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AnneLynn Gillian-Daniel agillian@wisc.edu; Matthew D. Stilwell mstilwell@wisc.edu; Nicholas L. Abbott nla34@cornell.edu; Wendy C. Crone wendy.crone@wisc.edu

BREWing better broader impacts

<https://www.nsf.gov/od/oia/special/broaderimpacts/>

The US National Science Foundation (NSF) requires all grant-funded research projects to include a “Broader Impacts” component, i.e. the potential to benefit society and contribute to the achievement of specific, desired societal outcomes (1-2). Large, NSF-funded research centers such as Materials Research Science and Engineering Centers, or MRSECs, have a unique opportunity to achieve broader impacts by using the researchers’ collective, interdisciplinary expertise to assist in both the development of novel products and programs and the evaluation of their scientific content. This type of engagement is particularly valuable to the creation of innovative and accurate educational products that can engage people outside of the research field with concepts related to cutting-edge research, help them understand the importance of science and engineering, and stimulate the future workforce’s interest in science, technology, engineering, and mathematics (STEM). However, achieving the broader impacts mission with full participation from all members is a significant challenge faced by research centers as well as other large groups of researchers who work together in departments, laboratory groups, and training grants. To engage participation of all Center members in educational products development, the Wisconsin MRSEC created the Breakthrough Research and Education Workshop (BREW). The BREW combines cutting-edge research presentations with an education workshop focused on the development of novel, research-inspired educational content.

The Structure of BREW

Beginning in 2013, the Wisconsin MRSEC has held an annual BREW to enhance collaboration and build community between all Center members, including faculty, staff, postdoctoral research associates, and graduate research assistants. The BREW is a half-day, all member event, beginning with 3-5 research highlight presentations followed by an interactive educational workshop. Faculty members introduce the research overview and then graduate students and postdoctoral associates present short vignettes on their contribution to that area of research. A primary function of the MRSEC program is to train early career researchers and the BREW provides an excellent opportunity for these researchers to practice their scientific presentation skills. The goal of the interactive education workshop is to leverage the research talks as inspiration for new educational activities or expansion of existing activities. The workshop is facilitated by the Center’s education/outreach (E/O) faculty and staff and is typically scheduled for the same length of time as all of the research presentations together, emphasizing the importance of education and outreach in the Center (Table 1).

BREW Education Workshop Outcomes

The BREW’s E/O workshop is designed as a brainstorming session, which produces a large volume of ideas. Additionally, the workshop also serves the larger purpose of emphasizing the importance of education and outreach in the Center’s mission and getting faculty, students, and staff thinking about how educational activities are developed. This workshop leads to further discussions throughout the year about how the Center’s research can be translated into public outreach activities. Ultimately, a subset of the ideas from the BREW is further developed into public outreach activities or programs. One example of content that arose from the BREW E/O workshop is a three-dimensional, touch screen

simulation called *AtomTouch* (3), which was developed in collaboration with the MRSEC faculty member who had the initial idea. *AtomTouch* was designed to engage middle school students in learning about how atoms interact with one another and behave under changing physical conditions. The game has been played over 130,000 times since it was released in February 2018 on the educational website, BrainPop. Other content that arose from the BREW includes a liquid crystal sensor that undergoes a dramatic visual change in the presence of volatile organic compounds and a board game about how crystals form. The analogue game was later developed into a digital game called *Crystal Cave* (4), which has been played over 135,000 times since it was released. All of these activities were developed, tested, and refined by the MRSEC's education and outreach staff in collaboration with faculty, student, and postdoctoral researchers.

Effective practices for the education workshop

We have developed a set of effective practices for these workshops that are designed to engage researchers in education efforts. These practices include: expecting all members to participate, connecting the E/O activities to the broader research mission of the organization, providing activities that require participants to work in diverse teams, engaging in small group work that requires refinement of the ideas generated, presenting top ideas to all participants for further refinement/prioritization, and evaluating the participant experience to enable continuous improvement.

An example education workshop would:

- 1) Begin with a short (5-10 minute) overview of the E/O activities of the Center to orient and update everyone to the work being done in this area.
- 2) Divide the Center members into diverse teams across research projects and career stages. Diversifying teams facilitates interactions and community building between people working on different research projects, provides opportunities for students and postdocs to network with senior faculty members, and enables these teams to brainstorm more creatively.
- 3) Assign a specific brainstorming task to the teams. For example, in previous years the E/O staff asked the teams to brainstorm a 5-10-minute table-top activity for middle school students. Because all Center members participate in public outreach events, attendees are familiar with these types of activities. However, E/O staff must give clear and specific directions for the task, including an overview of what the target audiences are expected to know about the science topic. For example, according to the Next Generation Science Standards (5), middle school students are able to describe the atomic composition of simple molecules, however these students have not yet been introduced to the periodic table and do not know that properties of elements are connected to the electrons in the outer shell. The overview helps the teams develop content that is accessible and engaging for the target audience.
- 4) Following the brainstorming session, ask the teams to select their best 2-3 ideas and expand upon them. Provide poster paper, markers, scissors, construction paper, and other supplies for the teams to write, draw, or otherwise represent their ideas. Pose questions such as: What will participants do at the activity? What is interesting or surprising about the activity? What are the materials required to build or make the activity? What concepts are the participants expected to learn? What background will participants need to understand the concept?
- 5) At the end of the workshop, have each team present their top two ideas to the entire group. Because the BREW is also designed as a fun, community building event, there can be a friendly competition to select the top idea. Everyone votes on their favorite idea, and the winning team is announced before the event ends.
- 6) Following the workshop, the E/O members collect all of the sketches and written materials that have been created. Feasible ideas are then developed into prototype activities with input from

the members of the team who initially proposed it as well as Center members who are experts in the area covered by the activity. Typically, the workshops produce initial ideas that undergo significant revision during prototype development and field testing.

Impact of E/O workshop on attendees

In order to evaluate the efficacy of the BREW E/O workshop, we have distributed surveys that led to improvements in subsequent workshop iterations. Data from two representative years of the workshop are shown in Figure 1. Suggestions the respondents gave for improving the education workshop included: giving the workshop more time, building upon existing outreach activities, and having people complete pre-workshop activities to prepare for the BREW. Some suggestions from the evaluation have been incorporated into subsequent BREW E/O workshops as part of its iterative improvement.

Extensions of the BREW E/O workshop format

The goals of the BREW E/O workshop can be altered to suit various needs. For example, instead of focusing on new activity development, teams can evaluate activities that are under development. The workshop format is similar to the one described earlier, but the session starts with an introduction of the activity and an opportunity for hands-on engagement. The brainstorming session then focuses on ways to improve and expand the scope of the activity. For example, during the 2017 BREW, researchers play-tested the prototype of a digital game about scientific modeling. The E/O staff and game developers evaluated the attendees' experiences through observation and written surveys. Then the Center members broke into teams to brainstorm ways to improve the modeling game and introduce more materials science-specific concepts into the game play. This valuable researcher feedback was incorporated into the game, along with teacher feedback and student playtest data, ultimately resulting in the final version of the game, *Lost at the Forever Mine*(6), that was released on BrainPOP in October 2019 and received 6,700 plays in the first 6 weeks.

Although the Wisconsin MRSEC created the BREW to address both research exchange and engagement of MRSEC researchers in broader impacts, the BREW format can be adapted for other groups. For example, departments or large laboratories could incorporate an education workshop into annual scientific retreats or training grant directors could create a BREW-like event for their grantees. The education workshop can also focus on other science communication goals such as creating blog posts or NSF highlights for public audiences, developing public engagement skills, or creating public elevator pitches on research topics. Our Center has found that this fun, engaging workshop is an excellent way to build community across our group and enhance all attendees' science communication skills, while addressing NSF's policy on Broader Impacts.

A. L. Gillian-Daniel, University of Wisconsin-Madison, Madison
M.D. Stilwell, University of Wisconsin-Madison, Madison
N. L. Abbott, Cornell University
W.C. Crone, University of Wisconsin-Madison, Madison

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Wisconsin MRSEC education & outreach games

Atom Touch

www.brainpop.com/games/atomtouch

Explore atomic bonds. Change states of matter by adjusting temperature and pressure in this simulation that demonstrates how atoms move and bond.

Crystal Cave

www.brainpop.com/games/crystalcave

When the kids find a crystal cave under the Yard, they learn all about crystal molecules and dig up some sweet crystals for their collection in the museum.

Lost at the Forever Mine

www.brainpop.com/games/lostattheforevermine

You just crash-landed on an abandoned mining planet! Use mathematical models to predict how to escape before time—and fuel—run out.

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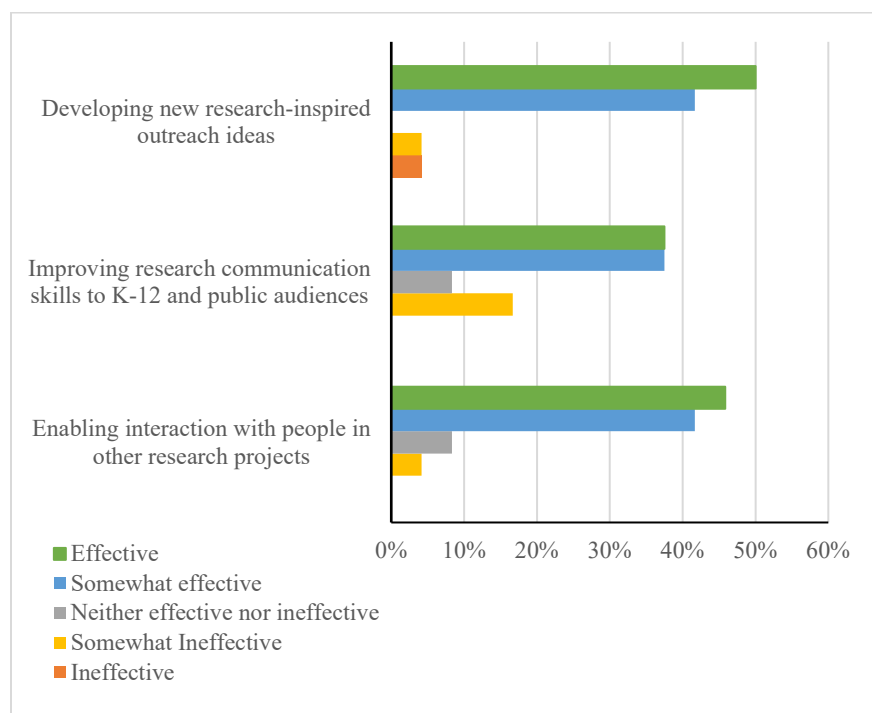


Fig. 1. Survey responses in two representative years of the BREW ($n=24$).

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For Further Reading

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Photo Captions



Photo_3 Caption

Wisconsin MRSEC members engage with and evaluate an educational activity that is under development during the 2019 BREW.