Scopes for Schools

A program of public outreach, curriculum development, and teacher professional development in astronomy at Vanderbilt University

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1 What is the *Scopes for Schools* program?

The *Scopes for Schools* program is a low-cost, field-tested model for astronomers to conduct outreach, curriculum development, and teacher professional development in astronomy. The program is aimed at girls, minorities, and other under-served students, with an emphasis on curriculum- and professional-development for teachers. Teacher participants benefit from inservice workshops which enhance astronomy content, and pedagogical content, knowledge; curriculum materials and hardware (telescopes and CCD cameras) for bringing hands-on astronomy to the classroom; and a long-term partnership with experts for ongoing curriculum and pedagogical development. Student participants benefit from astronomy activities that are inquiry- and standards-based, and from a hands-on experience building and using telescopes and digital cameras.

Teacher professional development: *Scopes for Schools* provides an inservice workshop for all participating teachers. This workshop exposes teachers to newly developed inquiry-based, standards-based, age-appropriate classroom activities for astronomy. Teachers also learn how to use reference texts and sky software, and learn how to make observations with telescopes like those they will eventually build. Teachers receive memberships in the Astronomical Society of the Pacific as a way of connecting them to a larger pool of teaching and support resources.

Telescope building: Working in teams, participating students construct 4.5-inch and 6-inch Dobsonian telescopes. Students learn about basic optics and develop a sense of ownership over "their" telescopes. Students learn how to plan sky observations (via software) and how to use their telescopes in the field to conduct night-time "star parties" as outreach for the community. Students also construct simple CCD cameras, allowing them to collect digital images and, if desired, to carry out AAVSO-style research projects.

3 Program assessment and evaluation

Classroom Observations

Time-Series Data for evaluating student engagement:
Data will be taken by an on-site observer of each student every ten minutes throughout the two-day activity (1) to determine the extent to which students are engaged in the telescope building activity and (2) to determine whether there exist gender-differences in engagement.

Field-Notes & Video-Taping for evaluating instructional strategies:
On-site and video-tape observations of the same sessions will be used to look for inequities and missed instructional opportunities to involve under-represented groups-particularly girls and minorities. These data will be used to inform current and future instructional practice.

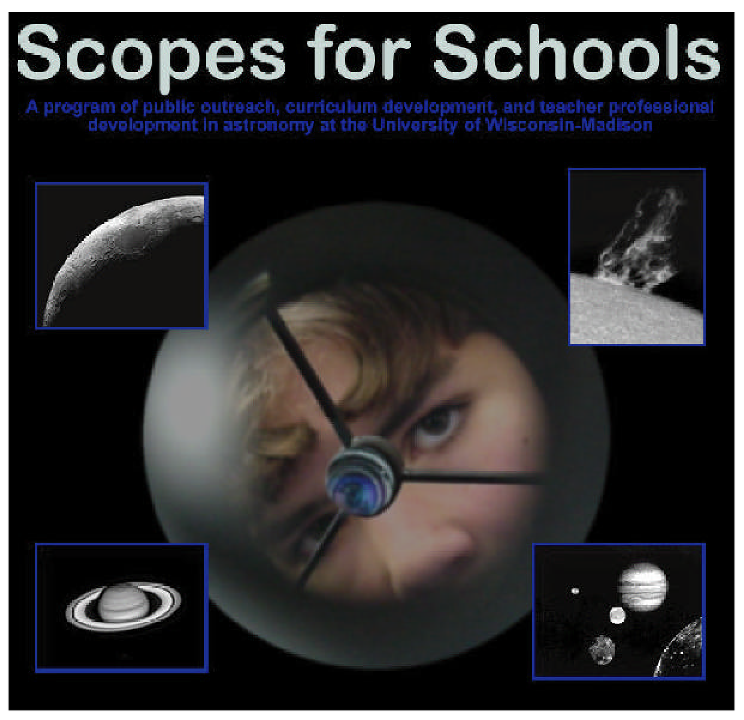
Student Interviews

Focus-Group Interviews for evaluating student perceptions of learning gains:
Post-activity interviews will be conducted, and video-taped, with all students asking them about components of the activity that helped them understand how telescopes work and how components of the activity increased their perceptions of themselves as scientists.

Teacher Surveys

Likert-Scale Surveys for evaluating teacher expectations and learning gains:
Pre- and post-workshop surveys will be administered to ensure teacher expectations and the workshop are well aligned. These data will also be used to make changes in the workshop to increase teacher-perception of their ability to use telescopes with their students.

4 Program dissemination



Benefits for Teachers:

- workshops which enhance astronomy content, and pedagogical content, knowledge
- curriculum materials (classroom activities) and hardware (telescopes and digital cameras) for bringing hands-on astronomy to the classroom
- long-term partnership with scientists for ongoing curriculum and pedagogical development

Benefits for Students:

- hands-on experience building and using telescopes and digital cameras
- astronomy activities that are inquiry - and standards-based
- individual research projects
- "star parties" as student-led public outreach for the community
- exposure to inquiry-based science for under-represented and under-served students

To learn more, contact Dr. Keivan Stassun (email: keivan@astro.wisc.edu) or visit our website: www.astro.wisc.edu/~keivan/scopes

Students constructing a Scopes for Schools 6-inch Dobsonian telescope.

Students participating in a Scopes for Schools activity to measure the rotation period of the Sun.

2 Curriculum development: A guided inquiry activity: Image formation by a telescope's mirror

Activity Summary

Given a light bulb on a flexible stand, a parabolic telescope mirror, and a white cardboard screen, students are presented with the challenge of manipulating these objects to "find the image of the light bulb formed by the mirror and project it onto the screen". Flat mirrors are subsequently introduced to gradually add complexity and to simulate the function of the telescope's secondary mirror. The students have previously been introduced to the concept of how mirrors "bounce" light with a demonstration involving a cut-away telescope and laser, which allows them to directly observe the path of a light beam through the telescope.

Activity Goals

Concrete goal: Students learn how light travels through a telescope and how the parts of a telescope function

Cognitive goal: Students explore their conceptions about how light propagates, how light interacts with matter, and how we see

Motivation: National Science Standards and Benchmarks

Benchmarks for Science Literacy, The Physical Setting, Grades 6-8, 4F
"Something can be 'seen' when light waves emitted or reflected by it enter the eye - just as something can be 'heard' when sound waves enter the ear."

Benchmarks for Science Literacy, The Nature of Science, Grades 6-8, 1B
"If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations."

National Science Education Standards, K-4 Science Content Standard
"Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object."

National Science Education Standards, 5-8 Science Content Standard
"Light interacts with matter by transmission (including refraction). To see an object, light emitted by or scattered from that object must enter the eye."

What do students already know about light and mirrors? Known misconceptions from the literature:

Light is identified with its source, by its effects, or the state of an object. Between ages 10 and 14, students develop some concept that light travels through space and bounces off objects, but they often revert to earlier models to describe how light and vision interact. Often the notion that light "travels" long distances, as from astronomical objects, is disconnected from how light moves from nearby sources (Guesne 1984).

We address this misconception in the following ways:
1) A cut-away telescope with laser illustrates the concept of traveling light. Students are encouraged to block the laser beam at various points to see the order of the beams (that is, which leads in and which leads out of the telescope).
2) Students are asked to describe what is happening when the light hits the mirrored surfaces. They verbalize the concept of "bouncing" light. Objects which are not as reflective are then struck with light, extending the concept of "bounce" to less shiny surfaces.

Only bright, intense lights are thought to produce the "traveling" and "bouncing" light effects. Students thus struggle with the idea that their eyes are receiving light from all objects in order to see. This misconception is often reinforced because only intrinsically light-producing objects are used as sources in optics experiments.

We address this misconception in the following ways:
1) Students notice that not only can the light bulb's image be seen on the screen, but the objects surrounding the bulb as well.
2) Students are asked to predict how the laser light in the cut-away telescope and the light from a distant star compare.

Light is not conserved - it can appear, disappear, be intensified or dimmed without interacting with matter. The concept that light from an object can fill a space is rare among students, but is essential to developing the useful, physics concept of light.

We address this misconception in the following ways:
1) Students are encouraged to place flat mirrors near the light-bulb to "catch" more light and send it back toward the parabolic mirror. The flat mirrors intercept the "extra" light.
2) Students place the cardboard screen at various locations and use flat mirrors to redirect the light bulb's image onto the screen.

Use of Manipulatives

The large number of manipulatives in this activity is especially useful for drawing girls into the scientific discourse. Manipulatives include: The parabolic mirror, flat mirrors, the light source, and the screen. Many studies have shown that "individual and small-group activities ... with hands-on, manipulative materials designed to develop students' spatial and quantitative skills [are] related positively to girls' enjoyment of science and gains in science achievement" (Kahle, J.B. & Meece, J. 1994, Research on gender issues in the classroom, Handbook of research on science teaching and learning). Since our program targets middle school, a time when girls drastically "drop-out" of science, this type of hands-on experience in crucial.

Addressing misconceptions: Steps to conceptual change (Hewson & Hewson 1988)

1) Diagnosis and clarification
Students are encouraged to verbalize their ideas/predictions about where the image formed by the mirror will be and how it will look. Students seem to expect to see a simple blob of light, and are surprised by how sharp the image actually is; they can usually read the writing on the bulb surface!

2) Dissatisfaction and cognitive dissonance
We are finding that the concept of an "image" is a challenging one for many students. For example, when asked to "redirect" the image of the light bulb using a flat mirror, students invariably place the flat mirror *at the location of the image*. Even through the use of manipulatives, understanding image formation appears to be quite cognitively complex.

3) Plausibility
Successfully finding and redirecting the light bulb image gives students confirmation that light is something that "travels" and can be manipulated. Students also recognize that, in manipulating the mirrors to form an image, they have effectively constructed a telescope similar to their Dobsonian.

4) Fruitfulness
Students experience difficulty in holding the various components of the experiment steady. This is easily used to illustrate the function of the other remaining mechanical parts of the constructed telescope, namely the base, pivot, spider secondary support, mirror cell, and the focus rack and pinion. Students discover that the sharpest image of the light bulb occurs when the image is bounced back in the direction it came from. This sets up the class for discussions of image focus and supports the mirror collimation part of the construction process.

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