

**Fostering STEM Career Awareness: Emerging Opportunities for Teachers**

Research on science, technology, engineering, and mathematics (STEM) career motivation indicates that the secondary school years are a critical period; the impressions of science that students form then are critical in impacting their career decisions (Subotnik, Tai, & Rickoff, 2010). We investigated strategies to connect students' science knowledge to potential careers as part of the evaluation of Bio-ITEST: *New Frontiers in Bioinformatics and Computational Biology*, a National Science Foundation (NSF)-funded project that brings bioinformatics skills and career awareness to high school teachers and students. In an exploratory study, "The Emerging Role of Science Teachers in Facilitating STEM Career Awareness" (Cohen & Patterson, 2012a), we surfaced one piece that may help solve the puzzle of how to promote STEM careers among students: missed opportunities to recognize and reinforce the role that high school teachers can play in fostering STEM career interest. We found that despite the considerable sums allocated to exposing students to engaging and challenging STEM curricula, we may be overlooking a critical step in engendering career motivation: high school science teachers' career knowledge.

When we queried educators about strategies to connect students' science knowledge to potential careers, they provided insights into the unique role teachers can play in STEM career guidance. They also shared with us concrete ideas for enacting those ideas in practice. We categorized our findings into four promising approaches for infusing career information into science classrooms: incorporating both formal and informal approaches, helping students see scientists as real people, connecting STEM content and related careers, and embedding reflection opportunities in career-related lessons. We discuss the implications our findings raise for changes in policies and practices to support student STEM career awareness. In particular, we

raise questions relating to the importance of ensuring equitable access to information about potential careers, possible changes to teacher pre-service education, systemic changes in coordination across buildings and districts, and overall support and partnerships from scientific and community organizations.

STEM careers make significant contributions to health and well-being, the economy, and national security. In addition, they can yield higher salaries than other careers. The Bureau of Labor Statistics (2007) notes that life sciences and other STEM professions are expected to grow at a faster rate than non-STEM professions, in part because of the rapid growth of technological innovations. In Washington State, job growth in the life sciences sector increased 8% between 2007 and 2011; at the same time, total employment decreased 3% (Washington Research Council, 2011).

News headlines routinely underscore our nation's pressing need for new entrants to STEM careers while decrying the lack of interest in, and preparedness for, these jobs (Engler, 2012; Resmovitz, 2012). As the number of national STEM workers increased 4.2% from 1980-2000, the rate of STEM degrees acquired during the same period grew only 1.5% annually (National Science Board, 2008). Data from other sources support the conclusion that the rates at which students currently enter STEM professions will be inadequate to keep up with the demands of our economy (Economic Vitality GMAP, 2008; United States Department of Labor, 2007; National Association of Manufacturers, 2005; Council on Competitiveness, 2005). In Washington State, our STEM education situation is particularly dire. Among the ten technology "peer states" with STEM-rich economies, Washington loses the most students from the STEM pipeline: "...for every 100 Washington students that enter 9<sup>th</sup> grade, only 18 complete a college degree within 150% of the time normally required" (Cook & Murman, 2011, p. 3).

Recent research shows that student interest in STEM careers is indeed declining (Lowell, Salzman, Bernstein, & Henderson, 2009; University of the Sciences [USciences], 2012). According to the President's Council of Advisors on Science and Technology (PCAST), "...the problem is not just a lack of proficiency among American students; there is also a lack of interest in STEM fields among many students" (PCAST, 2010, p. vi). This decline appears to be due in part to a lack of awareness of the wide range of careers that students can enter with a science background. For example, 18% of students in a recent Harris Poll cited a lack of knowledge about health science careers as the reason for low interest (USciences, 2012). Interest was exceptionally low among underrepresented minorities. The need to encourage women and underrepresented minorities to pursue STEM careers is particularly pressing, as their numbers in STEM fields are significantly lower than in the general United States population (National Science Foundation, National Center for Science and Engineering Statistics, 2013; National Research Council, 2011; Hill, Corbett, & St. Rose, 2010). This disparity is due, at least in part, to significantly lower completion rates among underrepresented minorities who pursue STEM degrees (Higher Education Research Institute at UCLA, 2010).

Consequently, there is a national effort to better promote STEM careers among young people (PCAST, 2010). National investments in STEM education are already substantial; a recent report from the National Science and Technology Council (2012) found that annual federal K-12 STEM education expenditures alone totaled well over \$2 billion in FY2010. President Obama recently announced a proposal to allocate \$1 billion from his 2013 budget request to fund a STEM Master Teachers' Corps (The White House, 2012). Given our nation's extensive allocation of resources toward STEM education, what more can educators, administrators, and policymakers do to fuel the STEM pipeline?

### **Methods**

Our findings are drawn from a series of formal and informal interviews, focus groups, and open-ended survey questions during 2010 and 2011. Insights gained from each set of interviews reshaped our line of inquiry, resulting in an iterative exploratory process. We queried over 70 informants, including high school science classroom teachers and other science educators. Of these, 47 were educators who participated in the summer professional development opportunities as part of Bio-ITEST and completed surveys. The majority of survey respondents were women (36/47, 76.6%). Of the participants who responded and whose race and ethnicity is known, 82.6% were white and 2% were Hispanic/Latino. On average, the respondents had taught for 11.6 years, and 85.1% had a master's or doctorate degree. Our interviewees included nine key informants representing post-secondary education, education policymaking, professional/technical education, and other science teacher professional development programs. Most of the study participants, and all of the key informants, were from Washington State. We asked our informants about their own perceptions of how students access career information, how teachers perceive their roles in raising students' career awareness, and strategies that science teachers use to impart career information.

#### **Educators as a Source of Career Information: Opportunities and Challenges**

Many of our study participants confirmed the sentiment expressed by one teacher interviewed regarding where students currently obtain information about STEM careers:

I think they get it in a hodgepodge of places, they don't know where to go. . . . I am struggling with knowing where to send them. They get it from TV and commercials. We used to have an amazing career center on our campus and two great staff, but due to budget cuts it is closed. We have no career counselor. There is no place to get brochures,

no one to talk to. If they go online and plug in “biotech,” they get two million hits and that is not helpful.

Students need knowledgeable adults to make clear connections between their interests, classroom lessons, and applications in the work world. For some youths, this may happen through participation in after-school clubs or interactions with career counselors, who can provide invaluable guidance as students seek to define and pursue their goals. Unfortunately, many high school students never come in contact with career counselors. In contrast, all high school students interact with at least one science teacher. In theory, these teachers may be best positioned to understand and keep abreast of STEM-related occupations. Yet teachers may be as removed from career knowledge as their students. Our study participants reported deficits in their awareness of science-related career options. As one said, “If I don’t understand how fields of STEM merge together, I am reticent to encourage kids in careers.” Teachers also reported lacking the pedagogical strategies and resource materials that would allow them to infuse career awareness into their lessons. Still others did not perceive making connections between science content and career applications as part of their science teacher role.

Understanding how high school students become aware of STEM career options, how educators can help students translate awareness into pursuit of STEM careers, and how to provide students with the support and skills they need to succeed are crucial elements in ensuring the future of our STEM workforce. We may be overlooking straightforward solutions to promote STEM careers that could result from preparing, supporting, and mobilizing high school science teachers. Our findings indicate that science teachers are in a powerful position to influence the awareness and interest of students in STEM careers. We have published our findings related to “Teaching Strategies that Promote Science Career Awareness” in a separate monograph (Cohen

& Patterson, 2012b). Our main recommendations specifically for teachers are listed below.

Although the interviewees described a diverse range of strategies, an analysis of the interviewees' comments revealed four promising approaches for successfully raising science career awareness.

### **Teaching Strategies**

**1. Incorporate both formal and informal approaches.** Students benefit from multiple paths of exposure to science careers. Teachers recommended infusing career awareness constantly, and not just as a separate unit. This may include incorporating into classroom lessons the authentic tools and approaches used by practicing scientists, or providing opportunities for students to see science performed in a variety of settings such as workplaces and science fairs. In conversations, some Bio-ITEST teachers expressed that curricula that explore current problems and use the real tools of science can interest students in STEM content and promote their feelings of self-efficacy. Our related investigation into the Bio-ITEST project also showed that purposefully integrating career components such as educational requirements and job descriptions helps students become aware of STEM Careers (Kovarik et al., 2013).

**2. Help students see scientists as real people.** One insight that echoed throughout the interviews was that many students don't envision themselves as scientists, in part because they don't see scientists as "real people." Formal and informal opportunities to connect with scientists can help students recognize that they are "regular people" who have hobbies, families, and outside interests. Several teachers provided examples such as inviting scientists as guest speakers into the classroom or interviewing scientists via an electronic connection such as Skype.

**3. Connect the dots.** Interviewees emphasized that teachers need to make explicit connections for students between STEM content and related careers. Several used the term

“connect the dots” to describe this practice. One educator said, “They [teachers] should connect the dots for students. For example, every chance they have, they should note for students—what you are doing in this lesson is the skill you will need to use as a (name the career).” One teacher suggested that when the students are using the Basic Local Alignment Search Tool (BLAST) which is part of the Bio-ITEST curriculum, a teacher can make sure that students are aware that they are using a tool that high-level scientists use all the time. A related activity includes embedding real-world assignments into the curriculum, such as creating a résumé, or “applying” for a job.

**4. Embed reflection.** Reflection leverages long-term impacts from discrete science lesson experiences. One key informant pointed out that even a powerful event like a science career fair can be forgotten if students don’t think deeply about what they learned. Reflective activities include journaling, responding to structured papers, and class discussions.

### **Implications for Policy and Practice**

Our findings highlight areas in which secondary school career awareness issues overlap with larger concerns about equity, policy, administration, and the role of the larger scientific community. Our study findings raise issues ripe for further exploration and consideration.

**1. Career awareness and equity concerns.** Solutions should address the persistent inequities that lead some students to drop out of the STEM pipeline early. While lack of awareness is problematic for the general student population, it may be particularly acute for students from populations underrepresented in STEM careers who often do not enroll in higher-level science classes. Underrepresented minority students are more likely to lack exposure to STEM role models and are less likely to enroll in advanced science classes (National Research Council, 2011). Our interviewees reported that career information is far more likely to be

incorporated in advanced science courses. Our findings suggest that it may be particularly important to infuse career lessons into all introductory-level science classes to reach students who might otherwise never go further. Teachers who teach introductory biology or 9<sup>th</sup> grade science, for example, reach a large number of students who may not go on to other science classes; these are especially important courses in which to introduce STEM careers.

**2. Policy changes and teacher education.** In our study, teachers noted various strategies for establishing career connections as an essential part of academic curricula. Teachers in our sample enthusiastically embraced the value of the career components of the Bio-ITEST lessons, which highlight a different STEM professional in each lesson and culminate in a stand-alone career lesson. However, none of the teachers we queried reported learning strategies in their pre-service education that would have prepared them to promote STEM careers. Pre-service instruction, certificate recertification/renewal, and continuing education could play a role in establishing these norms, imparting best pedagogical strategies and providing opportunities for teachers to experience science workplaces. For example, a required research practicum for science teaching certification as well as for certification renewal would allow science teachers to understand the research process more deeply, make personal connections with scientists, and have a better idea of the types of science careers currently available. Our informants also called out state science education standards, as well as requirements relating to continuing education credits and teacher endorsements, as missed opportunities to set expectations for infusing career information. For example, they suggested policy changes such as requiring an understanding of science careers as a prerequisite for a science teacher endorsement, and incorporating application of science careers into the end-of-year statewide student exams. Even providing basic information about possible careers obtainable with an associate, bachelor's, or master's degree



could greatly benefit students in planning their next steps after high school. While such understandings might be challenging to measure, more can be done to ensure that teachers are exposed to career possibilities in STEM-related fields during their own education.

**3. Administrative and district coordination.** Our respondents and research suggest that several structural changes can be feasibly implemented at the building and district levels. These include breaking down silos and facilitating career information sharing among guidance counselors and teachers. Our interviewees cited multiple resources that teachers often develop individually that could be more effectively accomplished district-wide; for example, securing speakers, identifying field trip opportunities, and providing classroom resources such as presentations that highlight a “career of the day.” The Bio-ITEST lesson materials, for example, profile a different science-related career for each individual lesson. These profiles are provided in the form of PowerPoint slides that can be used as “bell-ringers” or warm-ups when class begins, and they also connect to the content of each lesson. Teachers found these ready-made resources that integrated readily into their daily teaching practice to be easy to use, and they indicated that they would use more of such resources if they were available. In light of these findings, districts and administrators might consider pooling career resources across buildings, establishing career resources that could be “checked out” from a central facility, or providing a career resource listserv that would allow teachers to share successful innovations or career profiles that connect with commonly addressed science content in a variety of STEM fields.

**4. Community support.** Keeping up with the rapid evolution of STEM-related job definitions challenges even the best educators. Our informants called for funding and release time so that teachers can engage in job shadowing, internships, and workplace experiences. Community support and partnerships are essential. Business and industry can step up to the plate

by creating and funding innovative professional development opportunities. Bio-ITEST teachers noted how important the opportunity to network with professional scientists was for their understanding of STEM careers. Teachers interacted with scientists who served as tour guides, discussion panelists, and speakers during the Bio-ITEST professional development workshops. They had the opportunity to ask scientists questions about their work and their career paths, which helped to humanize the scientists for the teachers.

The Bio-ITEST bioinformatics education program was led by the Northwest Association for Biomedical Research (NWABR), a 501 (c)(3) non-profit organization that advances the understanding and support of biomedical research through dialogue and education. NWABR has over two decades of experience in developing curricular materials and providing teacher professional development focused on diverse STEM topics.

Organizations such as NWABR can help bridge the gulf that exists between the scientific and education communities, providing speakers to classrooms through speakers' bureaus, mentors to science students, opportunities to meet and engage in discussions with scientists in their laboratories, and ensuring that curricula address new directions and developments in science and research and prepare students for "today's science."

### **Conclusion**

We believe that actionable solutions, such as those noted above, have too often been overlooked, even as we dedicate significant federal and local funds to STEM education. Attention to these solutions might well increase the number of qualified students entering the STEM workforce. Teachers play a vital, though underappreciated, role in helping to foster the next generation of scientists and engineers. Using strategies highlighted in our studies, teachers can begin to infuse career information and resources into their classes in a way that enhances,

rather than detracts from, science content. However, teachers also need the support of the larger community in bringing career awareness to students. Administrators and district staff, as well as policymakers, all have key parts to play in helping students envision a future career for themselves in science and technology. Lastly, we believe that an awareness of STEM careers is important for all our students; even if students do not decide to become scientists, an understanding of science and science-related careers is important for basic scientific literacy and for understanding the role of science in our society.

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development and authentic research experiences in DNA barcoding for students (Kovarik et al., 2013). We thank our teacher collaborators, key informant interviewees, grant partners, and anonymous reviewers.

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#### About the Authors

Carolyn Cohen is an evaluation and strategy consultant and the owner of Cohen Research & Evaluation, LLC., based in Seattle, Washington. She works with nonprofits, philanthropies, and public agencies to develop and implement strategies that effect positive social changes, including in K-16 education. [cohenevaluation@seanet.com](mailto:cohenevaluation@seanet.com)



Davis Patterson, PhD, is a Research Scientist in the WWAMI Rural Health Research Center and Center for Health Workforce Studies at the University of Washington (UW), where he received his doctorate in sociology. Dr. Patterson has two decades of experience using qualitative, quantitative, and mixed methods to conduct policy-relevant research and evaluation in healthcare, education, and human services. His health workforce research has focused on the supply, demand, and education of physicians, nurses, and allied health professionals, with an emphasis on increasing underrepresented minority populations in the health professions.

[davispatterson@comcast.net](mailto:davispatterson@comcast.net)

Dina Kovarik, MS, PhD, is a Program Manager at the Northwest Association for Biomedical Research. Dina utilizes her background in molecular biology and epidemiology to develop applied high school STEM curricula, support teacher professional development, and provide guidance to students pursuing careers in the sciences. [dkovarik@nwabr.org](mailto:dkovarik@nwabr.org)

Jeanne Chowning, MS, serves as the Director of Education for the nonprofit Northwest Association for Biomedical Research (NWABR). For the past two decades, she has directed her professional efforts towards improving pre-college science education and promoting a greater understanding of biomedical research and bioethics among teachers and their students. Ms. Chowning has led several federal science education grants focused on preparing young people for a future in which new biotechnologies play an ever-increasing role. [jchowning@nwabr.org](mailto:jchowning@nwabr.org)