TEACHING AND LEARNING PORTFOLIO

by

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Learning

Research Teaching

This portfolio submitted in partial fulfillment of the requirements for the Delta Certificate in Research, Teaching, and Learning.

Delta Program in Research, Teaching, and Learning
University of Wisconsin-Madison

NSF

DELTA
Integrating Research, Teaching, and Learning

C I R T L

The Delta Program in Research, Teaching, and Learning is a project of the Center of the Integration of Research, Teaching, and Learning (CIRTL—Grant No. 0227592). CIRTL is a National Science Foundation sponsored initiative committed to developing and supporting a learning community of STEM faculty, post-docs, graduate students, and staff who are dedicated to implementing and advancing effective teaching practices for diverse student audiences. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Overview

This portfolio is a forum for the expression of my ideas about teaching and learning. It provides a collection of evidence from my experiences in putting those ideas into practice. I have focused in particular on analyzing the results of applying the Delta Pillars—Teaching as Research, Learning through Diversity, and Learning Communities—to my undergraduate non-major astronomy curricula and my K-12 informal science education and astronomy outreach. While careful assessment and sharing of materials among educators in undergraduate teaching is becoming the norm, in general science outreach programs lag behind in terms of assessment, revision, and effective dissemination of materials and lesson plans. As a science educator engaged in outreach, I am extremely interested in creating practical assessment tools, both for content learning and attitudinal changes, for the K-12 level. I have also been involved in developing online networks and websites for sharing quality materials with the greater outreach community.

This is a working document. Communicating these thoughts and reflecting on my experiences helps me to develop as a teacher and learner. I hope it will also demonstrate to you the kind of teacher I have been and will be.

Curriculum Vitae

Laura Trouille

Education

University of Wisconsin-Madison: Madison, WI (2004-present)
Defending Ph.D. thesis in Astronomy on May 7, 2010
National Science Foundation Graduate Research Fellowship (2006-2009)

Dartmouth College: Hanover, NH (1999-2003)
B.A. in Physics, Summa Cum Laude

Teaching

Teaching Assistant: University of Wisconsin-Madison (Spring 2006)
Developed and led weekly discussion sessions for six sections of 20+ students in an introductory astronomy course.

Tutor: University of Wisconsin-Madison (Summer 2006-present)
Tutor for introductory and upper-level undergraduate astronomy students.

Secondary School Teacher: (2003-2004)
Taught English language skills and basic computer skills to secondary school students, first in Prague, CZ and then in Tamil Nadu, India.

Mentoring

Undergraduate Research Advisor: University of Wisconsin-Madison (2006-present)
Mentored Thomas Finzell in the reduction of Subaru data using Perl-based Imcat codes and a 10-node computer cluster workingin parallel (2008-2009). Mentored Abby Cariker in her senior thesis project searching for high-redshift galaxies (2007-2008). Mentored Tim Larsen in a research project to investigate the evolution in the mass assembly history of galaxies (2006).

Co-leader of WOWSA: University of Wisconsin-Madison (2008-present)
Women of Wisconsin Strengthening Astronomy is a mentoring and networking program three of us graduate students created for the women astronomy undergraduates, graduate students, post-docs, and young faculty.

Research

Ph.D. thesis: University of Wisconsin-Madison (Successful Defense: May 5, 2010)
The OPTX Project: X-ray and Optical Spectral Properties of Active Galactic Nuclei
Advisor, Dr. Amy Barger.

Research Assistant: Southwest Research Institute. Boulder, CO (2002-2003)
3-D Monte Carlo Radiative Transfer Code modeling Titan's atmosphere.
Advisor, Dr. Eliot Young.

Research Assistant: Observatoire de Paris. Meudon, France (Spring 2002)
Modeling the transition between the solar radiative and convective zones.
Advisor, Dr. Jean-Paul Zahn.

Research Assistant: Dartmouth College. Hanover, NH (1999-2002)
Observations, isochrone fitting, and age determination of globular clusters.
Advisor, Dr. Brian Chaboyer.

Service

Galaxies Lunch: University of Wisconsin-Madison (2007-present)
Organize weekly extragalactic discussion group and lecture series.

WOWSA: University of Wisconsin-Madison (2008-present)
Wrote and obtained funding for visiting women astronomers to contribute to our department colloquium series and provide an additional lecture on issues relevant to women and minorities in the sciences.

NASA International Year of Astronomy Student Ambassador: Wisconsin (2009)
Created and exhibited a 'From Earth to the Universe' exhibit (forty 4'x3' astronomy images with captions in English, Spanish, and Hmong + scavenger hunt + website for further astronomy enrichment) at community centers, museums, planetariums, and observatories across Wisconsin.

Public Lecturer & Night Sky Showman: Madison, WI (2006-present)
Through the UW Space Place Science Museum and the 'Universe in the Park' program, have delivered dozens of public lectures and night sky shows with telescopes.

Expanding Your Horizons: University of Wisconsin-Madison (2006-present)
Leader of annual astronomy enrichment session for middle-school girls (ex. Created 'Where in the Universe is Sally Ride's Spacesuit?', an online astro-detective game)

Honors/Grants

♦National Science Foundation Graduate Research Fellowship, 2006-2009
♦NASA International Year of Astronomy Student Ambassador Grant, 2009
♦Co-PI for NSF WISELI grants to sponsor the campus visits for 12 women astronomers for department colloquia and diversity talks; a WOWSA program, 2008-2009
♦NRAO travel grant to attend the Taiwan ALMA conference, 2009
♦National Science Foundation travel grant to attend the Arecibo Single Dish Radio School, 2009
♦UW-Madison Vilas Travel Grant to attend the IAU General Assembly, 2009
♦AAS travel grant to attend the IAU General Assembly, 2009
♦Chambliss Astronomy Achievement Award, Honorable Mention, winter AAS, 2008
♦Wisconsin Space Grant & UW-Madison Knapp Grant for our After-school Astronomy Enrichment Program (ASAP with the Boys 'N Girls Club), 2007-2008
♦Wisconsin Space Grant to attend the CfAO inquiry-based learning PDW, 2006
♦Wisconsin Space Grant Graduate Research Fellowship, 2005-2006

The Delta Program in Research, Teaching, and Learning

As an astronomy Ph.D. student I participated in the *Delta Program in Research, Teaching, and Learning*, a learning community for graduate students, post-docs, academic staff, and faculty at the University of Wisconsin-Madison. Its purpose is to improve student learning in STEM fields through professional development for current and future faculty. The Delta website is at http://www.delta.wisc.edu.

The three central themes of the Delta program are:

- Teaching-as-research: *"The deliberate, systematic, and reflective use of research methods to develop and implement teaching practices that advance the learning experiences and learning outcomes of students and teachers."*

- Learning community: *"Bringing together groups of people for shared learning, discovery, and the generation of knowledge."*

- Learning through diversity: *"Drawing upon the diversity of students to enhance and enrich learning for all."*

The Delta Teaching and Learning Certificate

Through this program I earned the *Teaching and Learning Certificate*, which recognizes the completion of a program of study with Delta. Its requirements are:

1) Two graduate courses on teaching and learning.

I took the following two courses:
- *Instructional Materials Development*. We created an inquiry-based lab on Light and Color for the Intro to Astronomy non-majors lab course.
- *The College Classroom*. We developed teaching philosophies, created instructional materials, and obtained constructive feedback on short lesson plans from a community of STEM peers.

2) Participation in the Delta Learning Community.

I participated in the mentoring seminar where I met with a group of STEM graduate students and faculty to discuss readings, case scenarios, and our own experiences with mentoring undergraduates in research projects.

3) A teaching and learning internship.

I developed, implemented, and assessed a series of after-school astronomy enrichment activities for middle-school students and examined the impact on attitudes and motivations towards considering a career in the sciences.

4) Development and presentation of a teaching and learning portfolio.

Teaching Philosophy

Through the UW-Madison Delta Teaching Program, I have had the opportunity to think deeply about student learning and my role as a teacher. In brief, I strongly believe that a successful classroom experience boils down to both parties being actively engaged in the learning process. In the following teaching philosophy, I will discuss the positive impact of creating learning communities (both for the students and for the teachers), the empowerment that ensues from active learning, and the advantages of inserting new knowledge into students' pre-existing conceptual framework. I will also touch on the different approach I take with respect to non-majors' and majors' courses and the importance of engaging non-majors as well in the scientific process and enabling their development into scientifically literate citizens.

My ultimate goal as a teacher is to help students take ownership of their learning and enjoy the sense of empowerment from the ability to use scientific reasoning to address the most basic questions of life: Who are we? Where do we come from? Why does the universe look and act the way it does? Once curiosity is aroused and students know where and how to use the support that is available to them in their quest for knowledge, any student is capable of excelling in the college classroom. The first step is breaking the habitual passivity that students exhibit in lecture courses. Posner et al. (1981) discuss how setting up conflict within a student's conceptual framework, first of all, arouses their curiosity, and secondly, sets up a need for resolution. There are endless misconceptions and alternative explanations for physical processes. I like to start the learning on a specific concept by helping students see where their misconceptions fall apart. Together, we then determine the most valid explanation and move on.

Passivity also results from fear of embarrassment when wrong in front of their classmates (and the professor). To counteract this unnecessary inhibitor of education, I think it is essential to take time at the start of the term to make the classroom environment as comfortable as possible for all students. Especially at the start of the term, I like to arrive early and stay late after class to make myself available to students who may have special needs (or simply have a desire to know their professors). I also like to set up group work from the start and help facilitate the creation of study groups, which has been found to be especially helpful for minority students in the sciences. From my own experience as one of usually two females in my physics courses at Dartmouth College, I know how important the atmosphere in a classroom is to allowing all students to be able to simply concentrate on acquiring knowledge.

When I design my lectures, I am not thinking about how much of the textbook I can 'cover', but what I want my students to remember next week; next year. Studies have shown that if you can integrate new knowledge into a student's current conceptual framework, there is a better chance for long-term retention. If a class is small enough, I like to have students write mini-autobiographies on the first day (relevant information with respect to their previous experiences in this subject, both in the classroom and in general as well as their hobbies, interests). In this way I can tailor the demos, examples, and metaphors I use to their more specific interests. I also like to use the first day of class to carry out an assessment of the students' current knowledge and misconception in the subject. I can then start the course from their starting point rather than the textbook's.

But most importantly, to engage students, they should participate as much as possible during the actual class period (and outside the classroom as well). The traditional lecture format is important for setting up a framework into which my students can insert factual knowledge from the reading (and to present more up-to-date information), but the rest of the time, my role is as a facilitator. Even in large lecture courses, it is possible to have students work in small groups to analyze material, formulate problems, develop hypotheses, bring evidence to bear, and finally, criticize and evaluate possible solutions. Once the basic foundation is in place, students grappling with ideas leads to more meaningful and enduring learning than if they are simply told what to believe (Eriksen, 1983). In lab courses, my preference (and experience) is in inquiry-based labs in which there are no specific procedures to follow, but the students are both creators and investigators of their own experimental set-ups.

I strongly believe that science educators not only have an obligation to teach the fundamentals of their science, but also to develop science literacy and critical thinking skills in their students, so that they will be able to make informed choices when voting on science-related issues such as the environment and government funding for research. When teaching non-major courses, I believe it is more important to emphasize depth over breadth. My objective is to help students gain an intuitive understanding of the laws that govern the universe and sense of wonder at all the bizarre objects that exist within, but more importantly, to know how to use the scientific method to discern false claims from those supported by evidence. For the most part, my assignments and lectures are created to give the students as many opportunities as possible to interact with facts and figures and use their own ability to reason to come to conclusions about the materials at hand. Near the start of the term, these activities are strongly guided so that I am able to impart the correct tools and help the students develop a strong foundation to their inquiry process. Once that foundation is in place, I have my students list a few aspects of the course that they find most interesting and I use these lists to form groups. The final project is to participate in a poster session presenting their research on the particular question that their group found most interesting. I would open this poster session up the whole department and make it as professional as possible. In this way I try to have my students come away with improved critical reasoning skills and greater confidence in their ability to become ‘experts’ on a topic in the sciences.

On a broader level, once I establish myself as a researcher, I plan to use this position to help improve undergraduate and graduate education in the sciences, both at my institution and at the national level. In my own undergrad education, I was at times dismayed by the lack of importance attached to the quality of instruction in the sciences, which can have a chilling effect on the recruitment and retention of science majors. I hope to become involved in educational policy in order to make science teaching more effective and more engaging for all students.

Finally, a single class does not happen in a vacuum. As part of a team of teachers, I want to make sure that the overall curriculum for a student working towards an astronomy degree makes sense-- that we do not just assume that our students learned certain concepts in previous courses; that we coordinate the goals of one course with the overall goals for students working towards a degree within our department.

Mentoring Philosophy

Primary Goals: Empowerment, ownership, and a sense of community:

For short-term (semester-long) projects, particularly ones that are a student's first encounter with research outside of a classroom, I challenge myself to create a very well defined project which utilizes an obtainable skills set (given the time constraints) and has clear goals and definite milestones to celebrate along the way. I provide the tools and resources necessary for my students to develop the skills that enable them to tackle the given research problem. I am a demanding mentor, but because I constantly assess my student's abilities, I mold my expectations to match the current situation. And while it is a difficult balancing act, I aim to keep the momentum of the project going while at the same time allowing the student to push against the limits of his/her abilities in order to gain the sense of satisfaction and empowerment that comes with having tackled a problem using one's own knowledge and skills.

When working with a student for a longer term, I first meet with prospective students and assess whether my research and their interests are a 'good match'. I then begin the project as described above, but with time encourage the student to pursue their own research questions and ideas that arise once they have laid the foundation of knowledge through work on the initial project. Through my own experience, I know how essential it is to take ownership of and nurture a passion for one's research in order to maintain interest and progress. Yet I also feel strongly that students publish within their first two years of graduate school. The empowerment that comes from having been able to contribute to one's field is an enormous boost to a student's confidence and sense of belonging. So again, there is a difficult balancing act between knowing when to provide structured direction and knowing when a student will benefit most from increased freedom.

Whether with short-term or long-term projects, I have learned the importance of being a good listener. Not only because the collaboration then becomes a learning experience for me as well, but also so that I can constantly assess whether my student is gaining real knowledge and expertise from the experience. To this effect, I engage my students in an ongoing Socratic question-and-answer dialogue and strive to keep the conversation from being an exchange between expert and novice but rather one between peers in a quest for knowledge. Built in to this exchange is my recognition that each student is unique and brings their own talents and weaknesses to the table as well as backgrounds and learning styles. Once I am able to assess each student's particular strengths, I find appropriate ways to verbalize that I greatly value their contribution and share specific examples of how those particular strengths can be used to their advantage in their career as an astronomer. Through anecdotal evidence, I have learned that this is particularly important for women and people of color who, for cultural and historical reasons, are particularly prone to lacking confidence in their abilities as scientists. Also, because I seek out working with minorities, I incorporate into my praise valuing the contributions that come from having people working on a project from diverse backgrounds.

The experience of feeling isolated as the only woman in most of my physics classes as an undergraduate taught me the value of fostering a sense of community within my research group as well as within my department as a whole. As a result, I hold regular discussion groups with my students and encourage them to attend the department colloquia, informal lunches, and participate as much as possible in the ‘culture’ of the department. In our discussion groups (as in our one-on-one interactions), I set the example of treating my students as peers and placing equal weight and value on their opinion as my own. I use this forum to position our work in its larger scientific context and provide a space for my students to ask questions and practice explaining their research to a larger group in their own words. And most importantly, I use this space to celebrate our successes.

These formal and informal gatherings also provide a context in which to engage in a dialogue about life as an astronomer, what working in academia is like, and what career options are available following graduation with a bachelors in physics/astronomy, a master’s, or a PhD. Because being an astronomer is not only about the science but also about working within a community, I view my role as a mentor not only through the lens of providing support in a student’s quest to be a good scientist, but also providing support for everyone’s quest to feel like a valued member of this community. With this in mind, I will continue the tradition started by myself and a few other graduate students at UW-Madison of forming a women and minority discussion group. Besides meeting as a group with women and minority colloquia speakers and hearing how they navigated this sometimes subtly and not-so-subtly antagonistic environment, we discuss relevant articles and statistics, provide a space in which to support and praise one another’s accomplishments, and discuss concrete ways to be successful (i.e., publish high-quality articles as well as write successful observing and grant proposals) and retain the enjoyment of working in this exciting and interesting field.

Conceptual Understanding of the Delta Pillars

A. Teaching-as-Research

Teaching-as-Research is applying the methodology of a research project to one's teaching practices. This requires having a well-defined question, an activity geared at addressing the question, a clear method for assessing the effectiveness of the activity, and the ability to re-iterate the process. This process allows for the generation of quantifiable reasons to choose one teaching method over another. For example, in my DELTA Instructional Materials Development (IMD) course we were able to assess the quality of learning as a result of an inquiry-based lab versus a computer-based 'cookbook' lab. We were also able to improve the inquiry-based lab as a result of feedback through surveys.

B. Learning-through-Diversity

As an undergraduate, I had the opportunity to do an internship at the Paris Observatory. While in general astronomy research is conducted in the same way in France as it is here, there are a few institutional and educational differences that affect the way a particular research question is approached. Working within these differences led to insights on my research project. Similarly, in a classroom setting, the diversity of backgrounds, viewpoints, approaches, learning styles, strengths, and weaknesses all help to enrich the learning environment. However, this is only possible in an environment in which the diversity of people and backgrounds is valued and called upon.

C. Learning Communities

There is a growing movement within the scientific academic community to value education and public outreach efforts. A major impediment in this endeavor is that faculty and staff's time is spread quite thin and rewards are not based on teaching and community involvement. However, the support and sharing of materials, efforts, and assessment techniques through learning communities can lesson the tax on the individual and allow the work of many to enable the progress of the whole community. As astronomy TAs, we created an online repository for carefully prepared lesson plans (through the College Classroom course activities) to pool our ideas/resources and lessen the unnecessary individual reinvention of the wheel.

D. Personal Development of Understanding of Diversity

My father is French and most of his family still lives in France. My brother and I were lucky to spend our summers on my grandmother's farm in France. While we spoke mainly English while at home in the U.S. and participated in most traditional American activities, I grew up with two cultures. My worldview is defined by this experience of being both inside and outside of the majority culture.

Reflections and Artifacts

Teaching-as-Research

The Delta College Classroom and Instructional Materials Development Courses dramatically changed the way I approach teaching. The logic behind the 'Teaching-as-Research' model struck me from the first lesson plan I created using its principles—reverse engineering through first reflecting on common misconceptions, developing one's learning goals, creating formal and informal assessment, and finally designing the active learning activities with all of these aspects in mind. The first artifact included below is the final report for the Delta Instructional Materials Development Course for which I helped create an inquiry-based, hands-on lab to replace one of the passive, cookbook, often computer-based labs used in the ~20 student non-majors astronomy lab course. Our Light and Color lab encourages active, engaged learning and provides the opportunity to experience the scientific process. An important aspect of my teaching philosophy is the emphasis that I believe should be placed in non-major courses on experiencing the scientific process and developing students' critical thinking skills. This lab provides exactly that opportunity—the students generate their own research questions, develop their own hypotheses, create their own experiments to test these hypotheses, enjoy scientific discussions with their peers, and practice communicating scientific results. The emphasis in inquiry-based learning is on depth of learning as opposed to breadth of learning and on developing one's scientific literacy as opposed to focusing on the acquisition of facts.

As discussed in the report below, good facilitation is key to the success of inquiry-based learning. In our evaluation of this first experience with facilitation, we found that we were too hands-off. The balance between allowing the students to experience the 'failures' associated with the scientific process (going down the wrong path, allowing too many variables to cloud ones' results, etc) and controlling the experiment so that it only allows the right final answer is difficult to achieve. However, with experience and a better mastery of the scientific content being explored, good facilitation is possible. As TA (the following year) for the Intro to Astronomy Astro 103) non-majors course, I incorporated many problem solving, inquiry-based activities into my sessions. Because I had the opportunity to repeat the same lesson plan six times (with my six sections), my latter sections benefited from my having figured out the optimal moments to step in—i.e., after the students had wrestled sufficiently with a particular question but before too much time had elapsed and other important learning gains would need to be sacrificed.

In addition to carefully planning our facilitation, the next time I run an inquiry-based lab, I will be even more careful in terms of which initial questions I allow the students to pursue (see QWNDWTTS). It is important to begin with a question that is answerable with the given set of materials. Furthermore, if machines (like spectrographs) are involved in the exploration, I will be more vigilant about making sure the students are mentally wrestling with the concepts rather than trying to understand the inner workings of the black-box machine (unless this process provides insight into the scientific concepts in question).

Delta Instructional Materials Development Course, Research Report, Spring 2005
Team members: Laura Trouille, Laura Chomiuk, Bob Mathieu
Department of Astronomy

Introduction:

A. Background:

This report details the development of an inquiry-based exercise intended for the Astronomy lab courses at the University of Wisconsin—Madison. These lab classes, Astronomy 113 "Hands on the Universe" and 114 "Hands on the Solar System", are taught to introductory non-major astronomy students, and accompany a lecture course (either concurrently or subsequently, depending on the student).

Our project tackles two problems. The first is that many of the current labs are rather structured and formulaic, and we fear they do not encourage active, engaged learning. Many labs are centered around software on the computer, and answering a series of questions on a worksheet. We sense that these labs give little experience or understanding of the scientific process as a whole. We have come to believe in the central importance of these process skills, as the students in Astronomy 113 and 114 often do not pursue a scientific discipline. However, they will need the skills of critical thinking, synthesizing information, and collaboration throughout their lives.

Additionally, astronomy is a science about very distant objects and abstract concepts; we would like to find a way to bring these important scientific ideas "closer to home". For example, we are not at all sure that introductory astronomy students understand the concepts of light, color, and spectra in a concrete, applicable way. Most students simply see figures of spectra and blackbody curves in their textbooks, and we feel hands-on contact with these fundamental phenomena would prove extremely useful. Astronomers must glean all of their data from electromagnetic radiation alone, so it is important that our students understand that light can be very rich in physical information. Additionally, light is one of the more practical concepts that students will encounter in their astronomy classes.

B. Learning objectives:

Because we intend to develop a relatively free-form, inquiry-based lab, based in large part on individual curiosity, we must balance this technique by being clear in our learning objectives. Our goals for student learning are:

1. Color is a distribution of brightness at different wavelengths. Students can describe color of objects in terms of what colors (wavelengths) of light are being seen (detected). (Conceptual, Apply (Bloom 1956))
2. Students can create a graphical spectrum of an object of a certain color, with axes of brightness and color (wavelength). (Procedural, Apply)
3.Students remember that the colors of most "every-day" objects are due to reflection of specific colors (wavelengths) of white light. (Factual, Understand)
4. Students can predict correctly the emitted spectra of solid bodies (continuous) and hot gases (emission-line) from cases. (Factual, Understand)

5. Students remember that the color of light emitted by a solid object corresponds to the temperature of object. (Factual, Remember).
6. Students infer the relative temperatures of solid objects from their colors. (Factual, Apply)
7. Students remember that the color of a hot gas corresponds to the chemical composition of the gas. (Factual, Remember)
8. Objects emit light that cannot be seen by the eye. (Conceptual, Understand)
9. Students are able to inquire collaboratively, including evaluating how the collaborative work is proceeding. (Procedural/Meta, Evaluate)

The reader should note that we expect and hope our students will pursue their own curiosities in their own way. No individual lab group will have time to explore all aspects of Light and Color and therefore, it is unlikely that our students will achieve all nine of our learning objectives. Our hope is that they will truly understand 3 or 4 of them in an extremely deep, personalized way.

There is one exception to this rule, however; we expect every group to accomplish Learning Objective #9—that the students are able to inquire, collaborate, and iteratively assess their own work.

C. Evidence:

To understand what students are currently learning, and in what concepts student learning needs to be improved, we interviewed several students who took Astronomy 113 in the Fall of 2004. Several of the current labs in this course put students in contact with spectra, and all of the above learning objectives (except #9) are addressed to some extent.

We interviewed four students. By chance, the four students who offered to participate had a range of grades in the lecture and lab courses from A to C. Their relative abilities to answer these questions correlated reasonably well with their grades. Only the A student answered the questions well, at a level that suggested both deep and sustained learning. The other students had difficulty making a graph of any spectrum, including recognizing the appropriate axes of the graphs. They did have vague memories of blackbody curves and relationships of peak locations with temperatures. However, in two cases the ordinate of the graph with a peak was labeled as measuring temperature. They did typically know that the emission tubes were different because of different elements. (Note that all had seen them before in the discussion section of the lecture course.) The discussion of colors was based on "color wheel" ideas more than having a spectral base. All in all, it was clear that these students did not have a sufficient understanding of light to understand its many roles in their every day life.

Although there is very little quantitative data comparing student understanding and retention gained from cookbook labs with learning in inquiry-based labs, there is a large body of knowledge hinting towards the benefits of inquiry. First of all, giving students so much independence over their own investigations forces them to directly confront their existing conceptions. Often these conceptions are actually misperceptions about the natural world, founded on years of personal experience. These misperceptions would block and divert learning if they were not directly addressed, but it is difficult for a teacher to predict what these misperceptions will be! As students are given space to develop and state their own current ideas, the facilitator is given valuable insight into these previous conceptions. Deb O'Brien, a Massachusetts elementary school teacher, asked her students "What is heat?" and was surprised to find that her students thought sweaters, hats, and blankets were inherently hot (Watson & Kopnicek 1990). In this way, she gained valuable information about student misconceptions from their hypotheses. At this point, she could have addressed them in a lecture or demo. However, much evidence exists to show that this passive over-riding of preconceptions is not very effective. It fails to give students ownership of this new information, and therefore they return to their original ideas that were built upon a lifetime of experience (Posner et al. 1982).

By giving students the space and independence to pursue their own ideas, while still expecting progress and results, inquiry drives students to not only question the physical world, but to also question their own preconceptions.

D. Hypothesis:

We hypothesize that the depth and retention of student understanding will be improved by an inquiry-based lab focusing on the above objectives. The independently driven nature of inquiry will force students to delve deeply into these abstract, deceivingly simple-seeming concepts.

We hypothesize that an inquiry-based lab may appeal to a population of students not reached by more traditional teaching methods (lecture, problem sets, cookbook labs). Inquiry embraces the fact that there are an infinite number of paths to understanding, and they are all valid—thus making science more approachable. Also, inquiry-based labs stress values like curiosity, creativity, and communication, and may therefore have the potential to put some joy back in science for students who have been bored by such subjects since middle school. Finally, our lab will engage kinesthetic learners, who are often neglected in a large-university environment, where learning often happens in a lecture hall filled with hundreds of other students all taking notes.

Methods:

Inquiry may sound chaotic, but it actually needs to be very carefully choreographed in order to be successful. The procedure we plan to implement in our lab is as follows. It is drafted to take 4 hours total, comprising two 2-hour lab sessions.

At the beginning of the first lab period, we meet the students in the planetarium. We draw attention to Betelgeuse, an orange/red-colored star on the planetarium dome. We then briefly explain that the following lab is about color, light, and spectra. We begin with Betelgeuse because we want to place the lab in the context of why light and color are important to astronomers and hence to an introductory astronomy course. We then unveil 4 additional orange objects from under a sheet—a UV rock, an incandescent filament at low power, an orange incandesent light bulb, a neon gas lamp, and an orange cheese-head. Why are these objects orange?

We then lead the students through an activity that helps them think about how to ask good research questions. Mark Cook, from Animal Sciences and the IMD course, passed on an excellent activity that fulfills our needs. It begins with the statement of a fact: "5.5 inch Ruby-Throated Hummingbirds fly across the Gulf of Mexico (~580 miles) in one go, non-stop". We then ask the students to ask questions about this fact, which we write on the board. Questions that are too broad or too narrow can be discussed and revised as a group. At this point we could explain the concept of QWWWNDWATTs (Questions Which We Will Not Deal With At This Time—i.e., those with answers that cannot be investigated with the time and resources allotted).

This activity provides an effective segue into describing the next phase—the question-creation from materials at stations set-up in the lab room downstairs. Once downstairs, we divide the class into groups of four, noting that it is fine if they would like to work together, but each person must write their own questions. At each station (with different light and color materials) there are index cards onto which the students write their questions. Students spend 10 minutes at each station writing down questions.

Since the question classification takes a few more minutes to complete, we use this extra time to brainstorm as a class on the various aspects of creating a positive environment in which a group can work most effectively. The general procedure for this is that we ask the students to write down three positive group behaviors and three negative behaviors they have come across while working with others in the past. As a class we then write a few on the board under each category and allow discussion to develop. This activity not only lays the ground rules for effective group work but perhaps more importantly, emphasizes to the students that we highly value the collaborative aspect of the lab work and want them to be thinking about how well or poorly they are playing their individual role within their group. We then hand out the Team Evaluation sheet and briefly explain what is involved and how it will be used.

The questions that are now categorized have been posted in groups on the walls of the room. Once each student determines which group of questions they would like to focus on, they speak with other students interested in that area and form groups according to mutual interests. For the remainder of the first lab day, the students work with their group to investigate their line of inquiry with all the materials available in the room. During the second lab day, the groups complete their investigations and create a poster with which to communicate their results.

Before the poster session begins, we remind the students of the quiz that will occur at the very end. Since they have only investigated a fraction of the material that will be covered by the quiz, we urge them to find out from their classmates about the aspects of emission they may not have investigated.

After the peer instruction and synthesis by the facilitators, the students are handed the quiz with the question—Why are these objects orange? followed by the five objects.

Assessment:

Near the start of the first day of lab, the students know that we will assess their progress through three lenses—poster presentation of results, a short written quiz, and peer and self assessment of group work. We provide a clear and carefully constructed rubric for both the poster presentation and the peer review.

Results:

In an inquiry-based lab such as ours, the materials available to the students determines, in part, the type of questions they will ask and the depth of answers they may attain. Therefore, we ran several test-runs of the materials, using undergraduate and graduate student volunteers from within the astronomy department and from our Delta IMD class, before settling on a more permanent set to use in the actual Astronomy 113 lab.

Finally, we executed a "trial run" of our lab with Honors Students currently in Astronomy 113. Three students participated in the four-hour long lab. We were able to give these students a reasonably authentic experience. However, there were only enough students to form one investigation group. Therefore, only a sliver of all the possible material was covered, and there was no global exchange of understanding between their group and other groups during the poster session.

Our students chose to pursue the UV rock in their investigation. They noticed that, if the rock is sitting under the UV light and glowing orange and green in spots, when they turn up a nearby incandescent bulb to low power, the orange spots disappear. If they turn the bulb up to higher power, the green spots disappear too. The students asked: "Why do the orange spots disappear before the green spots?" We were impressed with this observation and this question. It dealt with issues of reflection, and understanding that color is a distribution of different intensities of light across different wavelengths. They spent the remaining time investigating their question (and related questions) and provided a coherent explanation during the poster session.

Our first attempt with this lab made us realize how incredibly important, and incredibly difficult and delicate, good facilitation is. We were too timid about "butting in", and only stepped in during the latter half of the investigation. This led to our students getting distracted by questions they could not answer, and even fundamental misunderstandings about the materials. For example, the students never figured out that the UV beads changed color when placed in UV light, thereby missing a lot of potential for interesting inquiry.

We had expected that the students would come to us and ask questions, but they never did. We hypothesize that they were able to maintain an investigation with such minimal facilitation because they were using a rather high-tech, fiber-fed, digital spectrometer for their measurements. This instrument is so rich in possibility, and can deliver so much (quantitative) information at any moment, that the students felt they were being productive whenever they were "taking measurements"—even when they didn't know what (or why) they were measuring! For a large part of the investigation, they were trying to figure out if the orange and green spots differed in brightness. However, it took them a half hour to realize that they'd been measuring the brightness of light at UV wavelengths—not at orange and green! At times, the spectrometer allowed them to substitute volume of data for methodical and comprehensive thought. At several points, they exclaimed to us, "It would be completely impossible to do this lab without this machine!" This dependence on technology is counter-productive, and we will have to devise strategies to prevent students from using the spectrometers as crutches.

Based on our informal assessments of the students' learning gains, we claim that our students did indeed gain a deeper understanding of fundamental physical concepts. When the students began the lab, they all had some introductory knowledge of reflection, emission, and their contributions to color. However, we noticed that their initial understanding was often flawed or superficial. For example, they had a difficult time answering the question, "Why does the rock change color when I turn the incandescent light bulb on (from orange/green to normal old grey)?" By the end of the lab, they were able to answer this question, and apply their knowledge in profound ways. A clear outcome is that during the approximately 60 minutes of unstructured activity, these students were carrying out a scientific exploration. And given that two of the three students expressed their dislike of science before the lab and then expressed their enjoyment of the inquiry process throughout the lab, we feel that this is an important accomplishment as well.

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Conceptual Change", *Science Education*, vol 66, 1982, pp 211-27

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Learning Communities

Faculty are expected to wear many hats and, as a result, spread their time thin between research, teaching, advising, committee work, etc. The importance of learning communities in this context is that the load is shared and, collectively, teaching techniques can be carefully designed, tested and improved. I have experienced first-hand the positive impact of an organized learning community as a graduate student in the astronomy department. A group of us astronomy graduate students took the Delta College Classroom course together during my 2nd year and developed and assessed lesson plans for the Intro to Astronomy 103 course. Throughout the term we served as guinea pigs for each other's lesson plans and provided constructive feedback for improvements. By the end of the term, we had created a dozen thoughtfully designed lesson plans for Astro 103 TA sessions. At the end of the term, we discussed ways we could improve the Astro 103 TA experience for future generations of graduate students. We decided to create an online wiki (www.astro.wisc.edu/goat) so that students who had not attended the Delta course could benefit from our hard work. We then requested past and current Astro 103 TAs to upload lesson plans they felt had worked well with their students, requiring them to use our lesson plan format which specifies learning goals, common misconceptions, materials needed, and a detailed description of the active learning activity. Over the years, several dozen lesson plans have been uploaded and current TAs actively use the wiki in creating their lesson plans. Since then, we have also included a section for after-school program activities, following the same lesson plan requirements. The wiki is open to the public and we have received positive feedback from people around the country. The artifact below contains a few snapshots of the wiki and an example of the positive feedback we have received.

Sharing Good Teaching Practices among TAs

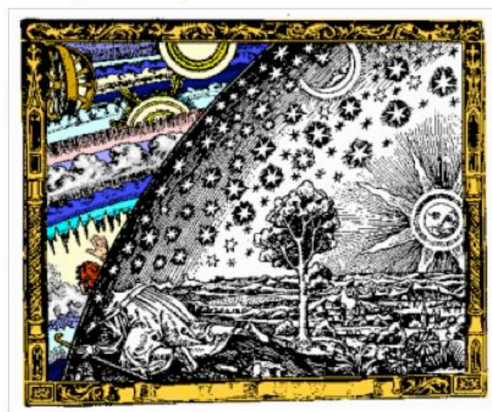
Each semester the astronomy graduate students who TA'd the introductory astronomy course reinvented the wheel—creating new learning goals, lesson plans, and materials. In 2006, a number of us astronomy graduate students attended the Delta College Classroom course and learned to apply the teaching-as-research method to developing lesson plans for the Astro103 discussion sections. In order for future generations to benefit from the time and thought we put into these lesson plans, we created GOAT—Guidance Online for Astronomy Teachers. This is a publicly accessible site that serves as an ongoing upload site for lesson plans designed for undergraduate astronomy courses as well as for after-school activities for the K-12 level.

The following is a screen grab of the front page of the website: www.astro.wisc.edu/goat:

Home | Lesson Plans | Links | How to Post | Contact

Guidance Online for Astronomy Teachers (GOAT)

We envision this site as a repository for lesson plans and teaching related materials that have been designed and collected by astronomy graduate students at University of Wisconsin - Madison. Our main goal is to make TAing more effective, less time consuming, more interesting, and reduce the number of times that astronomy grad students reinvent the wheel. However, we'd also like this site to have a broader focus and include outreach activities, book reviews and recommendations, lab activities, and teaching research information. We are committed to making teaching a priority and becoming better teachers ourselves.



Go ahead and check out the lesson plans. We've tried to standardize the format so that contributions are easily understood and compared. If you'd like to submit a lesson plan, please read the How to Post section. If you aren't an astronomy grad student here, you'll need to contact us in order to make a submission. Unless otherwise stated, lesson plans have been designed to fill a 50 minute discussion section attended by ~20 students.

The GOAT site is designed such that anyone with approval may post additional lesson plans. In order for these posts to be of the same quality as those designed and revised for the Delta College Classroom course, we created a set of guidelines and a template. We also allow space for comments, suggestions, helpful advice, etc. to be added to existing lesson plans as others try them out in the classroom.

The following is a screen grab of the webpage describing our guidelines for new posts:

Home | Lesson Plans | Links | How to Post | Contact

SO YOU WANT TO POST A LESSON PLAN

If you are a UW-Madison astro grad student and already have a login and password then proceed. If you don't have a login/password (or you aren't a UW astro grad) then please contact us for help.

After you login you'll immediately see the form where you can enter your lesson plan. Please use this milky way lesson plan example (txt file w/some html) and replace my words with your own. Use the "files" and "images" tabs to upload files and images and link to them as shown in the above example. We'd like lesson plans in the following format:

Topic/Concept:
Type of Activity: (individual, small group,large group, discussion, lecture, lab, outreach)
Prerequisite knowledge required:
Resources required:
Learning Objectives:
Common misconceptions:
Detailed description of activity:
Assessment:
Associated files and images:
Comments:

The following is an example of emails we have received from people outside of the University of Wisconsin-Madison who have also found this to be a useful resource.

---------- Forwarded message ----------
Date: Tue, 5 May 2009 09:58:46 -0500 (CDT)
From: <amanda.samuels@ddmail.org>
To: <freeland@astro.wisc.edu>
Subject: GOAT > Inquiry

Name: Amanda Samuels

Email: amanda.samuels@ddmail.org

Message: Hi,

I would just like to let you know that I have found several of the resources listed on www.astro.wisc.edu/goat/links quite useful, and I would like to thank you for the time and effort invested so far; thanks!

I'm not sure if you are interested in suggestions or not, but I thought that I would try to contribute something to further improve the resource for other visitors.

A resource that I have used myself as a starting point for research on multiple occations throughout the years is AcademicInfo (academicinfo.net). The website features hundreds of subject guides as well as educational resources and online degree information.

I think it would make a pretty good addition to your resource list. What do you think?

Keep up the good work!

Regards,
Amanda Samuels

Emphasizing the ‘Scientific Habits of the Mind’ in Undergraduate Non-Major Courses

As TA for the Intro to Astronomy 103 course, I developed, implemented, and assessed a small group activity designed to incorporate experiencing the scientific process into a large lecture course for non-majors. The artifact below contains a description of this group project and ways to improve it for future use.

I strongly believe that as educators we have a responsibility to future generations to facilitate the development of their scientific reasoning skills. Given the numbers of students each year that take an Intro to Astronomy course to fulfill their quantitative reasoning requirement, we have the opportunity to make a real impact in creating a scientific literate population, capable of thoughtfully evaluating news stories and political policies. My teaching philosophy for non-majors it to emphasize depth over breadth, incorporate active learning into the lectures and research-based projects into the overall curriculum. These research-based projects give the students practice generating research questions, developing hypotheses, and devising experiments and/or conducting scientific literature-based research. The peer and self-evaluations and clear rubrics help foster everyone’s engagement in the project and promote healthy communication and sharing of tasks. The final report and subsequent poster session provides the students’ opportunities to improve their communication and leadership skills.

Under the current format, the students research (by reading scientific journal articles, reviews in popular science magazines, online information sites, blogs, etc.) their topic and then synthesize and summarize their findings. While they do read about the scientific process, they do not experience it first-hand. To remedy this failing of the current set-up, in future incarnations I will have each group recreate a simple historical experiment associated with their line of inquiry. For example, I will provide the group that studies the expansion of the Universe the actual data (distance versus redshift) from Hubble’s observations of galaxies at the Mt. Wilson Observatory. With this data, they will determine that the simple relation between the distance and redshift is in fact incorrect (in terms of what we know today) and investigate the cause for this inaccuracy. Data based experiments will provide an essential additional dimension to this group project—the ultimate goal of which is to incorporate more opportunities for the students to familiarize themselves with the scientific habits of the mind.

Group Projects in Astro 103

During the spring of 2006 I TA'd for Astro103—Introductory Astronomy at the University of Wisconsin-Madison. This consisted of preparing for and running six discussion sections a week, holding office hours (3 hours a week), and providing review sessions before the two midterms and the final exam. I was very fortunate to TA for Dr. Matt Haffner, an astronomy staff scientist genuinely interested in assuring that his students truly learned about astronomy and the scientific process. Also, he gave me complete freedom in developing my lesson plans and provided constructive feedback and advice. Before the start of the term, I approached Dr. Haffner with the idea of including a group project in the course, using the Large and Small Magellanic Clouds (dwarf irregular galaxies orbiting our galaxy, the Milky Way) as inspiration for exploring fundamental questions about our Universe. We were both very interested in incorporating more opportunities in the course for the students to better understand the scientific process (rather than just focusing on learning the facts and history of our discipline).

Early in the term we exhibited beautiful radio through X-ray images of our Magellanic Clouds and listed seven categories of inquiry (black holes, interacting galaxies, dark matter, etc.). The students listed their top three choices, creating groups of three according to shared interest. After a first-round review of the literature, starting with a few suggested articles on their topic that we selected from popular science journals, each group sent me three questions they would be interested in researching. I then held a session, largely based on my experience creating and facilitating the Light and Color inquiry-based lab (developed for the Delta Instructional Materials Development course), on generating good research questions. During the TA sessions, we then used peer-review to revise the original research questions. Each group then researched their questions and wrote a report, for which I provided a comprehensive rubric. After receiving feedback about their reports, each group created a poster to present during the final week of class.

The poster sessions were open to the department and generated much positive feedback (both for the students and for the design of the project). Through my own experience and that of my peers, I was well aware of the potential pitfalls of group work. Based on literature reviewed in the College Classroom course, I included peer- and self-evaluation as part of the project grade and allowed flexibility at the start of the term for changes in group membership. In their evaluations for the course, a number of students discussed their previous negative experiences with group projects and their pleasant surprise that for this project the workload was shared, the variety in skills needed for the project emphasized different learning styles (allowing different members of the group to take the lead for different parts) and that the carefully constructed rubrics made our expectations very clear (see example on following page).

Mission #2 Due April 6th (Thursday in lecture):

2-4 page report including the following:

1) Definition of terms and important concepts.
2) How do we learn about your topic? Who are the main astronomers who have made significant contributions to understanding your subtopic? What wavelengths/telescopes/satellites are used to conduct observational studies of your object/subtopic? What theoretical basis supports particular relationships or ideas related to your subtopic?
3) What have you learned about your question/line of inquiry? Include diagrams or images if they are useful in helping you explain your ideas and your findings.
4) Lingering questions and further avenues of investigation. Through your research you will have learned an enormous amount about your topic, but we recognize that all good questions and answers lead to more questions. Please share with us your (and/or the astronomy community's) unanswered questions concerning your topic.

Rubric for the Report:

Level of Achievement	Organization	Scientific Content	Research and Interpretation of Data/Info	Integration of knowledge
Excellent 141 points	Organizes material in a clear, appropriate, and precise manner.	Uses many sources of different kinds. All information is relevant to the topic.	Correct interpretation of data or information. Analysis and conclusions are based on research.	Understands implications of findings and identifies further avenues of investigation.
Good 110 points	Organizes material in an appropriate manner, but may lack clarity or consistency.	Good number of sources. Shows some attempt at varying the 'type' of source. Information is relevant with only minor exceptions.	Combination of above, but less consistently.	Combination of above, but less consistently.
Adequate 70 points	Combination of above and below.	Uses a few sources. Information is for the most part relevant.	Correctly interprets data or information, but analysis or conclusion may not be supported by research.	Makes little effort to examine conclusions in a broader context.
Deficient 30 points	Little evidence of a cohesive plan. Little or no description or detail. Ideas seem scrambled, jumbled, or disconnected.	Research is minimal. Includes much information that is not relevant.	Incorrectly interprets data or information with little or no analysis or conclusion. Little or no evidence of research presented.	Makes no connections between conclusions and broader context.

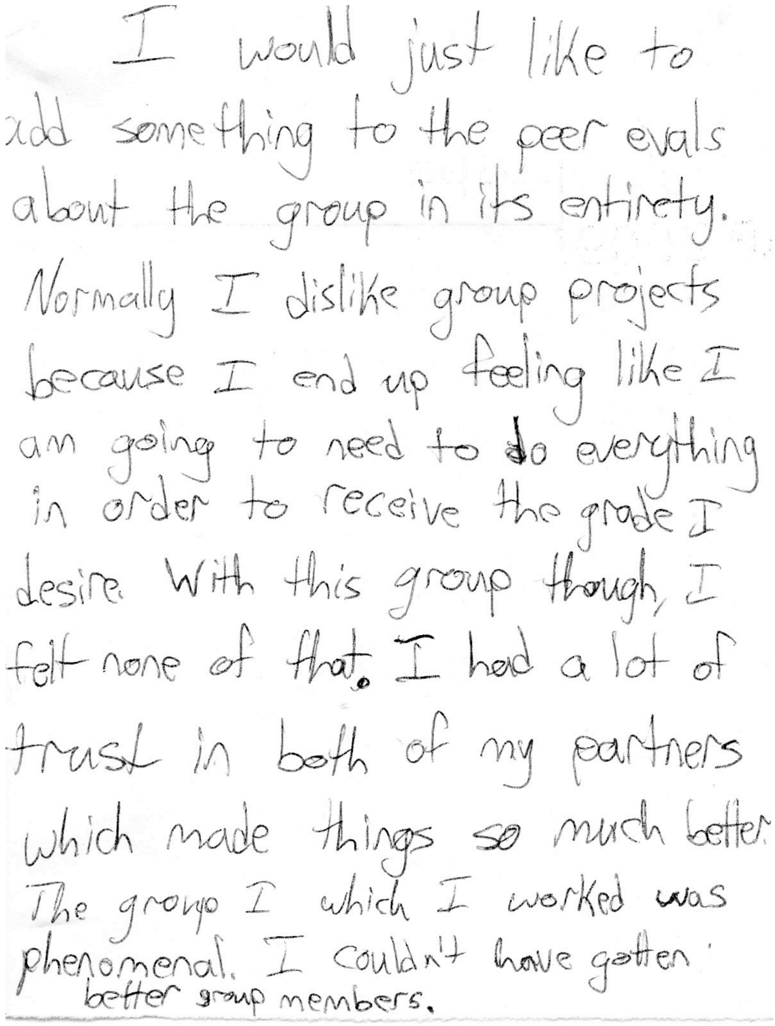
Peer Evaluations:

The following evaluation will contribute to the determination of your final grade for this project (25 points out of 260 total points). Each person within your group will turn in an evaluation of himself/herself and of his/her fellow group members (due April 15). I always avoided filling these out when working on group projects until one of my professors presented it as a guideline to help the group work together efficiently and effectively. It really helped! Please read through this rubric before starting to work together on mission #2 so that you know what is expected of you as part of your group. And please come speak with me if you see a problem arising within your group so that together we can work out the kinks.

Your Name:___________________
Group member being evaluated:_______________________

Category	4	3	2	1
Contributions	Routinely provides useful ideas when participating in the group and classroom discussion. A definite leader who contributes a lot of effort.	Usually provides useful ideas when participating in the group discussion. A strong group member who tries hard.	Sometimes provides useful ideas when participating in the group discussion. A satisfactory group member who does what is required.	Rarely provides useful ideas when participating in the group discussion. May refuse to participate.
Quality of work	Provides work of the highest quality	Provides high quality work.	Provides work that occasionally needs to be rechecked/redone by other group members to ensure quality.	Provides work that usually needs to be checked/redone by others to ensure quality.
Preparedness	Brings needed materials to group meetings and is always ready to work	Almost always brings needed materials to group meetings and is ready to work.	Almost always brings needed materials but sometimes needs to settle down and get to work.	Often forgets needed materials or is rarely ready to get to work.
Focus on the task	Consistently stays focused on the task and what needs to be done. Very self-directed.	Focuses on the task and what needs to be done most of the time. Other group members can count on this person.	Focuses on the task and what needs to be done some of the time. Other group members must sometimes prod, nag, and remind to keep this person on task.	Rarely focuses on the task and what needs to be done. Lets others do the work.
Working with others	Almost always listens to, shares with, and supports the efforts of others. Tries to keep people working together.	Usually listens to, shares with, and supports the efforts of others, but sometimes is not a good team member.	Often listens to, share with and supports the efforts of others, but sometimes is not a good team member.	Rarely listens to, shares with, and supports efforts of others. Often is not a good team player.
Monitors group effectiveness	Routinely monitors the effectiveness of the group, and makes suggestions to make it more effective.	Routinely monitors the effectiveness of the group and works to make the group more effective.	Occasionally monitors the effectiveness of group and works to make the group more effective.	Rarely monitors the effectiveness of the group and does not work to make it more effective.

A number of students included addendums to their peer evaluations, like the one shown below. The recurring theme was that previous group work experiences had been discouraging, but that this experience had gone smoothly and to their benefit—the load was shared equally, the interest and excitement about the subject was shared, and each group member brought different and useful strengths to the project.



I would just like to
add something to the peer evals
about the group in its entirety.
Normally I dislike group projects
because I end up feeling like I
am going to need to do everything
in order to receive the grade I
desire. With this group though, I
felt none of that. I had a lot of
trust in both of my partners
which made things so much better.
The group I which I worked was
phenomenal. I couldn't have gotten
better group members.

Broadening the Base:

Engaging a Diverse Population at the K-12 Level

The International Year of Astronomy (IYA) 2009 provided momentum and funding for numerous initiatives to engage young people in the sciences, in particular people of traditionally underrepresented groups in the sciences. The first artifact below describes the 'From Earth to the Universe' astronomy image exhibit with captions in English, Spanish, and Hmong that I designed, built, and displayed across Wisconsin—at the UW Science Expeditions, the Dane County farmer's market, the Milwaukee Planetarium, Yerkes Observatory, etc. I created a scavenger hunt to help guide people through the exhibit and a website for further astronomy enrichment (both of which are described in more detail in the artifacts below).

The second artifact under this heading is my Delta internship final summative report. As a Delta Intern, I created five astronomy enrichment after-school program modules that emphasize the contributions of women and minorities to astronomy. They are also designed to positively impact the attitudes and motivations of young people towards considering a career in the sciences. In partnership with the Toki Middle-school After-School program, I tested the modules on a dozen middle-school students. Through pre- and post-surveys, I assessed the effectiveness of this program in generating interest in pursuing a career in the sciences.

This summer I will begin a new phase in my career as a postdoctoral researcher at Northwestern University. My appointment is 4/5 as an astronomy researcher and 1/5 as coordinator for the NSF GK-12 program. I will serve primarily as a liaison between the STEM graduate students and the elementary through high-school teachers with whom they will be working 10 hours a week. Their project is to devise curricula that incorporate scientific research and the scientific process into the K-12 classroom. The participating secondary schools serve a very diverse population of students. In order for the exchange to be the most beneficial for the K-12 students, it will be very important to incorporate the lessons I have learned from the two experiences described below. Specifically, I have found that the students are most engaged when lesson plans include pictures and stories of scientists who resemble them (i.e., when I highlight the contributions to the sciences from people of traditionally under-represented groups), when the students have the opportunity to get their hands dirty and experience first-hand the scientific process through inquiry-based learning, and when connections between the science and their every day lives or local communities are pointed out explicitly.

Wisconsin's 'From Earth to the Universe' Exhibit

In the fall of 2008, I applied to be Wisconsin's NASA International Year of Astronomy Student Ambassador. I wanted to create a high impact astronomy outreach tool that would allow a diverse audience to connect with astronomy and science in general. I used the NASA grant money as seed funding to create an image exhibit consisting of forty of the most beautiful astronomy images, printed to large 4'x3' dimensions, and placed on stands. There are kid-friendly captions in English, Spanish, and Hmong (translated by the UW-Madison Hmong Student Association). I created scavenger hunts (in English and Spanish) to help guide kids and kids-at-heart through the exhibit and a website for further astronomy enrichment and to advertise upcoming astronomy-related events (see next two pages).

Calendar of Events

- **April 4, 2009:** UW-Madison Campus Science Expeditions
- **June 20, 2009:** Monona Terrace Planet Trek
- **June 25, 2009:** MSCR Summer-School Program, 15 people
- **June 27, 2009:** Dane County Outdoor Farmer's Market, ~800 people
- **July 8, 2009-Sept. 15, 2009**: Milwaukee Plantarium, > 1000 people
- **Sept. 15, 2009-Oct. 14, 2009:** Yerkes Observatory, >600 people
- **Oct. 14, 2009-Nov. 22, 2009:** UW-Whitewater & annual Science Teachers Conference
- **Dec. 12, 2009:** UW Space Place Saturday Morning Activity for grade school students
- **Dec. 31, 2009:** UW Space Place & US Bank Eve
- **Jan. 16, 2010:** Overture Center 'Kids in the Rotunda' program, ~750 people

Scavenger Hunt
Búsqueda de tesoro

Each image has a small RED letter on it. Write the letter of the image that best shows…
Cada imagen tiene una letra roja escrita en ella. Escribe la letra que muestra mejor…

______ Earth seen through Saturn's rings
La tierra, visto a través de los anillos de saturno

______ A comet with two tails
Un cometa con dos colas

______ The largest volcano in our Solar System
El volcán más grande de nuestro sistema solar

______ A planet passing between Earth and the sun
Un planeta pasando entre la tierra y el sol

Bonus: Can you name the planets in order?
Puntos extras: ¿Puedes nombrar los planetas en orden?

______ Madison's capitol building lined up with 2 planets, 1 star and the moon
El capitolio (edificio) de Madison está alineado con 2 planetas, una estrella y la luna

______ A constellation of 7 bright stars, known as "the Seven Sisters"
Una constelación de 7 estrellas, nombrada "las siete hermanas"

______ A group of 5 galaxies
Un grupo de 5 galaxias

______ A star forming region that looks like a horse's head
Una región de formación estelar que se parece a una cabeza de un caballo

---

Have you found the secret message?
¿Has encontrado el mensaje secreto?

For more astronomy enrichment activities visit:
www.astro.wisc.edu/outreach
www.astro.wisc.edu/~trouille/IYA09

Para más actividades en español visita:
http://oeop.larc.nasa.gov/hep/NASAespanol.html

I created a website for the International Year of Astronomy with further astronomy enrichment activities and information (www.astro.wisc.edu/~trouille/IYA09). The website includes 1) links to games (such as www.astro.wisc.edu/~trouille/EYH, an astro-detective game we created for our annual Expanding Your Horizons astronomy workshop for middle-school girls), 2) information about contribution by minorities to the sciences, a calendar of astronomy-related events in the Madison area, 3) links to science-related resources specific to minorities as well as for the general public, 4) and an 'Ask-an-Astronomer' page.

A write-up in the UW New & Notes about the FETTU exhibit (one of many news articles either advertising an upcoming event or describing a previous event).

News & Notes

COLLEGE OF LETTERS & SCIENCE University of Wisconsin-Madison

FRIDAY JUNE 19, 2009

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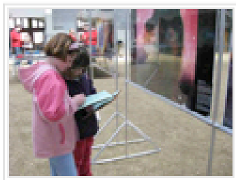
"International Year of Astronomy" promotes science literacy around Wisconsin

The International Year of Astronomy (IYA) 2009 celebrates the 400th anniversary of Galileo recording his first observations through a telescope.



Young astronomers walk through the "From Earth to the Universe" image exhibit in celebration of the Int'l Year of Astronomy.

Astronomers at UW and around the world are using this special event to promote science literacy in their local communities.

Laura Trouille, a UW astronomy graduate student, received a NASA IYA Ambassador Grant to bring the **"From Earth to the Universe"** astronomy image exhibit to Wisconsin. This scavenger hunt helps lead kids (and kids-at-heart) through the forty beautiful astronomy images with captions in English, Spanish and Hmong.

The exhibit is on tour throughout the summer:

- June 27: Dane County Farmers' Market, Madison
- July 8th-31st: **Milwaukee Planetarium**
- September 1st-October 15th at Yerkes Observator, University of Chicago

For the kids, **visit here for more information** and be sure to check out the **UW Space Place** for many astronomy events throughout Wisconsin this summer.

Come explore the Universe with us!

Category: Biological & Physical Sciences | SHARE
Tags: July, Space Place, Top Story, Astronomy

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Anyone take a class with Chem Prof Larry Dahl? He's a legend: http://ow.ly/gXo5 Top pic = the best. Enjoy retirement, Larry! #uwmad about 2 hours ago

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‘Teaching-as-Research’ Internship Summative Report

by

Laura Trouille

Last updated May 7, 2010

Abstract:
For my Delta 'Teaching-as-Research' internship, I developed, implemented and revised a series of five astronomy enrichment activities with an emphasis on contributions to astronomy and science by women and minorities. Through pre- and post-surveys of a group of twelve students participating in the program through the Toki Middle School After-School program, I found that this series of sessions overall did have a positive impact on these predominantly Latino and African-American students in terms of their attitudes and motivation towards considering a career in the sciences.

I. Question:

Can five after-school astronomy enrichment sessions for middle-school students traditionally underrepresented in the sciences positively impact their motivation and attitudes towards considering a career in science?

II. The Problem:

As other countries challenge the long-standing competitive edge of the United States in science, technology, engineering, and mathematics (STEM) disciplines, with international students outperforming their U.S. counterparts on achievement measures, many deem it imperative to enhance the quality and reach of K-12 science education and thus the future participation of all segments of the U.S. populace in scientific and technological fields (National Science Board, 2006).

Accompanying the rise in the percentage of minorities in the overall population, it is predicted that 80% of the undergraduate population will be minority students by 2015 (U.S. Census Bureau, 2000). At the same time, minorities make up only ~6% of the STEM workforce and only 4.6% of minorities in the STEM workforce hold doctoral degrees (US Census Bureau, 2000). This is not surprising given that in 2000, 66% of African American fourth graders, 74% of African American eighth graders, and 78% of African American twelfth graders performed below a basic level of science proficiency, markedly worse than their ma jority counterparts (National Assessment for Educational Progress, 2000). In order to increase minority enrollment in science majors at the University level and in the STEM professions, it is essential to support and strengthen their science education at the K-12 levels (Ntiri, 2001).

75% of Nobel Prize winners in the sciences report their passion for science was first sparked in out-of-school/after-school environments (Friedman & Quinn 2006). A recent study of after-school programs by the Coalition for Science After School at the UC-Berkeley Lawrence Hall of Science highlighted the high demand for partnerships with local science experts and assistance in implementing age-appropriate, thought-provoking science materials. While quality after-school science materials are available (see http://www.sedl.org/afterschool/guide/science), the majority of after-school program staff do not incorporate them into their programs, citing lack of expertise, time, and resources (Chi et al. 2008).

Furthermore, though minority students may have access to equal educational opportunity by occupying the same classroom space as their peers, they do not necessarily enjoy equal and fair access to the same quality of experience. This lack of accessibility results from the race-related beliefs and norms interwoven into the fabric of United States society (Herrnstein & Murray, 1994; Parsons, 2007). For example, there is a tendency in public schools for minority students to be placed in general tracks where they are less likely to be challenged academically. Also, the National Science Education Standards (National Research Council, 1996) noted minority students' lack of knowledge about and access to the educational resources of the surrounding community. These barriers result in lower educational aspirations and hopes for many minority children as well as lower academic and career self-efficacy (Ntiri, 2001).

III. Addressing the Problem

Toki Middle School provides after-school programming for about one hundred 6^{th}-8^{th} grade students on Mondays through Thursdays from 2:40-4:05 pm. Approximately 90% of these students are minorities, with 60% African-American, 18% Latino, 12% Asian, and 10% Caucasian (private communication, Hauck 2010).

Ariana Hauck, program director for the Toki Middle School After School program and mentor to many Toki students, advertised the astronomy program a month before in order to generate interest (see Appendix I). She also hand-picked half a dozen students she thought would benefit from the experience but who were unlikely to sign up without being directly solicited. Thus a dozen students obtained the necessary parental signatures for the IRB permission form (see Appendix-II and III). At the start of the first session, I met with the twelve students, learned about their backgrounds in science and had them fill out the pre-surveys (see Appendix-IV). The pre-survey gauges the students' attitudes and motivation towards considering a career in the sciences. It also attempts to understand the students' perception of scientists, whether they have accessible role models in the sciences, and whether they can envision themselves as scientists.

I have experienced first hand the importance of role models in being able to envision and confidently pursue a given career route. With this in mind, I deliberately incorporated pictures and biographies of women and minorities in all the lesson plans. For example, in the web-based astro-detective game, each clue page (for tracking down Pluto's location) has a picture of an astronomer from an underrepresented group and a brief description of their seminal contribution to the field. The clues are written as quotes so that each astronomer helps the student along in their quest. For the rocket day, I printed biographies of a dozen NASA astronauts, including Guion Bluford (the first African-American astronaut), Ellen Ochoa (the first Latina astronaut), and Jeffrey Williams (Wisconsin-born commander of the International Space Station). After talking about each astronaut, I had the students choose their favorite and tape the corresponding photo to their newly built rocket. As part of the matching objects of the Universe activity, I accompanied a quarter of the images with photographs of astronomers from underrepresented groups who study that particular astronomical object. I spent additional time talking about Dr. Eric Wilcots, astronomy faculty here at UW-Madison, who is African-American. I hoped that by focusing on a local example, it would make all of the biographies we discussed seem more real and accessible.

Because I ultimately wanted to impact the students' attitudes and motivations, second in importance to providing role models was to make sure that the activities were fun and engaging. Keeping in mind that my students are twelve and thirteen year olds in an after-school setting, I designed all of the lessons to be very hands-on and interactive. Rather than deliver a power-point show of all the beautiful astronomical images for the size-scale/astronomy overview session, I created a series of matching games to be done as races between two teams. Later in that session, each student manipulated play-dough to create a scaled model of the Solar System and rolled out toilet paper across the library to understand the relative distances between planets. The Light and Color session lent itself best to the inquiry-based learning style of teaching. After giving each student a pair of diffraction glasses and leading them through a short series of basic experiments, I had them go out and explore their surroundings. The only requirement was to return with a question that we could try to address as a group. We all have a natural curiosity about the world around us and I wanted to give time for them to enjoy this discovery-experience before launching into the specific planned activities. I also deliberately kept the Rocket Launch session for the final day so that they had a particularly fun activity, a reward, to look forward to.

An important aspect of changing attitudes is having students truly believe they are capable of being scientists. One of the best ways to achieve this is to provide ‘authentic’ science experiences. In particular, I designed the Galileoscope Building and Rocket Launch sessions with this in mind. The Galileoscope is a high-quality, low-cost telescope kit developed for the International Year of Astronomy 2009. In two teams, the students took turns reading the instructions and assembling the pieces. This required teamwork, good communication, problem solving (when pieces did not fit as expected), and perseverance. The assembly is not easy, but a working product in the end gives the students the satisfaction and self-empowerment that comes with hands-on creation. Once assembled, I had the students write secret messages, run across the playground, and see if their partner with the telescope could see what they had written or drawn. At this point they realized the image is flipped. This led to a series of experiments with lenses to understand what happens within the telescope to cause this flip. We also discussed the history of telescopes and connected their experience with that of Galileo 400 years ago. The Rocket Launch activity provided the opportunity to experience the iterative process of science. The students developed a hypothesis on what features of a rocket would allow for the furthest flight. They each built a rocket according to their hypothesis, flew the rocket, and went back to the drawing board to see how they could improve their original design (all the while eating astronaut ice-cream).

IV. Discussion of Evidence

The students’ attendance of the after-school program is often dictated by their parents/guardians’ schedules and other outside factors. While there were between eight and twelve students at each session, I was only able to obtain both pre- and post-surveys from five students who attended all five sessions. Four of the five students in the pre-survey said that they enjoyed attending science class. Three wrote that Tech class was their favorite class (including the student who marked that he did not enjoy science class). Tech class is a hands-on engineering/technology lab course offered at Toki. While all of these self-selected students indicated that they find science interesting and enjoy science or tech class, the pre-survey shows that only one considered science to be a possible career route. After the five sessions, one additional student marked that he thinks science is a possible career route. Three of the five students in the post-survey said that they would enjoy working in a science lab. It is important to note that in the pre- and post-surveys, the students who did not agree with these statements marked that they were ‘Not Sure’.

A major problem with these surveys is the 'Not Sure' response. Four of the five students marked 'Not Sure' for six or more of the eighteen statements. This response makes it difficult to gauge the impact of the sessions. The statements about friends opinions elicited the most 'Not Sure' responses and, unless significantly altered, should be taken off future surveys. It is possible to glean some information if the response in the pre-survey was 'Not Sure' and in the post-survey was positive. For example, one student went from being unsure about enjoying working in a science lab to strongly agreeing that he would enjoy working in a science lab. Two students went from being unsure whether their friends enjoyed science class to agreeing that their friends enjoyed going to science class.

Two of the five students showed very little change in their attitudes/motivations (none of their answers switched from strongly agree or agree to strongly disagree or disagree). This is because they already had a very positive attitude towards science and science careers and fortunately the sessions did not have a negative impact.

In addition to the formal assessment with the pre- and post-surveys, I incorporated informal assessment throughout the five lessons. The main method I used for informal content-learning assessment was to re-use certain images of astronomical objects in a number of the sessions. For example, in order to connect astronomy to everyday life, I made sure to include a few constellation images (the Big Dipper, Cassiopeia, and the summer triangle group) during the first session. The images re-appeared in the third session on Light and Color when we explored what causes stars to have different colors and what kinds of stars populate our visible sky. About half of the students remembered all of the constellation names from the first to this third session. Similarly, after discussing the images of particular stages of stellar evolution in the first session, I set up a game in the third session that had the students put the images in order, from birth of a star to death of a star. They worked in groups of three and in listening to their discussions; I was able to gauge how well they retained the information discussed in the first session. I was impressed with a number of the students who were true sponges to astronomy information. The same experience held for the online 'Where in the Universe is Sally Ride's Space Suit?' game, which had the students tracking Pluto to many of the astronomical objects discussed in the previous sessions. During this computer-based day, I had each student navigate to the Astronomy Picture of the Day website which contains many of the astronomical images I used in the sessions. Besides having each find the image that was published on their birthday, they chose their favorite image after browsing through the list and explained why they found that object particularly intriguing. My hope is that many will return to this website (and the other astronomical enrichment links I gave them) in the future on their own time.

V. Lessons Learned

I was able to achieve the goal of creating fun and engaging science enrichment activities for middle-school students in an after-school setting. The students' energy and excitement during the activities was infectious, and helped remind me why I am very lucky to be a life-long student of astronomy. Ariana Hauck, the after-school program director, overheard a few of the students talking about how fun and interesting the astronomy program was over lunch one day. Additional students joined the group partway through the sessions as a result of having heard positive descriptions from their friends. It is very important in an after-school setting where the students have the choice of what activity to pursue, to make sure that the science-related activities are fun and appealing. Only once you have students' participating can you have any impact on their choices and decisions.

One of the goals of the program was to connect students from traditionally underrepresented groups with local resources for additional science enrichment. With this in mind, after the Galileoscope Building session, I gave each student a flyer advertising the upcoming Friday Night Sky Show and observing with telescopes to be held at the UW Space Place Science Museum in Madison and the Saturday morning Science Workshops. I forgot to ask the students the following week whether they attended. Also, I have not been able to set up a practical way to track future attendance at Space Place by these particular students, so I do not have a way to gauge this aspect of the program.

The first day, two of the students were not able to stay on task (in reality, one student was interested, but was too easily distracted by his friend). One of the after-school program aides was helping me that first day, and after giving them a warning, he told them they could not participate and made them leave. Neither student returned for any of the subsequent sessions. I knew that the one student was truly interested in participating, but I was not able to take the time before the other sessions to locate him and let him know that he could return. The episode was particularly frustrating because it involved two of the four African-American students who attended.

I have much to learn in terms of being an authority figure who commands the respect (and silence when asked for) of the students as well as an adult person who shares in their enjoyment and excitement of science. This is a difficult balance to achieve. I look forward to working with middle-school teachers next year (through my position as a liaison for the NSF GK-12 program at Northwestern University which partners STEM graduate students with local teachers to create research-based curricula for the classroom). I hope to learn from them how to better keep discipline while having fun.

VI. Conclusions

In designing and implementing after-school science enrichment programs, it is very important to make the activities fun and engaging. Furthermore, there are simple and straightforward ways to incorporate discussion of the contributions to the sciences by women and minorities. The students thus gain access to much-needed role models and a greater sense of the true possibility of successfully pursuing a career in the sciences. Lesson plans are only useful if they have been properly assessed to gauge their impact on learning and/or attitudinal gains. This internship has allowed me to create a first draft of a pre- and post-survey to gauge the attitudes and motivations of middle-school students towards considering a career in the sciences. While this assessment tool requires some modifications, it has allowed me to recognize that just five after-school astronomy sessions can have an impact, albeit slight, on positively impacting attitudes.

The next step in this study is to run a year-long after-school astronomy enrichment program, administer surveys before, during, and afterwards (including a significant amount of time later), and conduct formal interviews. As a post-doc in astronomy at Northwestern University, I will have access to experts in science education and be able to implement my astronomy after-school program within an already established infrastructure of STEM outreach in local middle schools.

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Impact of the Internship on my Understanding of the Three Delta Pillars

Teaching-as-Research:

Astronomy plays a key role in helping to generate excitement and interest in the sciences, for people of all ages. NASA and NSF recognize that our nation faces a serious problem in terms of attracting young people into the sciences and have launched a major effort to create programs online, through schools, museums, etc. to engage the public. While many of these lesson plans and activities are posted online, very few have accompanying evidence of their effectiveness in terms of content and/or attitudinal gains. Each group therefore reinvents the wheel or perpetuates poorly designed lesson plans. This internship is the first step in my creating five lesson plans that other outreach groups will be able to implement in their programs with minimal start-up time and with the knowledge that they will have real impact. Because I first determined the learning and attitudinal goals and assessment technique for each lesson before planning what would actually be done, each activity is very intentional and focused. I ran a summer-school program prior to this internship with the main intent of determining common misconceptions among middle-school students with respect to each subfield addressed by the five lesson plans. This research allowed me to directly address these misconceptions in my lesson plans and use them to set up cognitive dissonances to pique the students' natural curiosity and interest.

Learning Communities:

I have greatly appreciated the weekly seminar meetings with my peers. In particular, I am inspired by Ashley's project for high-school teacher professional development and Ben's online structured research aid for the college classroom. I can see both of these ideas transferring well into the context of astronomy. Particularly valuable has been the sharing of concrete, specific ideas and materials to use for when I carry out my own variation of their projects. The Learn@UW drop site makes this sharing of materials easy and the structure of the course makes it such that I have felt very comfortable asking my peers to post their materials. Also, while this is not in the forefront of our conversations, I know that meeting with peers who are interested in providing an effective and stimulating learning experience for their students has helped keep me optimistic through another term of graduate school. The concentrated focus on research in graduate school is difficult for those of us who are interested in developing our abilities as teachers and outreach specialists as well as researchers. This DELTA community not only provides access to literature and ideas but also to emotional/motivational support and a sense that at least a part of the University community recognizes the importance of quality teaching and mentoring for the next generation of scientists.

Learning-through-Diversity:

All of the students who participated in the program were sharp, quick to understand, and hungry for knowledge. However, it was striking to see which students were comfortable navigating the Internet, using a diffraction grating, etc. versus those who were not. This had nothing to do with intelligence, and everything to do with access—at home and in their extracurricular activities. To simplify the issue, these differences in access will make a huge difference in terms of which of these students will most likely attend college, pursue science careers, etc. The more we are able to provide a level playing field from an early age, the more likely the STEM disciplines will see a real increase in applicants from people of all races and socioeconomic backgrounds.

Appendix

I. Advertisement for Astronomy Club
II. Pre- and Post-Survey
III. Example Lesson Plan (Rocket Launch)

AFTER-SCHOOL ASTRONOMY

Want to launch your own rocket? Build a telescope?
Ever look up at the night sky and wonder if there are aliens or what it'd be like to fall into a black hole?

THEN COME TO AFTER-SCHOOL ASTRONOMY!

The first astronomy session will be Tuesday, March 16th.

Following days: Wednesday, March 17; Thursday, March 18; Monday, March 22; Tuesday, March 23.

To participate, please bring with the signed permission forms.

SEE YOU THERE!
Laura & the astronomy team

Kalpana Chawla

Charles Bolden

Astronomy Enrichment Sessions—Questionnaire

1	2	3	4	5
Strongly agree	Agree	Not sure	Disagree	Strongly disagree

1) In general, I like school _____
2) I enjoy going to science class _____
3) My friends enjoy going to science class _____
4) If I had a choice, I would not study any more science in school _____
5) Science makes me feel like I am lost in a jumble of numbers and words _____
6) Doing science requires creativity _____
7) Learning science is mostly memorizing _____
8) Everyone can do well in science if they try _____
9) I like learning about science when it is not part of my homework _____
10) Science is useful for solving everyday problems _____
11) Science is interesting _____
12) I would enjoy being a scientist _____
13) I would enjoy working in a science lab _____
14) I think being a scientist is a possible career for me _____
15) My friends think being a scientist is a possible career for them _____
16) I trust the ideas scientists come up with _____
17) My friends think scientists are nerdy _____
18) I think science would benefit from my contributions _____

On the back of this sheet, draw a scientist.

Fill in the blank:
What is your favorite subject in school? ________
In what school subject do you perform best? _______

Yes/No questions:
Do your parents/guardians ever help you with your homework? _____
Are your parents/guardians involved with your school in any way? _____

Rocket Launch Lesson Plan

Learning Goals:--------------------------

- A general overview of rocket history, important astronauts and what they accomplished.
- A baseline understanding of rockets, what makes them go, what we use them for today.
- Have students experiment and understand the differences in a rockets trajectory based on aerodynamics and launch angle.
- Continue excitement going forward by tapping in to the future of space flight.

Common Misconceptions: -------------------------
We can travel to stars and planets in a short amount of time. (It will take New Horizons probe 9 1/2 years to reach Pluto! The nearest star outside our solar system is Proxima Centauri at a whopping 4.2 light years or 25,000,000,000,000 miles away. For comparison, Pluto is only about 90,000,000 miles away.

Materials Needed:--------------------------

Video:
A computer or projector for viewing rocket launch videos to start the demo.

Rocket Building:
9 Pairs of Scissors. Tape, instructions, PVC pipes, construction paper, astronaut fact sheets

Rocket Launch:
1 Rocket Launcher
1 Air Compressor
A long empty hallway or gym, or access to outdoors

Description of Activities: ----------------------

I. Videos: (5-Minutes)

- Video of Atlas 5 rocket launch and sonic boom (sonic boom at 1:55) distorting sun dog. http://www.youtube.com/watch?v=SsDEfu8s1Lw&feature=player_embedded

II. Important Astronauts: (5-10 Minutes)

- Give a brief description of a handful of influential astronauts from diverse backgrounds (Mae Jemison, Sally Ride, Deke Slayton—a WI native, etc.) and allow each participant to pick their favorite. Have them cut out the portrait of their astronaut in preparation of launching them into orbit!

III. Building Rockets: (15-20 Minutes)
- Split up class into 3 groups.
- Give each group 3 pairs of scissors, 3 rolls of tape, 2 sets of instructions, and 2 PVC tubes for rolling.
- Explain instructions, emphasizing that the construction paper tube should be tight to the PVC tube but still slide.
- Allow them to make 2 rockets each, with a different number or configuration of fins.

IV. Rocket Launch: (20-30 Minutes)

- Take group to launch zone with both rockets in hand.
- Have kids hypothesize what is going to happen before launches. What will changing launch angles and construction types do to the trajectories?
- Give each kid a turn to fire one of their rockets at a set angle (Approximately 60 degrees) to demonstrate flight differences based on the different rocket constructions of the class.
- Allow kids to choose which rocket they want fired next on their turn and to specify a launch angle.
- See if they can figure out how launch angle affects trajectory.
- Launch one rocket at 60 degrees, 45, and 30 degrees, to see what these changes do. What do they have in common? What is different? Why?

V. Future of Rockets:

- Show some of the things being done in Madison dealing with rockets (Orbitec).
- Show some of the commercial rockets being created right now (SpaceShipTwo, Space X)
- What are the differences between the companies? (SpaceShipTwo is designed for passengers to launch from an aircraft. Space X is designed for both passengers and payloads to launch from the surface.)

Websites: -------------------------------

Orbitec (based in Madison) http://www.orbitec.com/. SpaceShipTwo http://www.virgingalactic.com/. Blue Origin http://www.blueorigin.com/index.html. SpaceX http://www.spacex.com/. Space Dev http://www.spacedev.com/. NASA Astronauts http://www.jsc.nasa.gov/Bios/. Woman of Space http://www.astronautix.com/articles/womspace.htm.
Mercury 7 http://history.nasa.gov/40thmerc7/bios.htm.