International Workshop
Science Education in Schools

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USA
Informal Education Learning Activities

• Voluntary and self-directed, life-long, motivated mainly by intrinsic interests, curiosity, exploration, manipulation, fantasy, task completion, and social interaction.

• Informal learning occurs in an out-of-school setting and can be linear or non-linear.

• Often self-paced and visual- or object-oriented.

• Provides an experiential base and motivation for further activity and learning.
Project Funding

- National Science Foundation, Division of Informal Science Education, P.I. Anthony Johnson
- Program Officer: Dr. Sylvia James
- Support from SPIE, OSA, NOAO
Knowledge and Wonder

... for all knowledge and wonder (which is the seed of knowledge) is an impression of pleasure in itself ...
Project History

• 2001 National Science Foundation Planning Grant to Optical Society of America, SPIE-The International Society for Optical Engineering

• Result: Optics Education: A Blueprint for the 21st Century

• Recognition that professional societies have obligations/expertise to K-12 as well as to membership-oriented focus.

• Optics as a “stealth” field, contributing to many others

• Ubiquity of optics in everyday life in contrast to noticeable absence of optics in K-12 and informal education

• 22 recommendations, interventional strategies

• Importance of strategic partnerships
Role of Optics Resource Volunteers

- Each society has over 15,000 professional members.
- Over 2000 are conducting educational activities
- Train and utilize this volunteer force for optics education
- Need to utilize other mentors (undergraduates, graduate students, technicians, other practitioners)
Results of Planning Grant:
Focus on Middle School Age, Informal Setting, Broad Audience
Organization of Current HOO Program

**OSA** – The Optical Society of America
Project Principal Investigator Anthony Johnson

**SPIE** – The International Society for Optical Engineering
Project Co-PI Eugene Arthurs

**NOAO** – The National Optical Astronomy Observatory
Project Co-PI and Project Director Stephen Pompea

---3-year program in year 4 no-cost extension
All money committed by August 31, 2007
Our Approach:

- Experimentation
- Inquiry-oriented
- Build sense of ownership
- Create prolonged engagement
- “Fun and exciting”
- Career awareness
Professional Development Program is Essential

Strong (but flexible) professional development for educators and optics resource volunteers
Intersection of Hands-On Optics Functions

Educator/ORV Professional Development

Instructional Materials Development

Informal Program Development
Builds on Understanding of Children and their View of the Nature of Light

- Light is a source, may be an effect, but is not an entity (Guesne)
- Light paths and rays not well understood (Ramadas and Driver)
- Focus on seeing as the active process (not light reflecting from objects)
- Basic misunderstanding of shadows and even where they appear.
- Poor understanding of images and their location (Goldberg and McDermott)
- Poor understanding of how filters work and of colors. (Zylbersztajn and Watts) What is “black”?
- Reflections must be specular (Anderson and Smith)
HOO Modules: Builds on Existing Materials and Workshops: e.g., *Invisible Universe* Teacher’s Guide and workshops at the National Science Teacher’s Association, numerous SPIE and OSA efforts.
Project Goals

• Create links from the professional optics community to the informal science education community

• Reach underrepresented middle school cohorts in science and technology and connect with their parents, teachers, school districts and communities

• Provide opportunities for the target populations to succeed in collaborative learning and problem solving through inquiry-based, hands-on applications of optical and engineering skill and knowledge

• Increase science and technology knowledge for students and increase awareness of optics as a discipline and career that cross-cuts numerous fields
Goals and Plan

1. Target underserved middle-school aged audience
2. Use a volunteer network as mentors “Resource Agents”
3. Team volunteers with MESA teachers
4. Develop 6 modules with optics parts
5. Design professional development course for educators and volunteers
6. Develop a resource book for the volunteers to work in an educational hands-on environment.
7. Provide program for career awareness and capstone events
Primary Audiences for Hands-On Optics

1. MESA programs: Arizona, Colorado, California, Maryland, New Mexico, Oregon, Washington

2. Science Centers: Adventure Science Center, California Science Center, Chabot Science Center, Flandrau Science Center, Imiloa Astronomy Center of Hawaii, New York Hall of Science, Orlando Science Center
Selection Criteria for Science Centers

- Reach an underserved audience
- Interest in long-term physical science education
- Integration with current programs
- Number of kids reached/hours per kid
- Presence of volunteer community
- Long-term commitment of staff/management
What the project provides:

- HOO kits, curricula, advice (e.g., camp plans)
- Professional development for staff
- Materials for informational programs and festivals

What we need from our partners:

- A specific plan for use of HOO materials
- A coordinated plan for staff professional development
- Metrics on usage, formative feedback
These are the numbers for September 10, 2006 through January 12, 2007

<table>
<thead>
<tr>
<th>Program Type</th>
<th># of Classes</th>
<th># of Students</th>
<th>Total</th>
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<tbody>
<tr>
<td>Elementary Discovery Labs using HOO</td>
<td>3</td>
<td>30</td>
<td>90.00</td>
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<tr>
<td>21st Century Elementary Outreach</td>
<td>9</td>
<td>26</td>
<td>234.00</td>
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<td>NEW Middle and High School Focused Experience (Microscopy and Telescopes)</td>
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<td>35</td>
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<td>Middle School Optics Outreach</td>
<td>2</td>
<td>30</td>
<td>60.00</td>
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<tr>
<td>DDL Weekends using optics at 1 or more stations</td>
<td>32</td>
<td>150</td>
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<tr>
<td>DDL Weekdays using optics at 1 or more stations</td>
<td>5</td>
<td>150</td>
<td>750.00</td>
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<tr>
<td>Science Live Shows using HOO for guests</td>
<td>10</td>
<td>150</td>
<td>1500.00</td>
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<tr>
<td>Optics cart demos</td>
<td>10</td>
<td>150</td>
<td>1500.00</td>
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<tr>
<td>Darden Theater Shows (Chem and Physics shows)</td>
<td>5</td>
<td>242</td>
<td>1210.00</td>
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<tr>
<td><strong>Grand Total</strong></td>
<td></td>
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<td><strong>10179.00</strong></td>
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HOO Modules

- Playful, Exploratory
- Appeal to “Non-Science” Student
- Challenge-Oriented
- Balance of Low/High Tech
- Tied to US National Science Education Process and Content Standards, Mathematics Standards, and Technology Education Standards
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<th>Concept</th>
<th>Key Activities</th>
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<td>reflection off of a plane mirror</td>
<td>“Hit the Target”</td>
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<td>2. Kaleidoscope Adventures</td>
<td>multiple reflections</td>
<td>“Kaleidoscopes and Periscopes”</td>
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<td>3. Magnificent Magnifications</td>
<td>image formation</td>
<td>“Building a Telescope”</td>
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<td>4. Peculiar Polarizations</td>
<td>polarization and color</td>
<td>“Testing for Stress”</td>
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<tr>
<td>5. Ultraviolet and Infrared Light</td>
<td>EM spectrum, fluorescence and infrared</td>
<td>“Glowing Things”</td>
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<tr>
<td>6. Communicating on a Beam of Light</td>
<td>information transmission</td>
<td>Laser Communication of Sound</td>
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Sample Items in Kits
HOO Challenges: Module 6 Laser Communication
The Old Way…

Clear modulated laser: $475

Laser communication receiver kit: $139

Grand Total: $614
Our Kit < $100

The Receiver
MESA Competition 2007
(prolonged engagement)

• 4th Year, Took place April, 2007 in Tucson
• Changed to a version of “Hit the target”
• Teams received kits to practice
• 37 teams signed up
• 4th year
Some New Audiences: Boys and Girls Clubs

South Tucson and Sells Boys and Girls Clubs
Boys and Girls Club in Sells  
(Tohono O’odham Nation)

• 1.5 hours every other week  
• At least 15 children per session  
• Ages mostly between 7-12 years old  
• Program was very well received  
• Of 3 dozen kids on the last day
  — 90% of the kids had consistently participated in HOO
  — 90% wanted the program to continue

Special optics event at Pisinemo (with Tohono O’odham summer day camp)
Boys and Girls Club
South Tucson (Hispanic Community)

- Two 1.5 hour sessions twice week
- 73 children participated; an average of 22 students each day.
- An equal number of boys and girls
- Twice as many 7-10 year olds as 11-14 year olds
- As a capstone, 18 children with the highest attendance record traveled to Kitt Peak National Observatory for the Nightly Observing Program.
HOO Outcomes/Project Performance

High throughput/high contrast optical/educational system

or

Low throughput/high contrast optical/educational system
Optics Resource Volunteer Connection

- Volunteers are experts, but who is an expert?

- 180+ volunteers trained in 11 states, more being trained at each site

- Pairing teacher/ORV not always successful, but many success stories

- 2,100 volunteer hours recorded to date (January!)

- Project goal of 3,200 hours will be met
Program Evolution:
Astronomy from the Ground Up (AFGU)

- Created Module 3 mini-kits for AFGU—Used by OSA, SPIE
- Not a classroom set of materials but an introduction to one module
- Expect to reach 100 small science center and nature center educators per year with abbreviated professional development program
- One site has become a full HOO site
- Many have done large special optics events
Program Evolution: Timothy Smith Network of Community Centers (Roxbury, Massachusetts)

- 24 Participants from 20 Community Centers
- Ideal venue for informal program
- First professional development workshop held Nov. 2006, revisit this month

This makes 25 HOO workshops (2-day each)
Hands-On Optics in the Future

- OSA and SPIE—workshops planned
- Support for current HOO sites
- Widespread kit dissemination through Learning Technologies Inc.
- NOAO-Science Foundation Arizona grant
- NOAO-Adaptive optics kit development through NSF Giant Segmented Mirror Telescope Project

HOO is now a core NOAO project
Final Thoughts

• Demand for high-quality materials, training
• Use of undergraduates very valuable in the program
• Flexibility with science centers
• Importance of solid professional development
• Optics Resource Volunteers have been valuable
• Expansion