

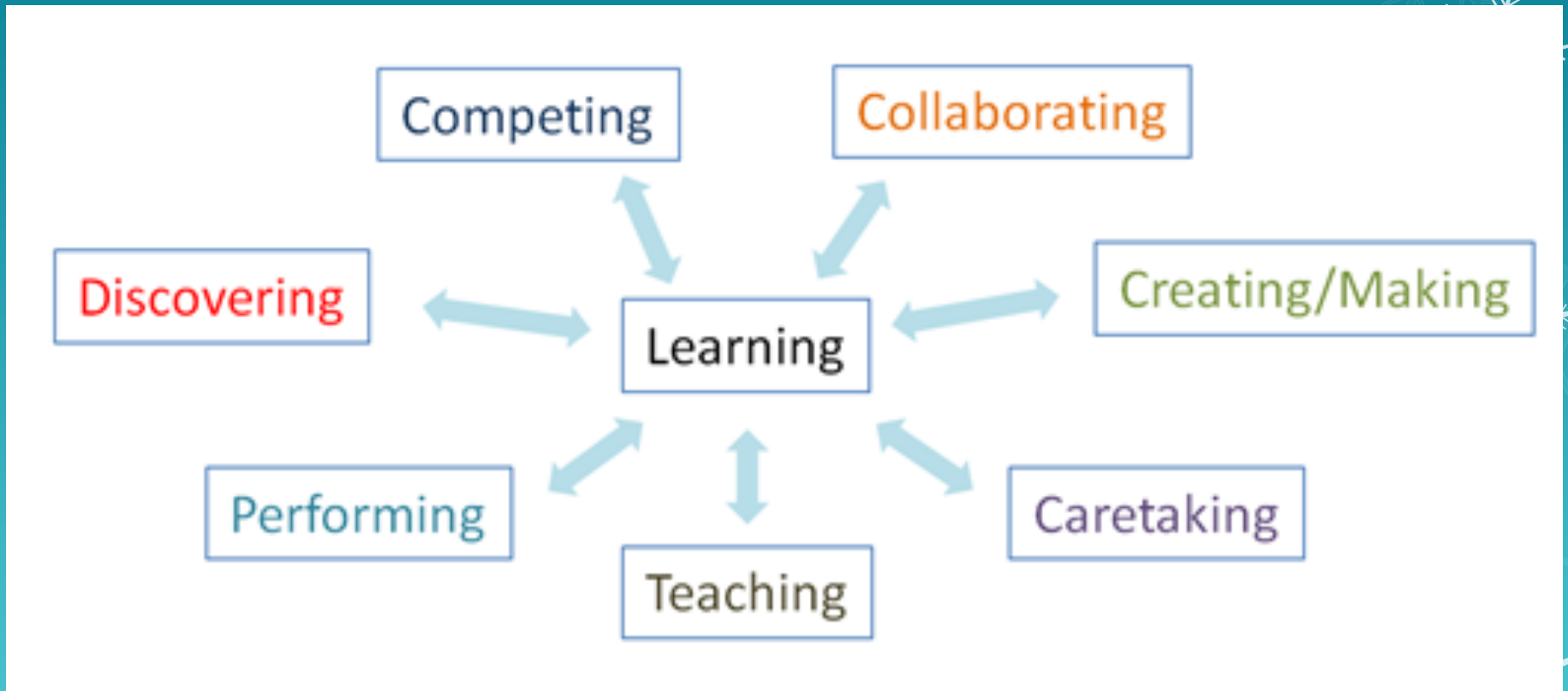
# Framework for the Observation and Categorization of Interest in Science

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MRSEC Education and Outreach  
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# FOCIS Typology

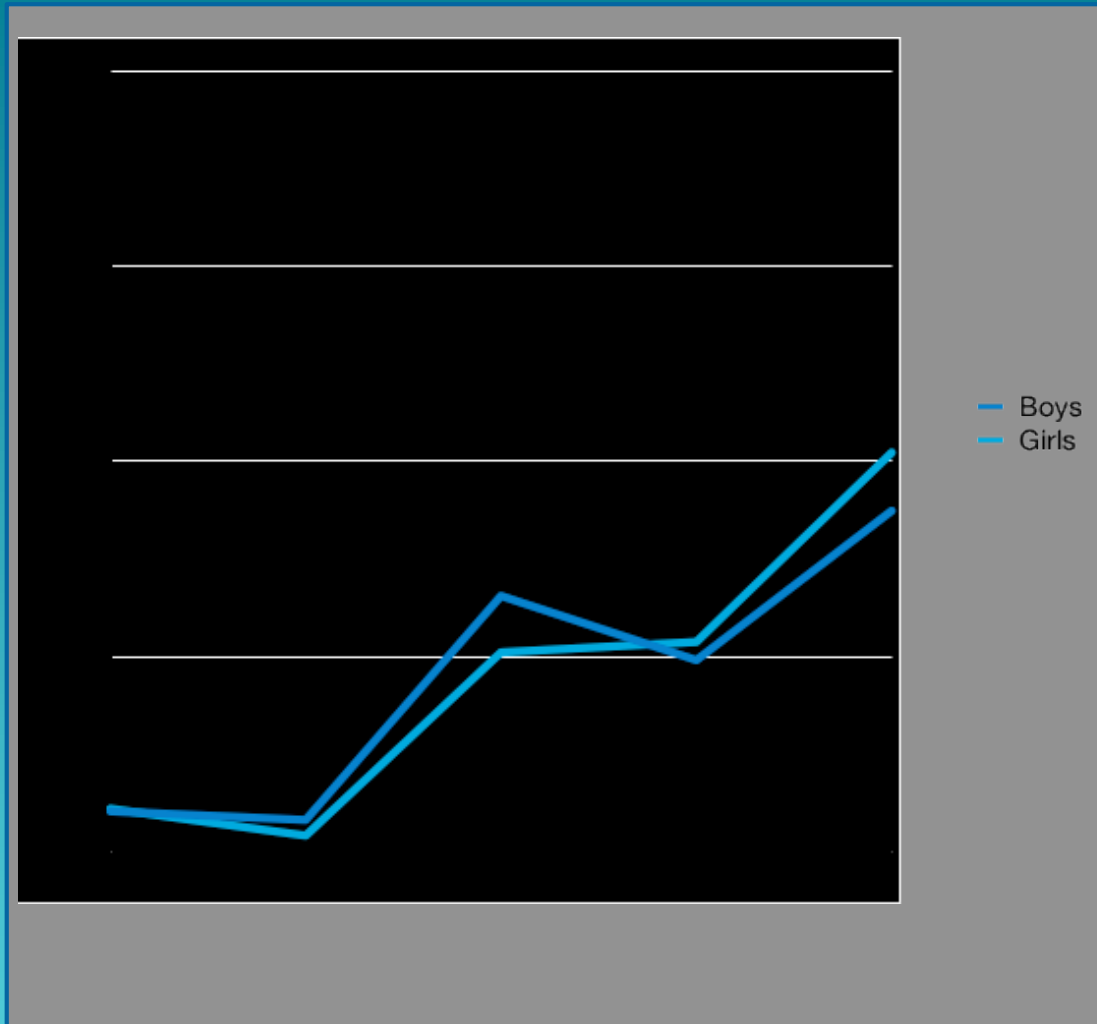


# Example of an Analysis

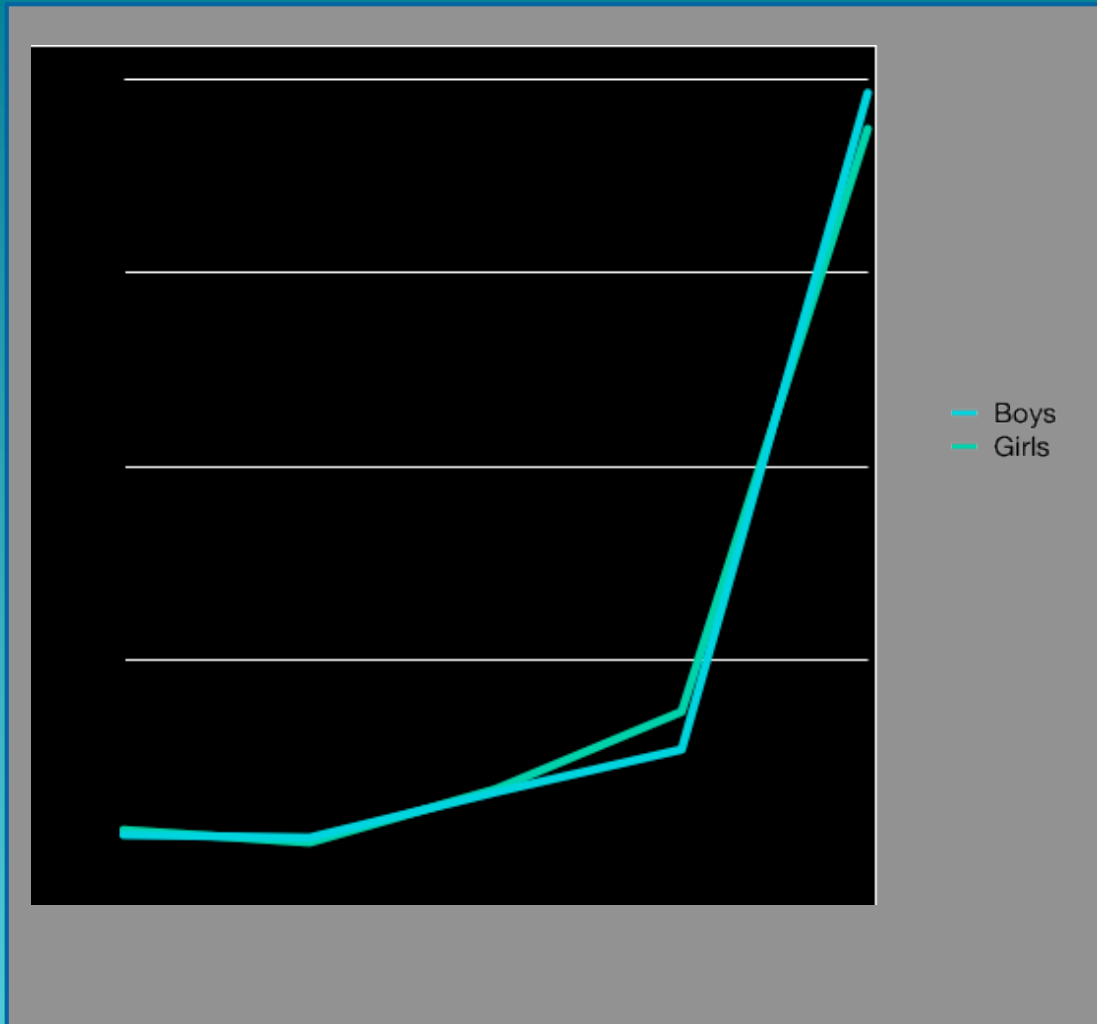
Results from FOCIS Survey test offer some insight on the use of the FOCIS typology

- A 5-Day Summer Science Program – 465 participants in Grade 4<sup>th</sup>-6<sup>th</sup> at 17 sites, nationally.
- 2:1 Male to Female Ratio of participants
- Analysis of Summer Program curriculum using FOCIS typology shows activities targeted to “Collaborating” and “Creating/Making”, but no “Caretaking” activities.
- Analysis of the FOCIS survey results produces the results below.

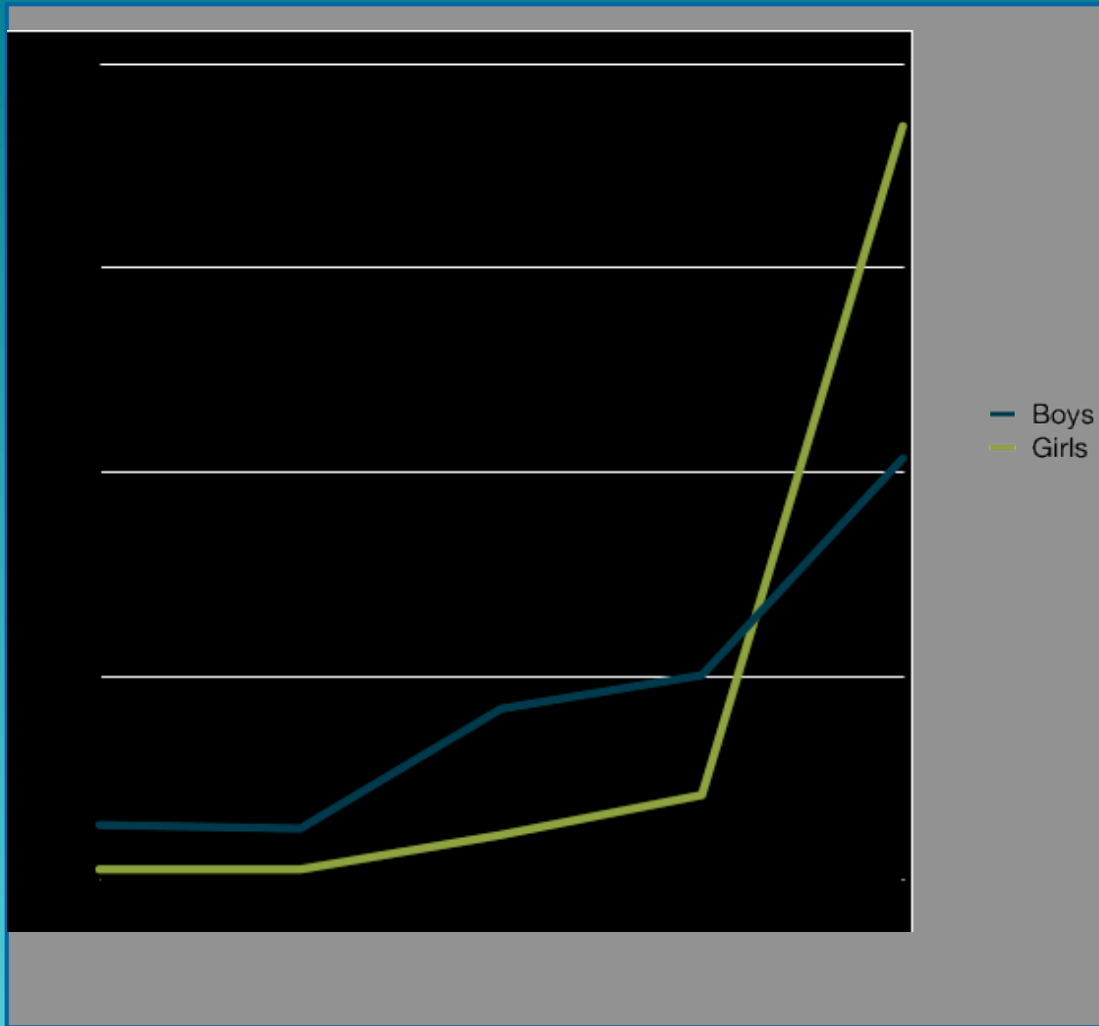
# Collaborating



# Creating/Making



# Caretaking



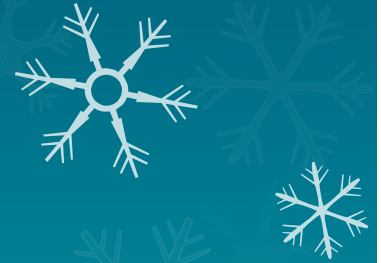
# 1. Pennsylvania Summer Science Initiative, PSSSI



This is a free four-week long program for local high school juniors and sophomores. I currently take 28 students, demography - 50% female, 29% minority this year. The program runs daily from 10:00 am-3:30 pm. The students have a formal materials science lecture by Penn Faculty followed by a computer lab. They divide into four groups and do a series of four labs, one per week, based on metals, polymers, concrete, and OLEDs/Solar Cells, for which they have to write individual reports each week. During the final week there is not enough time to write a report so I have each group give a joint oral report on the last day. In addition, I take them on field trips to a bronze casting foundry, a chemical company's laboratory, and the Chemical Heritage Foundation's museum. They also visit Penn facilities e.g. Regional Laser Lab, robotics lab, materials characterization facility, etc.

## 2. UW MRSEC – IEG Education Outreach Activity

In partnership with the Wisconsin Institutes for Discovery (WID), the UW MRSEC has developed and led a series of materials science/nanotechnology field trips in the WID's embedded teaching labs. These state-of-the-art labs were designed and built specifically for students to come to the UW campus and experience cutting edge research. The embedded teaching labs also give us access to equipment such as a tabletop SEM, which are typically unavailable in school classrooms. UW MRSEC leads at least one field trip per week on topics from introductory nanotechnology through liquid crystal synthesis. Students who participate range from elementary to high school and approximately 60% are from underrepresented minority groups. This partnership has given us the opportunity to test and improve our materials while disseminating to a large student population.





# 3. GT MRSEC RET

The GT MRSEC provides up-to six metro-Atlanta high school physics teachers an eight-week research experience every summer. The objective of the program is to familiarize participating physics teachers with the modern materials and physics concepts and their applications to engineering as well as their relevance to today's technology. Each teacher works on an individual research project with a MRSEC faculty. Participants get unique opportunities to:

- learn applications of modern physics concepts to microelectronics that are relatable to high school students;
- work in state-of-the-art research laboratories;
- prepare research-based curriculum materials for their classes; and
- participate in professional development workshops and outreach activities during the academic year.

Participants are expected to fully attend all components of the program. A summer stipend of \$6,000 is provided to each participant. The RET program is assessed professionally. The participating teachers are administered a pre- and post-program surveys and a utilization survey six months after completing their research experience.

## 4. CMSE Science and Engineering Program for Middle School Students MIT MRSEC



The science and engineering program for middle school students at the MIT MRSEC seeks to introduce local adolescents to materials science and engineering, demonstrate that science and engineering is fun, and give the students an opportunity to experience a college environment. Rising seventh- and eighth-grade students from two local Cambridge elementary schools participate in the week-long program with their science teachers each summer (one school attends one week; the second another week).

Typically, about 50% of the participants are from underrepresented groups. The program focuses on hands-on activities designed to engage the students. Each week, the students are at the Center from 8:30-2:45 Monday-Friday. The days are usually divided into three classes presented by faculty, staff, graduate students, and undergraduates. Classes on glassblowing, metal casting, electric circuitry, building simple DC motors, and making solar cells, as well as polymer and superconductivity demonstrations, are examples of the content. The classes change a bit from year to year, depending on the teaching staff available.

# 5. OSU MRSEC Teacher Professional Development



Week long materials camp (facilitated by ASM), with teacher follow-up throughout the year. Two levels, advanced camp and first year camp. We have two roles in the ASM camps. The first role is to evaluate the effectiveness of the workshops in terms of adoption of materials science activities, improvement of content knowledge and improvement in attitudes toward materials science.

Evaluation includes: a materials science concept inventory, attitudes towards engineering, a check-list of activities teachers plan to use (or did use) and an open response survey asking how general materials are used in everyday life and how materials lessons can help teachers meet 9th grade physical science standards.

The second role is to improve workshop materials by applying research findings on student difficulties to discussions in the workshops and rewriting of material science activities. So far, we have led active discussions and assigned homework reading during the workshop on student misconceptions in materials science. Identifying and addressing misconceptions in introductory materials science engineering course

## 6. Quarter/Semester long intervention in introductory materials science course at OSU

Based on extensive interviews and testing with engineering faculty and students, we developed a full set of research-based, classroom tested group-work recitation tutorials a diagnostic test for the introductory materials science and engineering course has been designed and field -tested. These materials have been iteratively constructed and field-tested for six quarters. The tutorials have been shown to significantly improve student performance. Currently we are following leads to expand the use of the tutorials at other institutions.

We have also begun a project to develop online practice assignments for essential engineering skills and knowledge, such as reading log plots and unit analysis when solving problems.

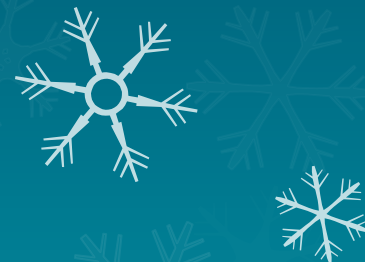
## 7. The Brandeis MRSEC Partnership Discovery Museum in Action

The Brandeis MRSEC has expanded its partnership with the Discovery Museum in Acton. We now sponsor one thematic day at the museum per semester. These days are publicized on the museum website as Brandeis MRSEC affiliated events and are open to the public with admission. For each day, we design and lead 5 to 7 exhibits throughout the museum based on the day's theme. Last year's fall event was entitled "Exploring the World Beyond our Eyes: Adventures in Microscopy with Brandeis Scientists." Activities included using microscopes to visualize protozoans and self assembly and the exploration of molecules in 3D using protein structure viewing tools. Based on informal assessments administered to exhibit participants indicating the need for more hands-on, interactive exhibits, in the spring, we sponsored "Adventures in Nanotechnology." These exhibits allowed students to look into microscopes and see tiny particles, but also allowed them multiple opportunities to "build" what they saw. This event was extremely popular bringing in more that 150 museum patrons.



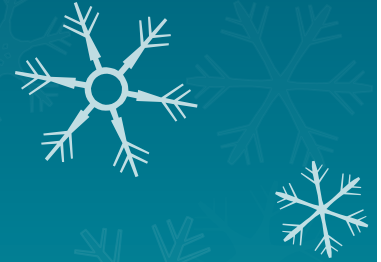
# 8. ASPIRE Program Description

ASPIRE (A Student-led Program in Research and Education) is an outreach and education program of the University of Massachusetts, Amherst, MRSEC that provides high school students with a unique opportunity to gain experience in chemistry, physics and engineering of polymers—areas of study rarely taught in traditional high school science classes. With the support of graduate student volunteers and a MRSEC outreach coordinator, ASPIRE welcomes 20-25 high school students from neighboring high schools to participate in a 5-week winter program. The high school students are engaged in hands-on polymer science lab experiences ranging in focus from synthesis to mechanical testing. The program aims to improve scientific literacy and expand future opportunities by increasing high school students' motivation, interest and enrollment in the science and engineering disciplines. Using multiple recruitment strategies, ASPIRE aims to reach and impact a diverse group of students including women, underrepresented groups, and students with limited exposure to science. Based on the involvement of graduate student volunteers, ASPIRE is designed to also improve graduate students' confidence, skill, and content knowledge, and increase their interest in mentoring and teaching.



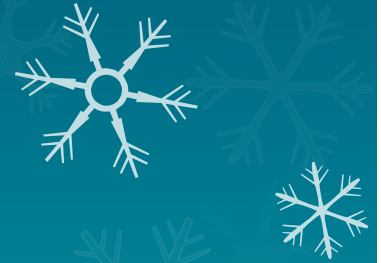
## 9. NanoDays at the Museum of Life and Science in Durham

$\Delta$ MRSEC has partnered with the NC Museum of Life and Science (MLS) in Durham to leverage MLS's projects in the Nanoscale Informal Science Education Network (NISE Net). On March 24, 2012,  $\Delta$ MRSEC Fellows and Investigators participated in the MLS NanoDays and reached hundreds of children and adults by presenting  $\Delta$ MRSEC relevant experiments. Enabled by native Spanish speakers in the  $\Delta$ MRSEC, some experiments were presented in Spanish. The activities found enthusiastic reception by visitors, fellows, and MLS staff alike, and form the foundation for additional outreach activities with MLS.



## **10. ΔMRSEC Fosters STEM Awareness through Collaboration with NCCU's W.I.L.L. Program**

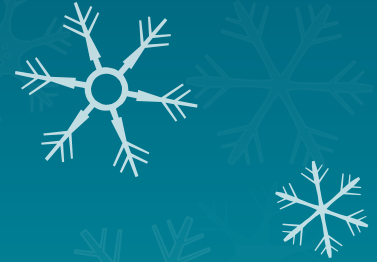
ΔMRSEC partners with the North Carolina Central University (NCCU) Women's Center which is in its third year of a program with Shepard Middle School in Durham, NC. This program, entitled Women Inspiring Learning Momentum (W.I.L.L.), is designed to encourage middle school girls to pursue STEM careers, and pairs girls from Shepard Middle School with NCCU female undergraduate students and STEM professionals for a six week Saturday experience. During Saturdays in the 2012 spring semester, middle school students came to NCCU's campus, to participate in mentoring sessions, academic enrichment activities, hands-on scientific experiments, a field trip, and seminars focused on breaking the barriers faced by women in the sciences.





# 11. CRISP Professional Development Workshops

This program provides content knowledge in and experience with interdisciplinary science to secondary and community college teachers (graded 8 --- 14) through participation in materials science, engineering and nanotechnology workshops. On average two workshops are offered per semester. The theme and corresponding content of each workshop varies and is often influenced by the needs of the participating school districts. To enhance impact, teachers gain experience with interdisciplinary hands---on educational materials that are posted on the CRISP E&O website and are available for use by teachers in their individual classrooms.



## 12. University of Chicago MRSEC After School Science Club



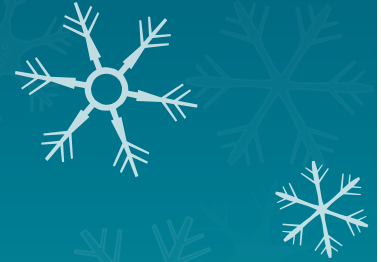
The University of Chicago MRSEC science club is a weekly, after-school, supplementary science activity conducted by MRSEC members at Andrew Carnegie Elementary School, carried out in collaboration with a 5th through 7th grade science teacher. An increased appreciation of, and enthusiasm for science among Carnegie students has been attributed to this club. Evidence for this shift in school culture can be inferred by the numbers of students requesting to enroll in the club during our years of operation at the Carnegie school: 40, 80, and now ~120. The club is open to all Carnegie students from K through 7th grades, but requires parents to fill out a formal application form and students to commit to attending.

The Carnegie School is a neighborhood elementary school, serving pre-K through 8th grade, located in the predominately black Woodlawn neighborhood just south of the University of Chicago. Drawing students primarily from the neighborhood, the demographics of the school are 98.8% black, 0.6% Hispanic. 79% of students receive free/reduced lunch; 47% are from households living below the poverty line. 6% of students have special needs. The school is host to a small regional gifted program and an International Baccalaureate program.

Using what interests us, as researchers who pursue careers in fundamental science, namely inquiry-based activities (i.e. interacting with phenomena, learning to ask questions about the phenomena, and answer them through experimentation, and allowing curiosity to dictate the direction of our investigations), we encourage students, through the science club, to foster the same curiosity and habits of mind.

## 13. University of Chicago: Physics with a Bang!


The general public – students, families, teachers, and the curious were invited to attend our 5th Annual Holiday Lecture and Open House. Two shows consisting of favorite physics demos, interspersed with research-related material, were performed by Jaeger and Nagel. High speed video cameras from our Imaging Facility were used to film and replay selected demos for the audience. The lecture hall was full for both shows and people crowded into the physics lounge (standing room only) for a live video feed of the presentation. Fourteen MRSEC laboratories (Dinner, Engel, Guyot-Sionnest, Irvine, Jaeger, Lee, Nagel, Rosenbaum, Scherer, Schuster, Sibener, Talapin, Witten, Zhang), and one shared facility, our Materials Preparation and Measurement Laboratory, allowed the public to tour their facilities and the researchers prepared audience-friendly demos for the general public, illustrating the spirit of their research. We estimate attendance of about 600 people, the majority of which were families. We featured Demo Alley again this year, with a number of undergraduate, graduate student and postdoctoral demonstrators. A giant soap bubble film was the highlight. Zhang organized Theory Alley, which consisted of simulations, with simplified physical representations of the phenomena simulated. Engel and Lee participated in an “Ask the Scientist” event held concurrently with the Open House.




# 14. Research Experiences for Undergraduate and High School Students




The University of Michigan's Center for Photonic and Multiscale Nanomaterials (CPHOM) aims to enhance the recruitment and retention of a diverse student population in science via focused research-related educational activities. The participation of REU (HS) students in research is expected to increase the likelihood of their matriculation into graduate (undergraduate) school within science, technology, engineering, and mathematics (STEM) fields.



For undergraduates, the center is expanding upon the successful international research experiences for undergraduates (i-REU) program, "Optics in the City of Light", where students are mentored by French scientists at a variety of institutions in Paris. The center has also developed an on-site research experience for undergraduate (REU) program, and a new research program for high school (HS) students within ~50 miles of Ann Arbor. During the summer programs, both UG and HS students are exposed to various research areas through weekly presentations by science and engineering professors. In addition, a set of professional development workshops on giving scientific presentations, applying to undergraduate/graduate school, and scientific ethics are offered to both REU and HS students. The summer programs culminate with a CPHOM Physics-Biophysics REU symposium at which both REU and HS students give ten minute research presentations.



The C-PHOM H.S. research program consists of a nearly year-round hands-on research opportunity. During the first spring, several Saturdays are dedicated to orientation, training, and matching with laboratory groups. During the summer, there is an 8-week residential program on the UM campus. Several Saturdays in the fall and winter are focused on student preparation of presentations and papers for science fair competitions. During the winter, the students are expected to participate in local, regional, and national science fairs. The H.S. research program culminates with an openhouse/ recruiting event late in the winter. The publicity generated by H.S. student participation in science fairs is expected to increase public awareness and interest in STEM in the region, state, and nation.



## 15. CCMR educational Outreach: Lending Library of Experiments

[Classroom modules/lesson plans (formal and informal education, depending on circumstances)]

The CCMR offers an online lending library of hands-on science experiments, many developed in house, that are available to teachers across the nation. In this program, any teacher in the Nation can borrow one of 38 prepackaged experiments from the lending library using a simple, web-based interface. The kits contain all of the materials necessary to perform the experiment, including lesson plans and worksheets. Many of these modules are also used at CCMR events, such as after-school programs and teacher in-service training. Over the past few years, the CCMR has been developing methods and instruments to evaluate the impact of these modules on three general areas: student content knowledge, student attitudes towards science, and teacher comfort and confidence with the material. Last year, a pilot analysis was run on five modules; this year the analysis was expanded to include a total of ten modules.



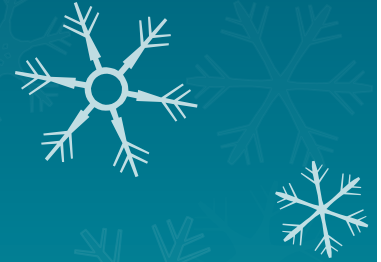
## 16. Princeton University: Princeton Center for Complex Materials

Princeton University Materials Academy (PUMA): Since 2002 PCCM has run PUMA, a full immersion three-week materials science program for Trenton New Jersey minority high school students. Topics include materials science aspects of research topics such as solar cells, solar ovens, sustainable housing, MEMS, art preservation. The students work in groups and the projects are designed to be hands on and inquiry based. Every student presents their results in a final evening reception attended by their families, friends and Princeton Professors. PCCM also conducts a middle school version of PUMA in partnership with Princeton University's Community House and another PUMA session for honors students in a high school materials science course at Middlesex High School. Won a \$50,000 nano-mini exhibit from NISE in 2012 and in October 2012 PCCM will start new public outreach program in partnership with the Princeton Library and the New Jersey State Museum in which PCCM scientists will frequently interact with the public and discuss materials science and nanotechnology at our new exhibit.

Other programs include: REU, RET, Partners in science high school summer research, PREM partnership with Cal state Northridge, Science and Engineering Expo at Princeton University, Young Women's Conference, Regional Science and Engineering expo (over 12000 in attendance), Annual Holiday Science Lecture for young children and their families (600 in attendance at Lecture Hall), Nanodays event in the Princeton Public Library, over 500 attended in 2012.

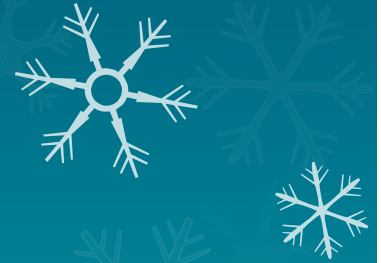
## **17. University of California Santa Barbara: Solar Car Workshops**

The UCSB MRL solar car workshop is a 2 hour workshop for middle and high school students that includes a presentation on alternative energy and photovoltaics and a hands-on activity in which participants build and race a small solar car. The presentation is aligned with the California State Standards for high school (grades 9 to 12) physical science, and provides a hands-on introduction to solar energy, familiarizes students with research in solar energy at UCSB, and reinforces the importance of higher education to first-generation college-going students. The historical strength in energy-related research at UCSB, particularly research for applications in photovoltaics, provides a strong scientific foundation for the outreach effort. In 2011, 300 middle and high school students participated in the workshop which was facilitated by UCSB graduate students and researchers.



## 18. Penn State Science-U: Science Leadership Camp (PSU MRSEC)

In a longstanding partnership with Penn State's Eberly College of Science summer science camp programs, the PSU MRSEC is currently involved in the Science Leadership Camp for high school students. This one week residential camp provides ~20-25 participants with the opportunity to carefully consider how leadership, teamwork, collaboration, ethics, and the needs of society (both locally and globally) are inherently connected and related to scientific advancement and STEM careers. The intense reflective nature of the program, the unique integration of the arts (literature, visual arts, music, etc.), and many field challenges (group projects, facility tours, competitions, and lab work) combine the theory and practice of innovative and creative thinking. MRSEC affiliated faculty and graduate students host campers at an interactive Scientist Mixer activity, as well as a 3-hour hands-on laboratory activity intended to provide a snapshot into a particular field of research and broader exposure to possible future career areas. Scholarships are awarded to successful applicants, primarily from underrepresented and underserved groups from a range of geographic and socioeconomic backgrounds. The diversity of the participant population provides an additional inherent learning opportunity for all campers. The PSU MRSEC has a history (and likely future) of also being involved in other one week science camps offered by Science U, including those involving elementary and middle school aged students.





# 19. Public Outreach Using Cart-based Science Museum Demonstrations (PSU MRSEC)



The longstanding collaborative partnership between the MRSEC and The Franklin Institute (a science museum in Philadelphia) has resulted in the completion and distribution four cart-based, docent lead, museum shows. The most recent one, titled *Hidden Power*, features 8 demonstration activities that focus upon the conversion of various sources of energy to create electricity (or vice versa): Sources of Power, Turbines, Solar Panels, Batteries, Thermoelectricity, Piezoelectricity, Light Bulb Efficiency, and Light Emitting Diodes. All demonstrations are designed to be a hands-on experience for the visitor (targeting mid/upper elementary ages and up). Generally, they begin with an attention grabbing macroscopic example of the concept and are followed by a physical model and explanation on the nano or atomic scale.

In addition to contributing initial inspiration and ideas, feedback during the development process, and ongoing technical oversight for accuracy, MRSEC faculty and graduate students assisted in writing Fact Sheets to accompany each demonstration. Each two-page Fact Sheet provides information beyond the scope of the demonstration itself, and highlights current related research occurring within the MRSEC and broader Penn State community. The Franklin Institute takes the primary lead in testing, evaluating, constructing the physical kits. Once constructed, MRSEC faculty and graduate students assist in training the representatives of 16 recipient museums.

The chosen recipient museums represent a broad and diverse array of geographical locations, socioeconomic and ethnic populations, and museum sizes. Two versions of the kit reside at Penn State, and these demonstrations are then used extensively by MRSEC members at public outreach events, school science fairs, various workshops for students and teachers, and at programs held in partnership with a local children's science museum.

Thank you



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