance in the range of focus is a very fine detail. With each telescope having identical magnification, which one will provide the most detail? Explain how you can tell. If you cannot determine, state so explicitly.

Pre - Intervention

Pre-Test on Resolution and Brightness (n=15)	Brightness of a Distant Source	Detail of a Distant Source
Correct Answer Based on Aperture	10 (67%)	2 (13%)
Incorrect Answer Based on Aperture	0 (0%)	3 (20%)
Incorrect Answer Based on Focal Length	4 (27%)	6 (40%)
Answer Based on Other Reasoning	1 (6%)	4 (27%)

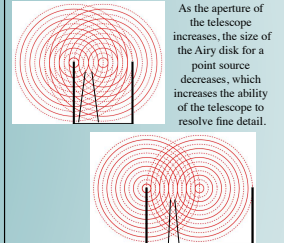
Sample Student Responses:

Aperture:
 "C, D, A, B. C and D have equally detailed images because the width is the same. Wider widths provide more focus and a range of detail the longer/thinner telescopes cannot."
Focal Length:
 "C = A, D = B because the focal length will give us a more precise image."




Intervention

Students in the course were given the pretest shown above. Following the pretest, students applied Huygen's Principle to investigate the qualitative behavior of the size of the Airy Disk for point sources in a telescope with diffraction limited optics. Students used materials to investigate how the Airy Disk changes as a result of altering the aperture, focal length, and wavelength. Students were then given a series of follow up questions on the midterm which attempted to measure any increase in student understanding.



Post - Intervention

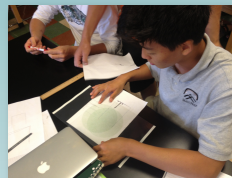
[10 pts] The images below show the view of Saturn at the same magnification through two different refracting telescopes under the same conditions. Describe the difference you observe in the images.

 1. Which telescope has the larger aperture? Explain how you can tell. If you cannot determine, state so explicitly.
 2. Which telescope has the larger focal length? Explain how you can tell. If you cannot determine, state so explicitly.

Post-Test on Resolution (n=15)	Detail of a Distant Source
Correct Answer Based on Aperture	9 (60%)
Incorrect Answer Based on Aperture	4 (27%)
Incorrect Answer Based on Focal Length	2 (13%)

Sample Student Responses:

Aperture:
 "The less blurry one has the bigger aperture because aperture is the size of the lens and it deals with resolving power and how much detail will be shown, so bigger aperture means clearer photos."
Focal Length:
 "We cannot tell which image has a larger focal length. Both pictures of Saturn appear to have the same field of view. We cannot tell by looking at these pictures which one was taken with a larger focal length."

CONCLUSION: Student performance on questions related to telescope resolution increased following a hands-on lesson targeting misconceptions. More students were able to use correct, reasoning based on aperture and significantly fewer students described changes in resolution in terms of focal length.



Student Background:
 ✓ Small (n=16) sample from a year-long high school astronomy course.
 ✓ 25% had prior physics/astronomy exposure.
 ✓ Students had previously been introduced to Dawes' Limit in lecture.



We gratefully acknowledge funding via NASA Astrophysics Data Program funds and NASA/IPAC Archive Outreach funds.