Leverage SMIF Outreach Programs for Your NSF Proposals!

Competitive proposals often require meaningful outreach and a clear link between the proposed research and the outreach increases the competitiveness of the proposal. In particular, significant Broader Impacts are a critical aspect of successful NSF proposal funding.

SMIF has leveraged NSF support to create a series of outreach programs that you can seamlessly customize and integrate your research and personnel (students and faculty) into with the support of the SMIF Staff. Dr. Holly Leddy and Michelle Plue (SMIF Staff) and Prof. Nan Jokerst have developed a series of outreach activities, outlined below, that are available for your NSF and other grant proposals.

Please contact Holly Leddy at holly.leddy@duke.edu to discuss how we can ***customize your proposed research*** into an activity listed below.

1. Proposal Outreach Programs for Faculty/Student Participation

Innovative outreach programs can be difficult for individual faculty and groups of faculty to generate on their own. SMIF has developed in the past 3 years a significant outreach program partially funded through the NSF RTNN NNCI program that focuses on engagement of K-12 and teachers in technology activities. In Duke FY 2018, over 1,100 K-12 students had a hands-on experience in SMIF programs and 60% of visiting groups specifically targeted participation of women or under-represented minority students.

SMIF Staff will support your NSF proposal outreach by offering specific programs that have been field tested, and that can be customized to reflect the specific research in your proposal. These programs are targeted to address Broader Impacts, including:

- Promoting teaching, training, and learning
- Broadening participation by under-represented groups
- Broad dissemination to enhance scientific and technological understanding

SMIF offers a series of program offerings that faculty can choose from that can engage graduate and undergraduate students and/or faculty as volunteers. Support includes:

- SMIF Staff will provide the training for all participants (students and faculty) and equipment for these programs.
- SMIF fees for equipment usage and staff time are currently leveraged by the NSF RTNN SMIF and are provided at a reduced cost to faculty for the duration of the RTNN grant (end date Oct. 2020). After October 2020, SMIF fees will apply.
    - Prior to Oct 2020
        - Volunteering/working with existing SMIF outreach programs is free.
        - Customized programs for your proposal:
            - Help in writing customized plan for your proposal is free.
            - If proposal is funded, cost for customized outreach program is 2% of proposal direct costs.
    - After Oct 2020 (or end of NSF SMIF RTNN support):
        - Customized programs for your proposal:
            - Help in writing customized plan for your proposal is free.

    - If proposal is funded, cost for customized outreach program is 4% of proposal direct costs.
- SMIF will work with you to modify the outreach program proposal text to customize the outreach program for insertion into your NSF proposals. This is particularly powerful showing that the proposed research can move into education and outreach during the proposed technical work period.
- Your program can be included in the SMIF/RTNN assessment. For an additional cost, SMIF staff can help to build rigorous assessments of your individual outreach efforts. Please contact us for more information on assessment.

The SMIF RTNN outreach programs provide K-12, community college, and communities (e.g. libraries, community centers) with access to programs and equipment through:

- The SMIF nanofabrication and characterization facility directly through visits to the facility;
- Travel to the classroom/library/community center with a **portable** Scanning Electron Microscope (SEM);
- Remote access by analyzing samples and bringing the results to the classroom.

All activities, including training, development, and implementation, are supported by SMIF staff and include faculty and student participation. In many cases, SMIF Staff will be involved in the activity with you and/or your students.

2. Specific Programs Include (see Appendix A for detailed descriptions)

1. Classroom technology experience: Scanning electron microscopy (10,000 magnification)

The specific SEM samples will be tailored to your research interests/specific to your grant proposal.

   a. Off-site visit to G6-12 classroom, library, community center, community college, with **portable** SEM and SMIF Staff member (for details);
   b. Visit to classroom with SEM images of student samples (for details);
   c. Student visit to SMIF for SEM use (for details);
   d. Remote classroom SEM experience with NC NGN; target rural areas (in development) (for details).

2. Classroom technology experience: Micro-computed tomography (i.e. x-ray vision)

The specific MicroCT samples will be tailored to your research interests/specific to your grant proposal.

   a. Visit to classroom with microCT images of student samples (for details);
   b. Student visit to SMIF for MicroCT use (for details).

3. Classroom technology experience: photolithography (patterning using UV)
   a. Visit to classroom with UV paper/photomasks (for details);
   b. Students visit SMIF cleanroom for hands-on photolithography experience (for details).

4. Summer camp technology experience

Campers already on campus for science-based camps.

   a. Campers visit your lab (for details);
   b. Campers use SEM at SMIF (or portable SEM); the specific SEM samples will be tailored to your research interests/specific to your grant proposal (for details).

5. Technology tour experience
   a. Students get tour of SMIF with hands-on science activities (for details);
   b. Create a new hands-on science activity; the activity will be tailored to your research interests/specific to your grant proposal (for details).

6. Write lesson plan based on your research interests/specific to your grant proposal that integrates with NC statewide science standards. SMIF has created 3 lesson plans to date, and will aid you in the development of a new lesson plan (for details).

3. Assessment of Outreach Impacts

We keep detailed records on all outreach interactions, which facilitates reporting to funding agencies. The SMIF staff also have the experience and connections to build rigorous assessments of outreach interactions. We have experience setting up surveys for student visitors, which enables the assessment of the impact of these outreach activities and can result in publishable outreach data.

4. Edit, Cut, and Paste Sample Text for Your Proposal

The SMIF Staff will work with you to customize your research into the SMIF activities. Here is some sample text:

Integrating cutting edge science and education is critical to the engagement and success of future generations of scientists and engineers. Hands-on activities can excite the imagination of students to complement classroom experiences. Studies indicate that student enthusiasm for STEM topics increases through exposure to scientists and to research equipment (Jones 2017. PLoS Biology 15(5):1-8. Margel 2004. Journal of Chemical Education 81(4):558-566).

We propose to **<<cite how the research will integrate into the SMIF program chosen>>**.

Example customized for pollution study (particulate matter, PM) proposal from SMIF Option 1a (previous page outline):

We propose to engage Grade 6-12 students in the study of air pollution particles, specifically, PM10 and PM2.5. These students often have trouble grasping scale (both large and small), thus the interaction starts with an activity geared towards increasing their understanding of scale, especially the differences in scale of things they can't see with their own eyes (a cell vs a PM10 particle at 10 microns vs an atom). Students will sort images ranging in size from an atom to an airport runway, including PM10 and PM2.5. We discuss with the students the different size of these objects, and what kinds of microscopes we need to use to view different objects at these size scales. Students will collect their own samples and look at them using light *microscopes. Next, we will bring the portable SEM into the classroom and let students take SEM images of PM 10 particulates and images of similar samples of what they collected.*

This outreach program will leverage the outreach network developed at Duke's Nanotechnology Facility (the Shared Materials Instrumentation Facility, SMIF) to introduce G6-12 students to state of the art scientific equipment. SMIF is a world-class nanofabrication and characterization facility that has created a vigorous and rigorous nanotechnology outreach program through NSF funding.

OPTIONAL: SMIF has established a critical network of connections with educators both in schools and in informal (afterschool, summer camp) settings that allow them to reach students from a wide range of backgrounds, particularly underrepresented groups in STEM. In the 2016-2017 fiscal year, SMIF hosted more than 700 outreach students, ranging from a science camp for middle school girls using the scanning electron microscope to local public school teachers learning about science opportunities in SMIF for their classes. The goal for each student engagement is to help students become excited and feel comfortable with science. SMIF has worked to refine their outreach program to maximize the impact on students. The activities focus on customized, dynamic, interactive outreach that require skilled instructors, and we propose to provide faculty and X graduate students supported by this proposal for Y hours per month, who are uniquely qualified to engage students in the air pollution aspects of the activity, to be trained by, and work with, SMIF staff, toward leading activities during student visits.

(Customized proposal portion)

Appendix A: Detailed activity descriptions of activities

1a. Visit to classroom with portable SEM

Standard Activity description:

Students often have trouble grasping scale (both big and small), thus the interaction starts with an activity geared towards increasing their understanding of scale, especially the differences in scale of things they can't see with their own eyes (a cell vs an atom). Students sort images ranging in size from an atom to an airport runway. We talk with the students about just how different in size these objects are and about what kinds of microscopes we need to use to view things at these size scales. Students are given collecting kits with guidelines for appropriate samples (not too big, not wet). They collect their own samples and look at them using light microscopes. We bring the portable SEM into the classroom and let students take SEM images of similar samples to those that they collected.

1b. Visit to classroom with SEM images of student samples

Standard Activity description:

Students often have trouble grasping scale (both big and small), thus the interaction starts with an activity geared towards increasing their understanding of scale, especially the differences in scale of things they can't see with their own eyes (a cell vs an atom). Students sort images ranging in size from an atom to an airport runway. We talk with the students about just how different in size these objects are and about what kinds of microscopes we need to use to view things at these size scales. Students are given collecting kits with guidelines for appropriate samples (not too big, not wet). They then collect their own samples and look at them using light microscopes. We bring these samples back to SMIF and take SEM images of their samples. We return to the classroom with an interactive presentation of the SEM images of their samples.

1c. Student visit to SMIF for SEM use

Standard Activity description:

Students often have trouble grasping scale (both big and small), thus the interaction starts with an activity geared towards increasing their understanding of scale, especially the differences in scale of things they can't see with their own eyes (a cell vs an atom). Students sort images ranging in size from an atom to an airport runway. We talk with the students about just how different in size these objects are and about what kinds of microscopes we need to use to view things at these size scales. Students are given collecting kits with guidelines for appropriate samples (not too big, not wet). They then collect their own samples and look at them using light microscopes. The class then takes a field trip to SMIF where the students can take SEM images of their own samples, as well as take a tour of the facility where they learn about how some of the equipment in SMIF is used to produce and characterize nano-scale research.

1d. Remote classroom SEM experience with NC NGN

Standard Activity description:

Students often have trouble grasping scale (both big and small), thus the interaction starts with an activity geared towards increasing their understanding of scale, especially the differences in scale of things they can't see with their own eyes (a cell vs an atom). Students sort images ranging in size from an atom to an airport runway. We talk with the students about just how different in size these objects are and about what kinds of microscopes we need to use to view things at these size scales. Students are given collecting kits with guidelines for appropriate samples (not too big, not wet). They then collect their own samples and look at them using light microscopes. The class then takes a virtual field trip to SMIF via web link where the students can see SEM imaging of their samples in real time.

2a. Visit to classroom with microCT images of student samples

Standard Activity description:

Students often have trouble grasping scale (both big and small), thus the interaction starts with an activity geared towards increasing their understanding of scale, especially the differences in scale of things they can't see with their own eyes (a cell vs an atom). Students sort images ranging in size from an atom to an airport runway. We talk with the students about just how different in size these objects are, what kinds of tools we can use to view things at these size scales, and what we can see with a light microscope compared with a MicroCT machine. Students play mystery object guessing game where they try to guess what an object is by only seeing MicroCT generated cross-sections. We bring their samples to SMIF, scan with the MicroCT and return to the classroom for another session with 3D scans of the students' samples.

<u>2b. Student visit to SMIF for MicroCT use</u>

Standard Activity description:

Students often have trouble grasping scale (both big and small), thus the interaction starts with an activity geared towards increasing their understanding of scale, especially the differences in scale of things they can't see with their own eyes (a cell vs an atom). Students sort images ranging in size from an atom to an airport runway. We talk with the students about just how different in size these objects are, what kinds of tools we can use to view things at these size scales, and what we can see with a light microscope compared with a MicroCT machine. Students play mystery object guessing game where they try to guess what an object is by only seeing MicroCT generated cross-sections. The class then takes a field trip to SMIF where the students can take MicroCT scans of their samples, as well as take a tour of the facility where they learn about how some of the equipment in SMIF is used to produce and characterize nano-scale research.

<u>3a. Classroom technology experience: photolithography: Visit to classroom with UV paper/photomasks</u>

Standard Activity description:

Photolithography is a technique that uses light to transfer a pattern onto a substrate (such as Si) to produce a device or structure such as integrated circuit. This class activity includes an introduction to photolithography and its uses in nanotechnology. Students will make their own photomasks with markers on clear plastic and use light to transfer their design into UV light sensitive paper.

<u>3b. Classroom technology experience: photolithography: Students visit SMIF cleanroom for hands-on photolithography experience</u>

Standard Activity description:

Photolithography is a technique that uses light to transfer a pattern onto a substrate to produce a device or structure such as an integrated circuit. The lab experience includes an introduction to photolithography and a demonstration of the photolithography equipment at SMIF. Participants will enter the cleanroom and perform photolithography on their own Si substrates using photomasks that ***they design***. This is a chance to not only learn about photolithography, but to perform the process and pattern a sample; participants can take their samples home as a souvenir!

*This activity is for high school students only and requires a short safety training before students are allowed to enter the cleanroom.

4a. Summer camp technology experience: Campers visit your lab

Standard Activity description:

Many STEM-focused camps bring students to campus in the summer. These camps are often looking for activities for their students. However, when student groups visit our facility, they typically do so in groups much larger than we can handle at once. We have solved this problem by dividing the students into smaller groups that rotate through a variety of activities. Tours of your lab can be one of the activities that students rotate through. We can help you design a tour that highlights your research at a level appropriate for the student visitors. We can guide appropriate camps to you for tours of your lab.

4b. Summer camp technology experience: Campers use SEM at SMIF

Standard Activity description:

Many STEM-focused camps bring students to campus. These camps are often looking for activities for their students. Campers can use the SEM at SMIF. The specific samples that the students look at will be tailored to your research interests/specific to your grant proposal. Students will look at your sample using light microscopes and they will take SEM images of the samples, as well as take a tour of the facility where they learn about how some of the equipment in SMIF is used to produce and characterize samples for research.

5a. Technology tour experience: Students get tour of SMIF with hands-on science activities.

Standard Activity description:

Students will take a tour of the facility where they learn about how some of the equipment in SMIF is used to produce and characterize samples for research. They will get a chance to try on cleanroom suits, as they learn about why the cleanroom is so clean, and they will make bracelets with beads that change color in UV light.

5b. Technology tour experience: Create a new hands-on science activity.

Standard Activity description:

When student groups visit our facility, they typically do so in groups much larger than we can handle at once. We have solved this problem by dividing the students into smaller groups that rotate through a variety of activities. Your hands-on activities based on your research can be one of the activities that students rotate through. SMIF staff will work with you to help create a hands-on science activity that will be tailored to your research interests/specific to your grant proposal. This activity will then be used during student visits to SMIF.

6. Write lesson plan based on your research interests/specific to your grant proposal that integrates with NC statewide science standards.

Standard Activity description:

SMIF staff will help you plug into the Scientific Research and Education Network (SciREN), which will guide you through writing a lesson plan that features your research and meets state science standards. Your lesson plan will be made available to teachers through SciREN's online portal. We will work with you to visit a classroom and do your lesson with students.