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Assessing the Impact of Education and Outreach Activities on Research Scientists

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Abstract

The purpose of this study was to investigate the attitudes of university-level research scientists toward educational and outreach activities that aim to help the general public understand more about their scientific endeavors. Interviews, observations, and survey results from 12 university research scientists, their colleagues, students, and the individuals they interact with were used to gather data for this study. Results indicate that although some research scientists value their education and outreach activities, many encounter obstacles to such efforts. These obstacles include a lack of support or resources at their home institution, the effort required to balance their research careers and outreach activities, and needing to find ways to connect with a nonscientific audience. A generational gap was also observed, with younger, nontenured research scientists tending to be more eager to involve themselves in such activities than their older, tenured colleagues.

Introduction

Since 2000, funding agencies have begun to request, and in some cases require, that principal investigators address the broader impacts of their research. As a result, many projects have developed with a core directive to find opportunities for research scientists (defined in this article as university faculty whose primary mission is research) to interact with both the public and K-12 educational institutions. However, several questions remain unanswered. Do real benefits accrue to research scientists who participate in education and outreach? Are research scientists truly embracing the idea of the need for public outreach and education? Has true change been occurring, not only in the views of research scientists toward these efforts, but within their institutions as well?

Education and Outreach Activities

When discussing the idea of "broader impacts" or "education and outreach activities," many accept that scientists have knowledge and resources that could benefit the educational community (K-12 teachers and students) and the general public. Indeed, many

people extol the value of outreach in research and education. As Shipman *(2013)* explains,

> The public lectures of Humphry Davy and Michael Faraday are thought of as crucial elements in the popularization of science in the 19th century, and they are as likely to be remembered for those outreach efforts as they are for their scientific contributions (which were considerable). (para. 1)

But as Shipman *(2013)* notes, peer-reviewed research reflecting this conclusion is hard to find, so scientific proof of this benefit is lacking.

Despite this lack of research, government agencies, such as the National Science Foundation (NSF), have begun to encourage meaningful involvement in such education and outreach activities and have even mandated their inclusion in grant proposals. Indeed, in 2000 the NSF revised its *Grant Proposal Guide* to include stipulations that in addition to the intellectual merit of the proposal, the broader impacts of the research effort must be detailed *(NSF, 2010)*. Since its implementation, this directive has often been fulfilled through the use of K-12 teacher training workshops, website resources, public lectures, and cooperative efforts with media outlets *(Moskal et al., 2007)*.

Although research is lacking on the true benefit of education and outreach activities, even while funding agencies begin to mandate their inclusion, the broader question is: If such activities are expected to be beneficial, will the research scientist be willing to participate in these activities? Dolanm, Soots, Lemauz, Rhee, and Reiser *(2004)* noted a number of compelling reasons for university-level research scientists to engage in outreach: increasing the general public's scientific literacy level, improving the teaching skills of K-12 educators, enhancing communication and understanding among a broader audience about the nature and benefits of research, and allowing researchers themselves to learn about educational theory.

One organization that evolved after the implementation of the NSF mandate is the Centers for Ocean Science Education Excellence (COSEE). COSEE grew out of a meeting in 2000, during which researchers and educators came together to discuss issues related to science literacy and the most effective ways to embrace science education concerns in the United States, specifically in regard to the ocean sciences. This led to a recommendation to the NSF to

develop a nationally coordinated effort to enhance ocean sciences education. In 2002, this goal was realized with the establishment of the COSEE Network, made up of 12 centers (as of 2012) located across the United States. These centers bring together research scientists, educators, and the general public though public symposia, workshops, online meetings and websites, and broadcast media to help engage and educate *(Keener-Chavis, Rom, & Elthon, 2007)*.

In 2009, as part of the American Recovery and Reinvestment Act *(2009)*, the NSF awarded a Grants for Rapid Response Research (RAPID) grant to COSEE Central Gulf of Mexico to create online case studies of research scientists from the currently awarded centers and the National COSEE office in order to investigate how they viewed education and outreach activities, as well as the challenges and benefits they perceived such activities could offer to research scientists. These case studies became known as Scientists Making an Impact in Ocean Sciences Education. As the interviews with research scientists and their colleagues and collaborators progressed, the authors of this article (who conducted the study) noted several themes that might help answer some fundamental questions related to research scientists' engagement in education and outreach activities. This article will focus on three of these themes that were developed into research questions:

1. What value do research scientists place on education and outreach activities?
2. What challenges and/or benefits have research scientists and researchers encountered in education and outreach activities?
3. What kind of support have research scientists received from their colleagues, collaborators, and institutions when they engage in education and outreach activities?

Methodology

As part of the RAPID grant-funded project, the active Centers for Ocean Science Education Excellence (COSEE) centers and the National COSEE Office were each asked to select a research scientist with whom they had worked in the past to be portrayed in the Scientists Making an Impact in Ocean Sciences Education project. The authors then used grant funds to travel to interview these COSEE-selected research scientists and produce video-based case studies for an interactive website project. In all, 12 research scientists representing universities from Massachusetts, New Jersey,

Maryland, Rhode Island, North Carolina, Louisiana, Minnesota, California, Washington state, and Alaska were actively interviewed and observed by the authors and were included in this study (see Table 1).

Table 1. Demographics of Research Scientists Interviewed

#	Rank	Gender	Discipline	Institution
1	Assistant Prof.	Male	Biology	U. of Minnesota
2	Assistant Prof.	Female	Environmental Science	Louisiana State U.
3	Associate Prof.	Male	Environmental Science	Western Washington U.
4	Associate Prof.	Female	Marine Science	U. of California Santa Cruz
5	Associate Prof.	Female	Marine Science	North Carolina State U.
6	Full Professor	Male	Marine Biology	U. of Alaska Fairbanks
6	Full Professor	Male	Environmental Science	U. of Maryland
7	Full Professor	Male	Atmospheric Science	U. of Rhode Island
8	Full Professor	Male	Environmental Science	U. of Maryland
9	Full Professor	Male	Marine Science	Rutgers U.
10	Full Professor	Male	Oceanography	U. of Washington
11	Full Professor	Male	Environmental Science	U. of Massachusetts Boston
12	Full Professor	Female	Ecology	U. of California Los Angeles

Two researchers were sent to each representative institution to conduct the interviews with the subjects. Over a series of days, each research scientist was interviewed on camera by one researcher about his or her involvement in education and outreach activities, with an emphasis on the three research questions outlined in this study. The second researcher observed the interview and made additional notes on the demeanor of the subject and their overall impressions of what the subject was reporting. Total amounts of video and observations collected for each researcher ranged from 6 to 12 hours over the course of 2 to 3 days. These videos and observational notes were then transcribed for data analysis. Following the on-site visit, a follow-up survey was sent out to each subject asking them to discuss their thoughts on what was recorded during the interview process and to answer each of the research questions in their own words. This was done to ensure that the researcher's views were accurately recorded and observed. Additionally, the researcher's colleagues, graduate and undergraduate students, and collaborators were interviewed in person or on the phone to get an outside perspective on the researcher's views and efforts. These added, on average, an additional 75 transcribed interviews per

interviewed scientist and 12 surveys for qualitative analysis. Finally, visits were coordinated to make direct, on-site observations of six of the 12 research scientists actively participating in education and outreach activities (videotaped and then transcribed along with observer notes). Institutional Review Board approval was secured prior to implementation of the study.

For the purpose of analysis, the data from the 12 research scientists was analyzed using qualitative methods that allow patterns of analysis to emerge from the data *(Patton, 1990).* The subjects' videotaped transcriptions were compared to the direct observations, interviews from their peers and colleagues, and the written surveys administered after the visits to ensure reliability and validity through data comparison and triangulation. Thus, patterns identified in this way were verified by returning to the data using an iterative process of hypothesis generation and verification. Common themes were identified, and these provide the structure for reporting and discussion of results. These themes, reported below, are based on the converging responses of a number of participants, thus minimizing the effects of personality and other individual differences.

Results

Observations, interviews, and surveys of the research scientists as well as their colleagues, students, and those who have worked with them, all seem to indicate that the researchers personally believe that there is value in their education and outreach efforts. Indeed, many have found their efforts rewarding both professionally and personally. However, some themes appeared repeatedly: a lack of resources and support for outreach and education efforts at many institutions, the amount of time required to implement outreach and education programs, and the toll that outreach and education efforts take on the career track of some individuals. Importantly, there also seemed to be a generational gap in the attitudes of research scientists of varying ages concerning the net worth of outreach and education.

Value of Education and Outreach

Overall, the research scientists in this study placed a high personal value on their education and outreach efforts. Indeed, one research scientist noted:

> The role of a scientist is not only to do research, but also to communicate their research to the general public.

> This includes a population of all ages, from those in kindergarten to my grandmother, regardless of their background. Indeed, that is our job as scientists, because who else can say or explain science better than us? That is why I do my best to act on [education and outreach] and be involved where I can. By doing that, I also impact the quality of my science, because it makes me look and find projects that can have an impact on society. It is important to let [the public] know what scientists do [and why] it is important for the planet.

Several research scientists noted that they learned, from observing K-12 teachers for whom the goal is to have every student pass, to aim for higher pass rates in their own undergraduate classes. "There are undergraduate courses where the passing rate has gone from 50 percent to 90 percent because of the way the course is taught, because of an understanding that people learn in different ways," said one nontenured research scientist.

Working with outreach and education efforts has also allowed researchers to think about science differently, resulting in new and different proposals and new and different collaborations. For example, their research may start to focus more on a core concept or fundamental understanding that has yet to be fully explained, which may have been revealed to them through an outreach effort. In turn, as more faculty begin to be affected by their work in education and outreach, they also begin to shape the values held by the university. One research scientist at a university in New England said:

> Working with the local school district becomes valued; there is an understanding that you are learning from your work with teachers, learning about pedagogy. There are higher expectations for your own teaching, and that you might get some grants that you may not have gotten before, which helps support your lab. Ultimately, as more faculty who have experienced the benefits of working in education and outreach become active members of search committees, the science faculty as a whole begins to reflect these values.

Research scientists who received their doctoral degrees 10 years ago or less (and who are nontenured) generally had the greatest enthusiasm for their efforts in education and outreach and looked

upon these efforts as a way to act as role models. One research scientist, who works with high school students in her lab on the university campus, said:

> I routinely get calls and letters from the grade school teachers of the students I work with. They thank me profusely, saying [they] teach and teach these [science topics] in the classroom, but until they can get into a lab and see how it is applied, and do the hands-on research, it does not mean as much. For me, it makes being a scientist acceptable. I am not this "old professor with the bushy hair," I am a regular person and we do serious science and make it fun.

For another research scientist, the education and outreach efforts he had been involved with gave him a greater appreciation of the values and needs of the native populations in his area. He noted:

> With the native people and students that I work with, the sense of place and the sense of belonging and ownership are important and it is not just what is going on scientifically. This is their land and that is their water, and that needs to be there and be healthy and preserved, because that is what it is to be [Native American]. Indeed, if those are not there, it's not just the food or commodity is gone; it is that the people are gone. So, I am not just doing science on biological processes and impacts, for instance, I might be finding the answers to things that can help preserve not just [the environment], but the culture as well, and that is really important to me.

All the research scientists reported some nontangible benefit to their lives or outlook on K-12 education, and in many cases to how they conduct and report their research. This was especially true for those with children of their own. In many of these cases, the researchers' education and outreach efforts made them think about not only what their children were learning, but the content and quality of the knowledge. "Recent assessments have well-documented how poorly the United States is doing in educating its young students in math and science, compared with other countries," one tenured research scientist from Maryland noted. "The good news is that for many of our active research scientists, this realization of the younger generation's deficiencies in understanding basic science

represents a watershed moment, propelling them into action—and involvement in education and outreach. I know it has been for me." However, nearly all of the research scientists interviewed noted that despite these goals and benefits, there are many challenges to being successful in education and outreach efforts.

The Challenges and/or Benefits of Engaging in Education and Outreach Efforts

When addressing the challenges and/or opportunities facing research scientists who make the effort to be engaged in education and outreach activities, those interviewed had numerous and varied answers depending on their career stage. It was noted that graduate students often have the opportunity to get exposed to educators in action, which may inspire them to become teachers themselves. They may also bring back this inspiration to their professors and in turn influence them to become involved in education and outreach.

Many of those interviewed noted that early career (nontenured) faculty at their respective institutions have had the opportunity, through education and outreach activities, to improve their teaching skills and add presentations and publications to their tenure portfolio. Senior, tenured research scientists have additionally been able to effect a change on a university-wide scale, attract additional funding, and engage other faculty in collaborations that will in turn also affect their careers. One research scientist, who was also a dean at his university, noted:

> It would be irresponsible for me in today's academic world to think that we can pull off academic research, and then say if the public wants to learn about it, they can read about it in my book or journal article. We are getting more and more pressure from the public asking us for help, wanting to know what we are doing, and asking how they can help. That is not solved by me giving a lecture using [scientific jargon]. That is not going to help, and they will lose interest. It is just as important for a sixth grader to be inspired by a scientist who talks directly to them at their level and inspires them. If you believe your job as a scientist is to make sure science continues, and have those young people in your career thirty years from now, then [education and outreach] efforts become a really easy decision.

Another common observation reported by research scientists who were interviewed involved their effort to find the resources they needed to be successful in education and outreach efforts. Although many research scientists are receptive to finding ways to pursue education and outreach, they are unsure what their first steps should be. As one department head noted:

> It can be challenging, especially for older, [tenured] scientists that are used to being in a lab all the time. It used to be that you could just include a website or some sort of online component, and let your grad student do that for you, but things are changing, and the educational and outreach components are becoming more important and need to be more diverse. I often tell scientists that are faced with trying to figure out how to include these efforts in their research to look at centers on campus that specialize in such endeavors. These centers often are already pursing activities that might be able to be included in some form in their research grant ideas, or they may be able to work with their staff to find ways to achieve both the scientist goals and those of the center.

A majority of those interviewed noted that research scientists often have a finite amount of time, and getting involved in education and outreach activities can mean choosing to write one less paper or spend less time in the field. As one research scientist who routinely holds summer workshops and tries to encourage colleagues to participate noted:

> In our area, most of the active research is going on in the summertime, so it is a hard time for them to devote six weeks [to our program], but those that do have told me they get a lot out of it once they have committed the time. It is a challenge. You have to juggle two lives: research and scientific education. They are indeed two separate lives and it is hard to do. It is also two different ways of thinking, that of research and working with the public. It can be mentally challenging.

The overall theme the authors have noted from the observations of the research scientists and their colleagues is that those scientists who have the time and resources to put into education and outreach efforts tend to see the benefits, even if they are per-

sonal and nontangible in nature. The researchers' need to publish and spend time in the lab and in the field as they start the tenure process was reported as the largest challenge when choosing to commit to education and outreach efforts. Thus, institutional support becomes of even greater importance in the decision-making process.

Support for Educational and Outreach Activities

The research scientists who were interviewed for this study had differing views on the support they received from those around them and from their institutions. At some universities and colleges, education and outreach activities are seen as something that all faculty should be engaged in and are highly valued and encouraged. At these institutions, the research scientists and their colleagues had a positive outlook on education and outreach, no matter their age or what point they had reached in their career. One commented:

> When I was first starting out, there were some messages that were being sent raising concern on the amount of time I wanted to devote to education and outreach activities. I was told it was not the best investment of my time for my career goals, but most of that has disappeared over time with changing attitudes. More and more of our faculty have thus come up through a system where these efforts are more of a priority, and it is not a concern for them. So, the classic model of scientific research in a lab has changed here. We are transitioning and our department is actually hiring faculty whose primary goal is outreach and education.

However, research scientists noted that at most institutions, although education and outreach activities are seen as important, they are usually not rewarded, nor are they given much weight in tenure and promotion decisions. Thus, education and outreach often become activities that are seen as "something you do on your own time." As one senior, tenured research scientist and department head noted:

> We all have a finite amount of time. If a person makes this choice to be involved in education and outreach, it usually means they write one less paper or a few less proposals for research. If they are not penalized, then there is no reason not to do it. However, for young sci-

> entists, who do not have tenure, it is great that they want to be involved, but that is no substitute for academic excellence that we expect. They need to be careful. But, I have noted they have more energy to do these [projects] than older scientists, and are often able to do both [research and outreach] and find a balance.

One senior, tenured colleague of a research scientist noted:

> It has been an interesting thing to observe. I think [the scientist] has made a tremendous contribution to science education, but at some sacrifice to his scientific career, because obviously, this takes a lot of time. There is a trade-off there and that is always an issue with this idea of engaging scientists in science education. It is a judgment that each professional researcher has to make.

At institutions where education and outreach was not an emphasis, a diversity of opinion on the importance of education and outreach also emerged, based on what point the interviewee was at in his or her career. Individuals just starting their careers felt that it was something they wanted to do, especially if they were exposed to education and outreach activities as a graduate student or postdoctoral candidate. As one early career, nontenured research scientist put it:

> Our generation is interested in interacting with public venues more often in a way that is acceptable. We can spend our research life behind a desk and in lab, but given the urgency of some of our problems regionally, nationally and globally, and given the interest that our community is putting on increasing science knowledge, it is important for us to get out of the lab and get familiar with public venues. It should be an integral part of our career and should be rewarded.

Research scientists in the middle of their careers (those actively seeking tenure) placed an emphasis on education and outreach, but not at the expense of their research and other scholarly duties. They noted that promotion and tenure required a shift in their priorities, especially given the lack of rewards for such activities. Senior, tenured research faculty were found to often have the most negative views on education and outreach activities. They were most apt to believe that they should be concentrating on pure research and

viewed outreach as an unwelcome distraction that can, in some cases, hinder one's career.

Conclusions, Recommendations, and Limitations

Some potential limitations of this study should be noted. The study population consisted of self-selected research scientists from COSEE member institutions with an earth sciences background. This fact limits the generalizability of the results. Extending the population to include scientists from other research areas is recommended to determine if there are different results. In addition, the population of this study was relatively small. Further research involving a larger, more diverse sample is needed to replicate the findings. Furthermore, the sample was skewed toward more senior faculty and researchers. Expanding the sample population to include more early- to mid-career scientists could provide richer data.

These limitations notwithstanding, the findings of this study do indicate that the shift toward integrating education and outreach activities into the academic careers of research scientists is still evolving. At some colleges and universities, an emphasis is placed on education and outreach and is rewarded within the tenure process. Observations seem to indicate that where this occurs, research scientists are the most willing to engage in such activities.

At most institutions, however, the value of education and outreach is often considered to be low. It is something "to do in your spare time" and as such requires that scientists balance their research and academic duties against their outside pursuits. However, given that including education and outreach activities in grant applications is becoming the norm for many governmental institutions, such as the National Science Foundation, it is important to find ways to help research scientists to engage in these activities. It is also important to ensure that all research scientists, academic department heads, and persons in authority at the university level recognize the importance of education and outreach efforts. This can be difficult given the lack of a robust body of data, both quantitative and qualitative, in peer-reviewed publications to support recognizing and defining the benefits of such activities. It is in this regard that centers and groups such as Centers for Ocean Science Education Excellence (COSEE), which have the expertise, experience, staff, and funds to help support research scientists as they pursue these activities, can be of most help.

The generational gap that was observed seems to indicate that younger, nontenured research scientists who are moving up the ladder are more interested in pursuing education and outreach activities and are changing the attitudes of their colleagues and the direction of many of their departments. It may be that in the future, all colleges and universities will require some component of education and outreach in their tenure and promotion process, but in the meantime, research scientists must continue seeking a balance to be successful in both their careers and their education and outreach endeavors. One solution may be creating some sort of resource, such as a website, that could help connect research scientists who are interested in pursuing education and outreach activities. This could also allow those who are less experienced to connect with those who have more experience in a more collaborative way. The challenge, however, is that such a site would have to be easy to find and/or marketed, whether by word of mouth, e-mail correspondence, or advertisement at symposia. It would also require a group or agency to acquire the funding to start and maintain such a resource and then maintain it over the long term.

The anecdotal evidence and the results of this study indicate that time devoted to education and outreach activities is well spent. However, there need to be incentives for research scientists to pursue such endeavors. Otherwise, most scientists will (understandably) decide to limit their engagement with outside groups in order to spend more time in the lab or field. Thus, we need to start a dialogue with research scientists, university and administrative officials, funding agencies, and the general public to find out what can work, what won't work, and what we can scientifically prove about the benefits of education and outreach activities.

All of these findings are important in light of recent initiatives announced by Washington and President Obama that call for science research and education that challenge scientists to use their knowledge to think about creative ways to engage people in science and engineering and improve student achievement in math and science. The authors believe that it is important for scientists to address this call to action and do their best to engage students and the general public, but success ultimately will rely on incentives for these researchers to buy into these efforts and additional training for the scientists to participate in education and outreach.

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