

Tabletop Optics: Implementing Inquiry during *Stars, Sight and Science*

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Past Design Presentations
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COSMOS: Stars, Sight and Science

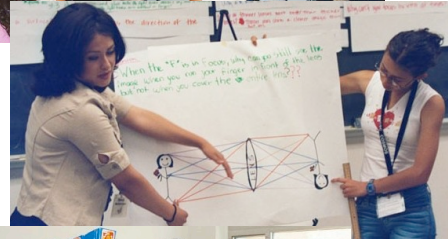
- Eighteen talented and motivated high school students
- Immersive, four-week experience
- Cluster topics:
 - Astronomy
 - Vision Science
 - Science Communication
- Astro course developed with Lynne Raschke & later with Scott Seagroves (now taught by Kathy Cooksey)



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Designing the Course

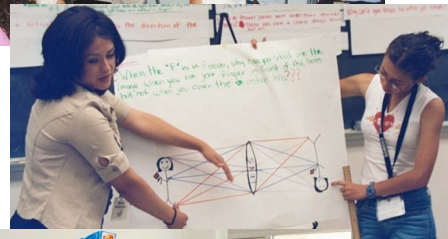
- We approached designing the course by first setting out our goals:
 - Content
 - Process
 - Attitudinal



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Designing the Course

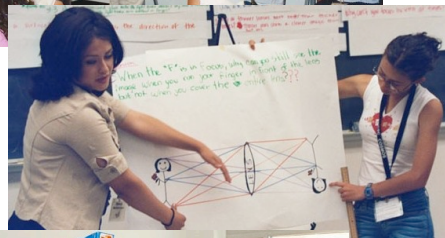
- Content
 - Optics
 - Telescopes, Adaptive Optics, Astronomical Imaging
 - Astronomical Taxonomy, Stellar Life-Cycles
 - Research Project Content



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Designing the Course

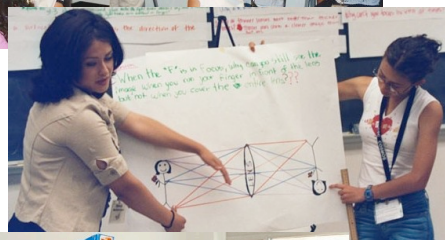
- Process
 - Good Laboratory Procedures
 - Posing Questions
 - Experimental Design
 - Data Analysis
 - Science Communication



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Designing the Course

- Attitudinal
 - Broaden Perspective
 - Enhance Self-Confidence
 - Promote Career Opportunities
 - Modeling Higher Education Paths



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Challenge of Teaching Optics

- Optics forms basis of several components of course
 - Telescopes
 - Adaptive Optics
 - Connection with Vision Science
- Intuitive understanding of optics requires hands-on laboratory work

→ Inquiry



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Challenge of Teaching Optics

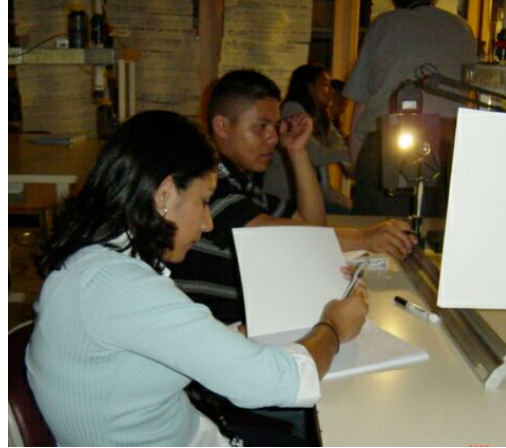
- Content objectives
 - Fundamental, intuitive knowledge of how optical elements work
- Process objectives
 - Generate questions
 - Construct experiments
 - Communicate ideas to peers
- Attitudinal objectives
 - Self-Confidence
 - Exposure to Science as practiced



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Implementing Inquiry

- Timing within course is critical
 - The optics content needed to be taught early
 - Young students needed time to connect with instructor and create social group prior to inquiry activity
- We now place inquiry after:
 - Intro “Wow” lecture
 - Social games
 - Assessment through writing exercise



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Implementing Inquiry

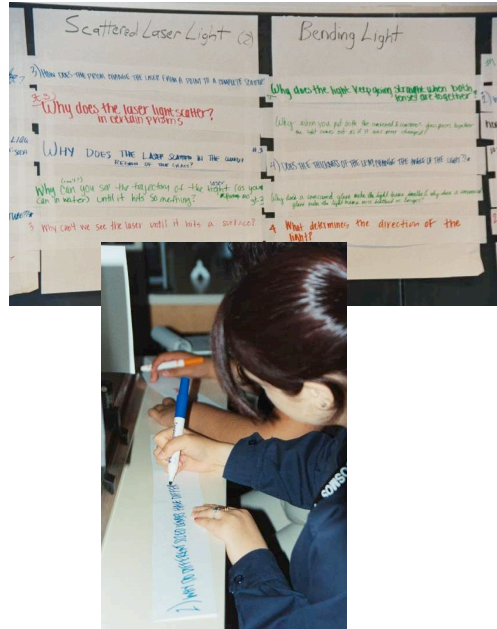
- Inquiry Starter
 - Students Explore Phenomena, ask questions
- Facilitated Investigation
 - Students devise experiments, construct and test explanations
- Sharing
 - Students communicate their ideas to each other
- Synthesis
 - Instructor reviews and expands



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Tiered Content Goals

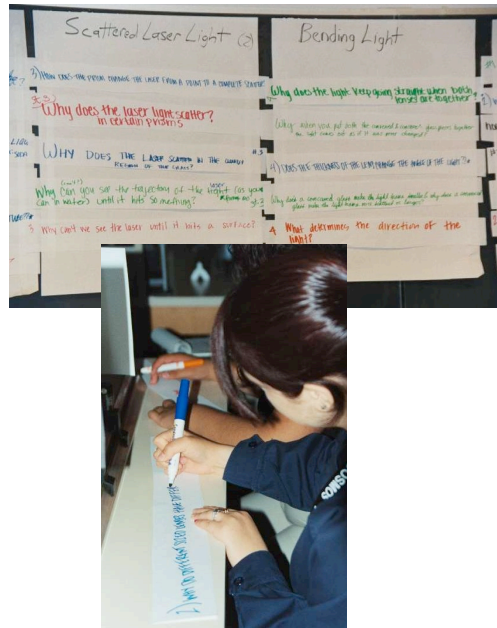
- Students prior knowledge varied dramatically
- Conceptual overview
 - We created a tiered set of content objectives
 - This, in-turn helped us design the optics inquiry
 - Tradeoffs:
 - Provide ample materials
 - However, limit materials to focus exploration
 - We provide experience-appropriate avenues of exploration



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Tiered Content Goals

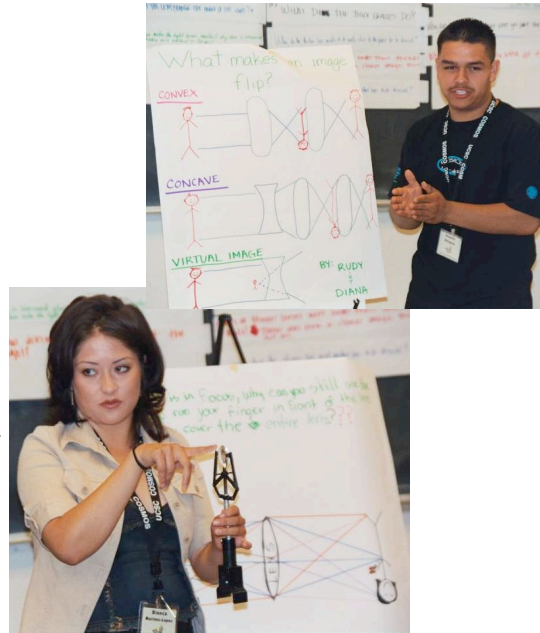
- Our aim:
 - All students grasp first tier objectives
 - Many students grasp second tier objectives
 - Advanced students challenged by third tier objectives



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Overview of Tiers

- First Tier, Understand:
 - the way lenses and mirrors change the path of light
 - the difference between diverging and converging beams of light
 - the different way convex and concave optical elements affect beams of light



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Overview of Tiers

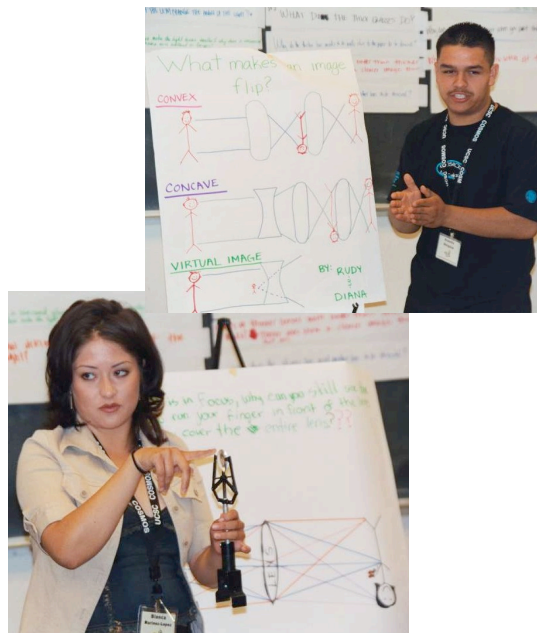
- Second Tier, Understand:
 - the concept of focal point
 - the way convex lenses form images (including image inversion)
 - the relationship between magnification and the distance to the image plane



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Overview of Tiers

- Third Tier, Understand:
 - the relationship between curvature of the lens and the focal point
 - the derivation of the law of reflection
 - retro-reflection
 - “magic illusion” mirror



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Inquiry Starters

- Image Formation with Convex Lenses
 - “F” shaped light source, optics rail, convex lenses, image screens.
 - Phenomenon - Image inversion/magnification
- Image Formation with Convex and Concave Lenses
 - “F” shaped light source, optics rail, convex & concave lenses, image screens.
 - Phenomenon - Image with convex, no image with concave



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Inquiry Starters

- Light Ray Kits
 - Kits with light source and slits producing parallel beams, lenses, mirrors
 - Phenomenon - Light path bent by lenses, reflected by mirrors
- Mirrors
 - Flat, concave and convex mirrors
 - Phenomenon - Image inversion/magnification



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Synthesis

- The students' investigations cover our content goals
 - all first tier objectives
 - most second tier objectives
 - perhaps one or two third tier objective
- We reinforce several concepts, leveraging the students' work
- We introduce the term “focal point”, and drawing upon several groups' work we illustrate the definition



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Results

- The inquiry has been a success
 - Students are interested, enthusiastic and motivated
 - Their work addresses almost all of our content goals
 - Assessment of their prior knowledge and learning styles is invaluable
 - Material scores well in our course-end “Knowledge Survey”



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Final Thoughts

- Use the results of Education Research to design course
- Apply inquiry as a tool when and where appropriate (along with lecture and activity)
- Inquiry is good for content, process and attitudinal goals
- Tiered content goals work well for groups with disparate backgrounds
- Include assessment



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