Art + technology in optics educational outreach programs

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ABSTRACT

In the modern era, art and technology have been at opposite ends of the spectrum of human study. Artists tend to be non-technical and technologists tend not to be artistic. While this is a broad generalization, it is rare to find an artist teaching science or an engineer teaching art. However, if we think back several centuries, it was very common for great artists to be at the forefront of technology. The prime example being the great Leonardo Di Vinci. Over the past several years, the optics educational outreach programs of the Optics Institute of Southern California (OISC) have incorporated using art and artists to help teach optics and related science. The original use of this was with material from the General Atomics Education Foundation, Color My World, which has been used in a number of settings. Recently, the OISC has partnered with the UC Irvine Beall Center for Art + Technology to provide Family Day Event presentations that use the themes of current Art + Technology exhibits to help attendees learn and understand more about the fundamental science through the art. The two main concepts here are that artists are using science and technology as the basis for their art, also sometimes making some social statements; and the technologists are using the art to make the science more accessible and interesting to the general pubic. This paper weaves a path from the original OISC uses of art to the recent work at UC Irvine.

Keywords: Optics education, outreach programs, art + technology

1 INTRODUCTION

The Optics Institute of Southern California is an Orange County-based nonprofit organization dedicated to the promotion of math, science, and engineering education through the use of optics and related technologies and phenomena. Our educational approach is hands-on, student-centered, and engaging. We seek to foster the curious scientist, the artful mathematician, and the creative engineer in every student, regardless of age. The OISC was founded in 2003 to focus on science educational outreach programs using optics. We enlist parents, teachers, professional optics and science volunteers and others to work with the students. We believe that we must first get the students attention and using art has proven to be an effective means; since it has a universal ability to reach people in general and young people in particular. Then we aim to keep their attention using story telling techniques.

In this paper, we will briefly describe the approach we have developed and implemented and then focus on presenting examples of the results we have achieved using art as an introduction to science and technology to hook young minds on the great mysteries that the scientific approach helps us solve. The examples of art + technology in optics educational outreach programs are divided into the following sections: Color My World – grades K-4; Optricks Suitcase – grades 5-8; Kaleidoscopes – grades 5-8; Teen Optics Bench – grades 9-12; Girl Scouts; and professional Art + Technology exhibits.

2 CAPTURE AND KEEP THEIR ATTENTION

When standing in front of a room full of young people who have been told something about what they are going to experience, the first thing an 'educator' would like to do is to capture and then keep the attention of the students. We have found that by using colorful images of friendly easy to see objects, we can capture their attention. Sometimes some types of sounds are also helpful to pierce the din of the young people's voices to get them to look in the direction of the colorful images. Another very helpful technique is, if you have control of the room lights, to dim or even turn off the room lights and have some very colorful light sources like a blinking LED spun around on a string. If it can change color while it is spinning and blink in somewhat random periods that is also helpful. We have done this many times very successfully with Strobe FX and other similar commercially available products. In Figure 1, we see the author at the beginning of an Optricks Suitcase presentation, dressed as an Optricks Apprentice, with a very colorful image on the screen behind him, waving his Strobe FX.

Fig.1. Capturing their attention.

The images on the screen together with the costume and the spinning blinking light give the audience a sense of a story or mystery about to unfold. So once the attention is captured, we keep their attention and get them involved right away by asking them questions that form the basis of a story. In this case; the questions might be like; "What do you see?" and we let them provide answers by calling on them individually. We get to the point where they answer something about colored lights blinking and spinning and we then talk about light and other objects moving in space and in time. It's the old "space – time" concept we want to get them to think about. We can move about the floor, walking backwards and forwards and side to side and tell them that we can move in 3D space forwards and backwards and up and down and side to side, but in time we can only move forward and at the same rate all the time. In 3D space, we can move at many different speeds and in all different directions.

This is then an example of a move from art to science and technology. The students can relate this story to their personal experiences; because they move in the 3D world every day all the time and they see flashing and moving lights a lot too.

3 GIVE THEM SOMETHING TO HOLD AND EXPERIENCE

Once you have captured and have their attention, you need to keep it by moving the story to the next phase. This is not something that can be read in a book, or programmed and delivered over the internet on a computer or by having the 'lecturer' stand in front of the students and 'tell' them or write it on the board; this is something the students need to hold and experience. They need to do something or even make something that they can take away with them and share with their family and friends.

At this point we move on to the examples phase of this paper and share the results of working with hundreds (actually thousands by now) of students in real life settings.

Color My World – grades K-4

Fig. 2. Students in the process of making a liquid color wheel.

In figure 2 we see some summer school students gather around an outdoor table covered with white butcher paper. They have a number of plastic glasses each partially filled with colored water. They seem to be arranging these glasses in some particular order, which will become obvious in a moment. One most important note about this activity is that these students started with water of only three colors, cyan, magenta and yellow. These being the primary colors for mixing inks (likes those used in color ink jet printers.) So in this activity, the students learned about colors and in particular, primary colors, and then they had a really fun and interesting time trying to make a liquid color wheel.

In figure 3, below, you can see the results of the students' activity and you can be sure that these young people were very proud of their efforts.

Another fun and colorful activity with a similar theme is to have these young people paint using only cyan, magenta and yellow. An example of this activity can be seen in figure 4, where they have first painted paper plates, each with a different amount of cyan, magenta and yellow and arranged them in a color wheel fashion and then they painted whatever they wanted; with some samples shown in the middle of the color wheel.

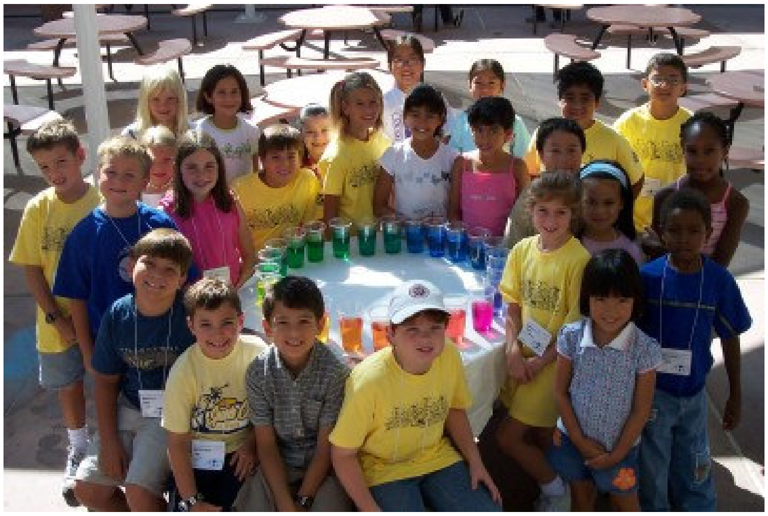

Fig. 3. Students sitting around the table with the finished liquid color wheel

Fig. 4. Painted color wheel and student art.

A final example of the young students' exploration with art and technology (remember, they are relating this to printing they see from color printers, printing photographs and newspapers, magazines and books) is with 'stained glass' art that they made using ink from marking pens on transparent patterned pages that they then taped to the window.

Fig. 5. Young students' "stained glass" art work displayed on a glass door .

3.1 The Optricks Suitcase – grades 5-8

Fig. 6. The Optricks Suitcase

The Optricks Suitcase, seen at the left in figure 6, has become a foundation of our science educational outreach programs, as it incorporates many (or maybe even all) of the concepts discussed in this paper. Since there are many different 'tools' (or toys) that make up the Optricks Suitcase, including the Strobe FX we started with at the beginning of this paper, we will only review the four "Theme Packs" that the students get to use and then take home with them to share with their family and friends. The four "Theme Packs" are: The Magic Dots (a lens to see the colored dots printed by a laser printer), The Magic Stripes (polarization filters and plastic ware to see the stresses in materials), The Magic Patch (cholestric liquid crystals – like the mood rings that change color with temperature) and The Rainbow Peephole (radial diffraction grating and a small flashlight to see the rainbows in your eyes.)

The Magic Dots – A Lens and a Printed Page

By providing the students with a lens and a colorful printed page with images that go from white to shades of different color, they are able to see the "Magic Dots" pop out of the page by using the lens to magnify the images. Once they have a lens and a printed page (we use the nice periodic table of elements, as shown in figure 7, and discuss that briefly as time permits) they can explore the world of magnified images as shown in figure 8.

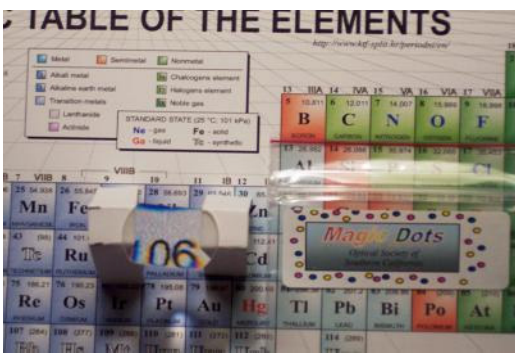

Fig. 7. Lens magnifying the colored dots on the periodic table of elements.

Fig. 8. An older sister and younger brother explore magnified images together.

The Magic Stripes – Polarization filters

The second "Theme Pack" is known as the Magic Stripes and consists of a plastic thin film polarization filter about 2" wide and 3" long wrapped and taped into a cylinder; a clear plastic spoon snapped into two pieces, and a small transparency with printing; as shown in figure 9. The transparent object, such as a clear plastic spoon, can be placed inside the cylinder, as shown in figure 10, and viewed with room light to show the stresses that are produced when using a polariscope. A similar but slightly different effect is produced when the other objects are placed in this cylindrical polariscope. More dramatic effects can be produced in a darkened room with an overhead projector used as the light source as can be seen in the results shown in figure 11.

Fig. 9 Magic Stripes Theme Pack

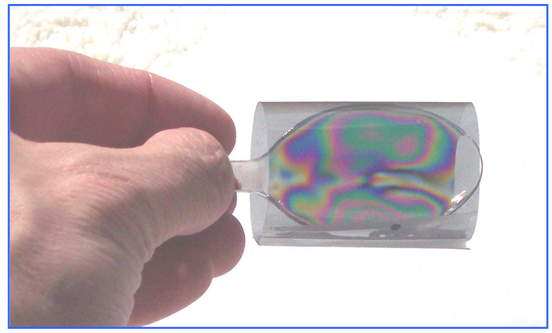

Fig. 10. Stress fringes from cylindrical polariscope

Fig. 11.Young students use an overhead projector,
two linear polarizers and plastic utensils to experience polarization.

The Magic Patch – Cholesteric Liquid Crystals

The third take home theme pack, The Magic Patch, provides another familiar art concept that many young people have experienced in the form of a ‘mood ring’. These inexpensive thin film cholesteric liquid crystals are commercially available in a number of temperature sensitive ranges and typically come in large 8”x10” sheets, as shown in figures 12 and 13, that can be easily cut into smaller 1.5” x 1.5” squares and given to the students, figure 14, in our traditional small labeled plastic bags, as shown in figure 15.

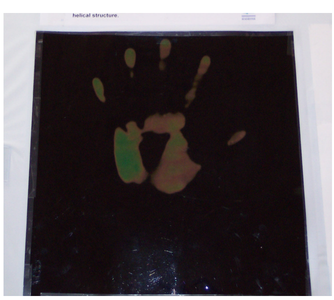

Fig.12. A large cholesteric LCD thin film

Fig.13. The author demonstrates the Magic Patch to some students

Fig.14. A small 1.5” square cholesteric LCD

Fig.15. The Magic Patch

Once the students are drawn into experiencing this Magic Patch, we ask them how they think this works. Since they probably have not yet wondered about this mystery of nature (science) we have a small diagram that helps them get familiar with some fundamental concepts of cholesteric LCDs, as shown in figure 16. Here we describe that within each layer, molecules align with long axes parallel to the plane of each layer; and protruding side groups force molecules in adjacent layers to be displaced, creating a twisted, helical structure. In more basic terms, when the thin film LCD is cool, layers expand providing a longer pitch for the red light or longer wavelengths to be reflected. And when the thin film is warmer, the shorter pitch of the contracted layers reflect the shorter, bluer wavelengths.

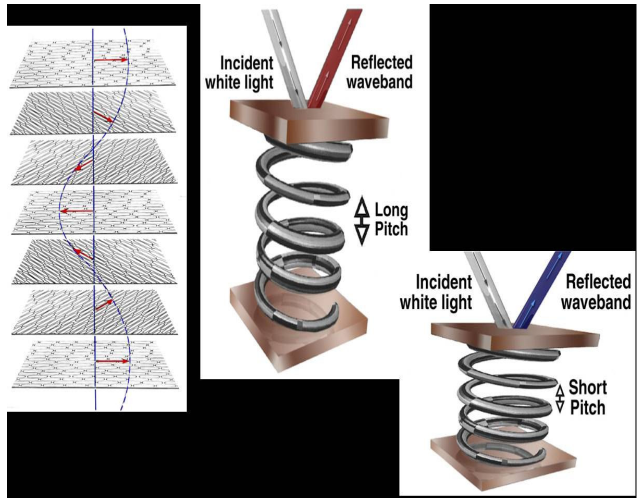

Fig.16. Graphic explanation of cholesteric LCDs

Rainbow Peepholes – Diffraction Gratings

The last of the four take home theme packs is the Rainbow Peephole that includes a commercially available small plastic radial diffraction grating mounted in a small colorful cardboard mount, a small flashlight and a small card with a diagram of how to use the system, as shown in figure 17. The card also contains a small 3D profile of the surface of the diffraction grating showing the periodic rough surface that diffracts the light. The colorful pattern on the cardboard mount is the first artistic component of this theme pack to catch the students' attention; but when they project the light from the small flashlight through the grating into their eyes (rainbows in your eyes) as shown in figure 18, their thoughts run wild wondering how this can be accomplished. This is when we ask a series of questions about where the colors come from and how is it that we see these colors. Figure 19 shows an image taken through a Rainbow Peephole, with a standard digital camera, of some students shinning their flashlights at the author, who is taking the picture.

Fig.17. Rainbow Peephole Theme Pack

Fig.18. Student using a Rainbow Peephole

Fig.19. Image through a Rainbow Peephole

3.2 Kaleidoscopes – Hands-On Optics (HOO) Project

Another very successful optics outreach program funded by the NSF and sponsored by SPIE, OSA and NOAO is the Hands-On Optics project. The author has been a trained optics professional volunteer since the program's inception. One of the six modules developed and deployed to date, is the Kaleidoscope Adventures. This module, among other activities, includes an activity where each student makes their own kaleidoscope. The author has led a number of events in Southern California sponsored by UC Irvine MESA (a former partner in the HOO project) with significant success. While the HOO version of these activities were primarily structured for a classroom size group, the author, with some assistants, has lead events ranging in size from about 20 students at a time in a standard classroom to about 50 students at a time in a school cafeteria. These particular events focus mostly on the activities of learning about and making the kaleidoscopes and the actual connection to the science and technology was not as obvious as other projects. Some results of these activities are shown in figures 20-23 below. The potential for actually having the students learn about the science of mirrors and kaleidoscopes has been left for their future at home and at their schools.

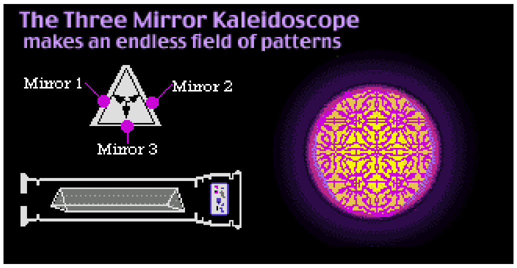

Fig. 20. Diagram of the three mirror kaleidoscopes the students made.

Fig. 21. Students making and using kaleidoscopes.

Fig. 22. Students making kaleidoscopes in a large elementary school cafeteria.

Fig. 23. Students with their finished kaleidoscopes in a large elementary school cafeteria.

3.3 Teen Optics Bench – grades 9-12

The Teen Optics Bench is actually a Pasco Scientific Model OS-8500 Introductory Optics Systems kit. The OISC has used these kits for a number of years beginning in 2004 with the Think Together after-school programs in Orange County. Figure 24 shows a couple of teenaged girls using such a kit during an after-school program. The primary introduction of optics to students using these kits usually comes after the students have had some experiences with some of the other optics educational materials discussed earlier in this paper. Typically, we will start with a colorful experiment (there are 22 experiments in these kits) such as diffraction gratings or the color mixing. Figure 25 shows an optics professional with a kit set up demonstrating diffraction of a white light source during a recent Optricks Days event at the Discovery Science Center in Santa Ana, CA. This, along with many other hands-on demonstrations, was used as teasers to get interested students to sign up for an activity workshop were other optics professional volunteers helped the students work with this and other optics experiments; an example of which is shown in figure 26.

Fig. 24. Teenagers using the Teen Optics Bench at a Think Together After-School program

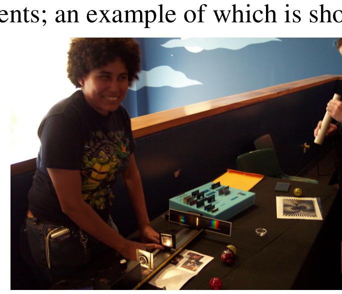

Fig. 25. Optics professional volunteer with the Teen Optics Bench set up demonstrating diffraction during Optricks Days at the Discovery Science Center

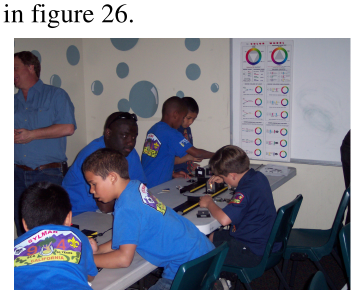

Fig. 26. Cub Scouts with the Teen Optics Benches during Optricks Days at the Discovery Science Center

3.4 OSA Foundation and Girl Scouts of America

A recent development in optics education outreach programs is collaboration between the Optical Society of America Foundation and the Girl Scouts of America. To launch their collaboration, they have jointly published, "Lighten Up – Discovering the Science of Light" see figure 27. This booklet of easy to read, follow and do activities for girls ages 11-15 seems (in the author's opinion) to be one of the best written publications of its kind to date. The author and an assistant were invited to participate in an Orange County Council Girl Scout event, "Harry Potter Carnival", and set up a booth were the girls could come and explore the world of optics. We created the Hogwarts School of Optics and the author dressed as the Headmaster Wizard and his assistant was a Wizard Apprentice. Following in the theme of art + technology, the main attraction at the booth was the first activity in the Lighten Up booklet, "Spinning your (color) wheels", see figure 28.

This activity used blank CD disks as the main portion of the spinning disk and preprinted white CD labels with some information about the OSA, OSSC and OISC (websites to visit for more fun.) The girls were provided crayons to draw on the white labels and then some tape and a small golf pencil to stick though the tape covering the middle hole in the CD disk; and their spinning disk was complete. If they did their work according to the description and spun their disk fast enough, the colors blended into white. Figures 29 and 30 show the girls during these activities.

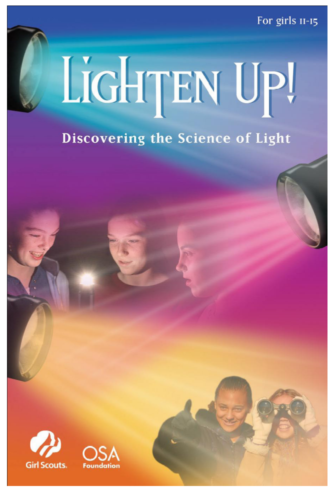

Fig. 27. Cover of Lighten Up

Fig. 28. Spinning your color wheels

Fig. 29. Explaining the color wheel activity

Fig. 30. Making the spinning color wheels

Moving from the artistic activity of making and using the spinning color wheels to some optical science and technology activities, we offered the girls the opportunity to 'play with' our 'AlphaNumeric Optical Inverters.' These are simply cylindrical 'test tubes' filled with water and sealed with a cork. They make a very nice cylindrical lens. Holding this device above a printed page of red and blue letters, the girls notice the blue letters and numbers are inverted and the red ones are not. Some of the girls figure this out quickly, while other do not. Figure 31 shows a picture of a couple young girls pondering this mystery. The most technically challenging activity the girls had the opportunity to participate was naming the stars with the telescopes. There were two different telescopes, one that provided an upright image of the stellar chart posted in the ceiling of the outdoor cover and one that provided an inverted image of the chart. This activity is shown in figure 32 and we had many young girls complete the 'easy' telescope challenge and only four completed the challenge using the inverted telescope. Three of these four are shown in figure 33 with the author and his assistant. We many prize for the girls as rewards for their efforts in these various activities.

Fig. 31. Two girls pondering the AlphaNumeric Optical Inverter.

Fig. 32. Two girls taking the telescope challenge, one easy, one hard.

Fig. 33. Three winners of the hard telescope challenge with the author and his assistant.

4 PROFESSIONAL ART+TECHNOLOGY EXHIBITS

In October 2004, the OISC organized and implemented an exhibit at the Irvine Civic Center titled, "The Speed of Light". This exhibit was the idea of Larry DeShazer, OISC Founding Treasurer and Irvine Center for Applied Competitive Technologies (CACT) Director. The concept began with the fact that Albert Michelson built his final 'Speed of Light' experiment on the Irvine Ranch in 1930, near the new site for the South Orange County Community College District's (SOCCCD) Advanced Technology and Education Park (ATEP), where both the OISC and CACT are moving this fall. This exhibit centered on a display of a modern version of the experiment with equipment donated by Newport Corp. and a few others. Figure 34 is a photo of this experiment with the author and friends from Newport and figure 35 is a photo of some of the poster displays created for this exhibit.

Fig. 34. A photo of The Speed of Light experiment at the Irvine Civic Center with the author and friends from Newport Corp.

Fig. 35. A photo of some of the poster displays created for this exhibit.

A new installation of an expanded version of this exhibit is being planned by the Optical Society of Southern California (OSSC) and the OISC for the UC Irvine Beall Center for Art + Technology for the summer of 2008. This installation will build on the material in the first exhibit by adding significant hands-on interactive demonstrations for young people of all ages to experience. A core audience for this exhibit will be UC Irvine K-12 summer school students who attend programs offered through the UCI Center for Educational Partnership (CFEP), which includes the Math Engineering Science Achievement (MESA) program and the Gifted Student Academy (GSA) program which the OISC has been associated for almost 5 years. Many of these hands-on interactive demonstrations will be based on those used during the annual Optricks Days events at the Discovery Science Center and some will be new. A draft layout of this exhibit is shown in figure 36. The OSSC and OISC are currently recruiting volunteers to help bring this new expanded exhibit to life over the next 10 months. The OISC is also sponsoring an Art Competition for this project. Ten pieces will be selected from those submitted, one for each of ten chosen themes:

1) Humanity Sees the Light
2) Stained Glass
3) Color My World
4) Kaleidoscope
5) Medical Laser
6) Bar Code Scanner
7) Fiber Optics
8) Spectrum
9) Heads Up Display
10) Quantum Entanglement

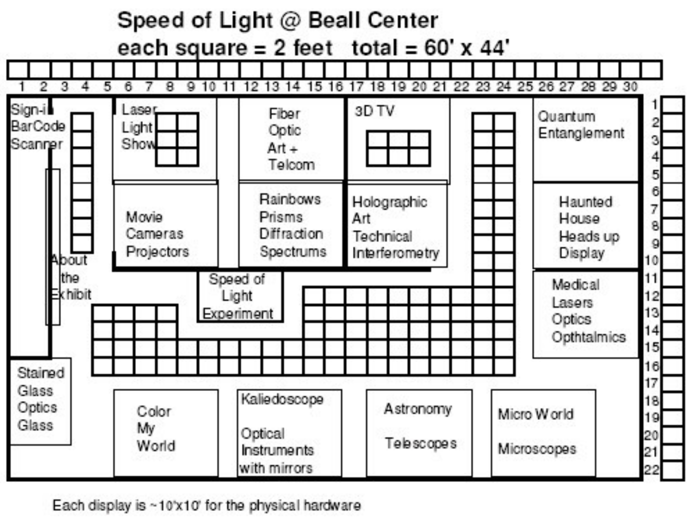

Fig. 36. Speed of Light Exhibit layout at the UC Irvine Beall Center for Art + Technology

5 CONCLUSIONS

As we move forward with our optics educational outreach programs, we have experienced that using art can be very successful as an introduction to science and technology. First we capture the attention of our students with artistic objects and images and then provide a story line of mystery with questions about what it we are seeing and experiencing. We have used these techniques with students of all ages, from K-12 (and even younger) to community college and university students and the general public.

More details about all the topics, programs and materials covered in this paper can be found on-line at http://oisc.net and by contacting the author.

One concept not mentioned in this paper, but is used by the author at the end of some OISC programs is the theory that nothing can go faster than the "Speed of Light." In modern science fiction, it is common to travel at speeds faster than light. This is brought to the attention of the 'students' and the possibility is raised that someday our understanding of the laws of physics will change and humans will discover how to actually navigate the galaxy. "When will we make…..the jump to hyperspace?" is a question posed in the "Speed of Light" exhibit. Encouraging more young people to study science and technology may help bring about this and many more discoveries in the future.

6 ACKNOWLEDGEMENTS

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1. Larry and Wendy Woolf for their pioneering work with color, art and science with children, Color My World and the General Atomics Education Foundation materials.

2. Darlene Boyd and Vivian Bottino of UC Irvine Gifted Student Academy for inviting the OISC to teach physics and astronomy to their middle school summer students and develop the K-4 Exploratorium based on Color My World.

3. Steve Jacobs and his team at the University Of Rochester Institute Of Optics for the original Optics Suitcase.

4. Kara Johnson and now Becky Newman and their colleagues at Think Together more inviting the OISC to bring science education programs to their students (about 650 of them in 2003-2004 and now looking to bring it to 1000's in 2008 and beyond.)

5. Joe Adams and his staff and volunteers at the Discovery Science Center who has hosted our now four annual Optricks Days at the Discovery Science Center where we have reached a few thousand young people of all ages.

6. OSA and SPIE for their continued support both financially and with much encouragement.

7. Larry DeShazer at the SOCCCD Irvine CACT now part of the ATEP for his ongoing encouragement, collaboration, financial support and inviting the OISC to be co-located at the facility.

8. The Optical Society of Southern California, without whom none of this would have happened.

9. Desire Whitmore from the UC Irvine OSA Student Chapter and Brian Monacelli from the OSSC, who are both now official Optricks Apprentices.

10. Eleanore Stewart and her staff and volunteers at the UC Irvine Beall Center for Art + Technology for inviting the OISC to participate in their Family Day events and for providing the space for our next Speed of Light Exhibit.