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The Emerging Role of Science Teachers in Facilitating STEM Career Awareness

prepared for

Northwest Association for Biomedical Research

Bio-ITEST: New Frontiers in Bioinformatics and Computational Biology Project

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Introduction

A recent review of literature concludes that "high school appears to be a key point at which young people's impressions of science influence their future career decisions."[1] However, just at the critical juncture for making career decisions, high school students face multiple challenges, including lack of clear and timely guidance, in planning their careers.[2]

One initiative to address these gaps is the National Science Foundation's Innovative Technology Experiences for Students and Teachers (ITEST) grants, which seek "solutions to help ensure the breadth and depth of the STEM [science, technology, engineering, mathematics] workforce." The program probes questions such as: "What does it take to effectively interest and prepare students to participate in the science, technology, engineering, and mathematics (STEM) workforce of the future?"[3]

Bio-ITEST: New Frontiers in Bioinformatics and Computational Biology, an ITEST project, brings bioinformatics skills and curriculum to high school teachers and students.[4] Bio-ITEST's external evaluation collected feedback from teacher-participants on their experiences with the career awareness components of Bio-ITEST lessons. Teachers' reflections on their own inclinations and abilities to make connections for students between science lessons and potential science careers revealed an increasingly important—and not yet fully recognized—role for science teachers in fostering student motivation to enter STEM careers.

Teachers commented that student acquisition of science career information is "random" at best. In some school districts, budget cuts have eliminated or scaled back funding for career counselors who

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[1] Subotnik, R.F., Tai, R.H., Rickoff, R., and Almarode, J. (2010). Specialized public high schools of science, mathematics, and technology and the STEM pipeline: what do we know now and what will we know in 5 years? *Roeper Review*, 32(1), 7-16.

[2] For example, see the following: Johnson, J., et. al., Why Guidance Counseling Needs to Change. *Educational Leadership* v. 67 no. 7 (April 2010) p.74-9; or Reese, S. A Leading Role for Career Guidance Counselors. Techniques (Association for Career and Technical Education) v. 85 no. 7 (October 2010) p. 16-19.

[3] National Science Foundation (April 21, 2011). Innovative Technology Experiences for Students and Teachers (ITEST). Retrieved August 18, 2010, from http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5467

[4] Bio-ITEST is a project of the Northwest Association for Biomedical Research (NWABR). For a full description of the Bio-ITEST curriculum, see http://www.nwabr.org/curriculum/introductory-bioinformatics-genetic-testing; http://www.nwabr.org/curriculum/advanced-bioinformatics-genetic-research.

have traditionally provided students with occupational information.[5] When asked where students get information on preparing for science careers, one teacher noted:

> "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. "

Challenges exist even in schools with career specialists. Students may have limited access to these school staff members, who are often charged with serving several hundred students. Also, it is difficult for these professionals to meet all student needs and keep informed of the rapidly changing array of career options.

In this environment, science teachers play an increasingly important role in encouraging students to explore science-related career options. Although students may not have access to career educators, all high school students have contact with at least one science teacher.[6] This access to a knowledgeable science professional who can potentially provide career information and connect students with science-related opportunities may be especially significant for students from populations underrepresented in science careers. Also, due to the rapid evolution in the types of science-related occupations, science teachers may be best positioned to understand and keep abreast of career information. However, even science educators face challenges in supporting student awareness of science professions. For example, job definitions in biology are evolving rapidly, particularly with the integration of informatics into biology careers, making it difficult for teachers to keep apprised of prospective career descriptions and the new skills necessary to enter these fields.

This report shares the results of our inquiry into this role: how it manifests in the classroom, challenges and solutions to infusing career awareness into science lessons; and the implications for science education policy and practice. This initial exploration into the potential for secondary science teachers to increase student awareness of, and interest in, science careers is intended to contribute to field-building efforts that address how to best support the STEM pipeline at the high school level. It also seeks to pinpoint areas for policy and practice changes, as well as for new resources.

Findings to date are derived from structured interviews and focus groups conducted with a purposeful sample of science and career educators and other key informants—an iterative process involving deepening exploration over a period of 18 months.[7] As part of this process, focus groups were conducted with all Bio-ITEST teacher participants in both the 2010 and 2011 summer sessions. The teachers in this study came from a variety of states, but the majority were from Washington state. They also taught in a range of schools—public, private, urban, suburban, and rural. A further description of methodology and a list of interviewees can be found at the end of this report.

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[5] For example, in the 2009- 2010 school year, as part of budget cuts, the Seattle School District scaled back funding Career and College Center Specialist positions from 14 to a total of 3.5. These positions remain vulnerable to budget cuts; for example, an editorial in *The Seattle Times* (March 20, 2011, p. A20) supporting a reduction in the amount of a proposed Families and Education levy, states that "Plans to expand college and career guidance beyond students academically farthest behind should be shelved."

[6] In Washington State, high school graduation requirements include completion of two science credits (including one lab course), which is generally two years of science. Source: Washington State Office of the Superintendent of Public Instruction. (n.d.) Graduation Requirements. Retrieved October 22, 2011, from http://www.k12.wa.us/graduationrequirements/Requirement-Credits.aspx

[7] For background on purposeful sampling, see Patton, Michael Quinn. *Qualitative Research and Evaluation Methods*, Sage Publications, 2002, p. 45- 46

SECTION 1:

How Do Science Teachers Perceive their Roles in Fostering STEM Career Motivation?

"We haven't given ourselves enough credit for our influence."

An important underlying question in this investigation is whether, and in what ways, science teachers view developing STEM career awareness as part of their job. Our interviewees were asked to describe views of their own roles in fostering STEM career motivation. We heard a wide range of responses: for some the idea of deliberately supporting student career awareness was new, or they expressed the view that high school seemed "way too early" for a student to be thinking about a career; while others were already "on-board" in integrating career-rich activities into their lessons. One respondent reflecting on teachers' roles in career awareness said, "a disservice we do as teachers is that we haven't really thought about it. But I get emails all the time from kids saying, 'I went into global health because of what I learned in your class….' We haven't given ourselves enough credit for our influence."

In general, those who did infuse career lessons did so in Career and Technical Education (CTE) credited classes rather than in introductory biology courses.[8] CTE teachers are required to include career awareness in their curriculum, and proved to be thoughtful and deliberate about their strategies. In many cases, these teachers had sought out the CTE certification in order to be able to offer an advanced or wider range of options for their students, such as courses in Biotechnology.

Even many educators who did infuse career awareness into their lessons said they had not received preparation to do so in their teacher education programs, that their knowledge of careers was limited, and that they didn't have time to add in any topic that wasn't part of preparation for mandated end-of-year exams. The policy implications of teacher perceptions of their roles, and potential lessons to be learned from CTE teachers, are discussed below in "Section 4: Implications for Policy and Practice."

[8] CTE (Career and Technical Education) is a term used nationally to refer to secondary and post-secondary classes or educational programs designed to equip students with professional and technical skills needed to enter specific occupations. In Washington State, school districts create their own CTE "pathways," which are as varied as Agricultural Biotechnology, American Sign Language Interpreter, and Auto Body. Source: Washington State Office of the Superintendent of Public Instruction. (n.d.) Career and Technical Education. Retrieved October 22, 2011, from http://www.k12.wa.us/careerteched/.

SECTION 2:

Teaching Strategies that Promote Career Awareness

> **"We can't assume that just exposure to information on scientists or science careers will translate to career motivation, it is important to be explicit with students and connect the dots."**

In order to better understand the ways in which science teachers might effectively impact student motivation, we first conducted a literature scan on the cognitive-behavioral building blocks of career development. This scan focused particularly on four areas: student awareness, relevance, self-efficacy, and engagement as they relate to STEM subject matter and careers.[9]

- **AWARENESS: expanding career awareness**
  Students develop an understanding and appreciation of a variety of STEM careers (e.g., knowledge of required skills, education, work/life issues).
- **RELEVANCE: seeing the relevance of the subject matter to their lives**
  Students find the content meaningful (e.g., relevant to everyday experiences or decisions they may need to consider in the future).
- **ENGAGEMENT: engaging with the subject matter and STEM careers**
  Students show interest in learning and experiencing more (e.g., active participation in discussions, asking questions that go beyond the content presented).
- **SELF-EFFICACY: feeling comfortable using the tools of science**
  Students develop a sense of self-efficacy in approaching scientific tasks and mastery of tools employed by real scientists.

We view career awareness as a necessary precursor to the other components of career development, because students cannot become interested in a career or a field, particularly one as highly technical as bioinformatics, without some awareness of the field's existence and the possibilities it offers.[10] We therefore focused our questions primarily on career awareness by asking respondents to describe how they foster student understanding of opportunities in, and necessary preparation for, science careers. In their responses, interviewees addressed strategies related to the other constructs as well. Their responses provide insights into both formal and informal pedagogical avenues to engaging students in thinking about science careers. Some of their examples were specific to use in self-contained classrooms (e.g., through classroom assignments), while others describe how to "touch" a wide swath of students (e.g., bringing scientists to school-wide activities such as career fairs). They also described ways that a skilled teacher enriches a science lesson with career content and engages with individual students about career possibilities and interests.

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[9] Further detail on these constructs can be found on the NWABR website at nwabr.org/about-nwabr/publications. "Literature Scan: Student Awareness and Career Motivation in the STEM Fields."

[10] Dorsen, J.; Carlson, B.; Goodyear, L. (February, 2006). *Connecting Informal STEM Experiences to Career Choices: Identifying the Pathway*. ITEST Learning Resource Center. Available at http://itestlrc.edc.org/sites/itestlrc.edc.org/files/itestliteraturereview06.pdf. Accessed January 20, 2012.

One science educator summarized this multi-faceted career exposure as analogous to an oil painting. It starts with a layer of gesso—a primer material that prepares a surface of the canvas, after which the image is built up with many layers of paint applications. She said it is the combined effect of the different experiences: "They participate in the Health Science Department open house, that is a layer in the oil painting; they see what goes on in a surgery pavilion and a pathology lab, that is another layer. They participate in NWABR's Student BioExpo. It takes multiple applications and they need to come back again and again and get different exposures."

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.

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.

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.

3. CONNECT THE DOTS
   Interviewees emphasized that teachers need to make explicit connections for students. Several used the term "connect the dots" to describe this practice. One educator said, "We can't assume that just exposure to information on scientists or science careers will translate to career motivation, it is important to be explicit with students and connect the dots." Another key informant 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)."[11] One teacher suggested that when the students are using BLAST[12], 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 resume, 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 included journaling, responding to structured papers, and class discussions.

Exhibit 1 (pg.16), synthesizes replicable teacher practices gleaned from the interviews and focus groups. Findings clustered into ten "Career Strategy Areas." For each area, we offer examples of "Replicable Teacher Practices" for science classrooms and then categorize strategies according to the relevant "Career Development Concepts" of awareness, relevance, engagement, and self-efficacy described above.

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[11] We observed an example of this strategy in one of the Bio-ITEST teacher's classrooms. Throughout the lesson, she underscored connection between careers and the Bio- ITEST curriculum. For example, she called attention to the fact that a scientist highlighted in a slide shown at the beginning of the lesson was a bioethicist; she noted that the students' wet lab experiences are similar to what a laboratory technician does; and she briefly noted some uses of genetic testing with animals in discussing a veterinarian's work. She also identified for the students names of local community colleges known for high quality Lab Tech programs.

[12] Basic Local Alignment Search Tool, or BLAST, is a bioinformatics tool used to compare nucleotide or protein sequences to one another, or to sequences in public databases.

SECTION 3:

Challenges and Solutions to Infusing Career Information into the Science Classroom

Interviews and focus groups uncovered deep-felt concerns about factors that affect science teachers' abilities and inclinations to infuse career information into their curriculum. These challenges include: deficits in up-to-date knowledge of science career pathways and new and emerging science-related occupations; the lack of classroom resources to support student learning; and a need for increased access to science professionals.

Teacher Knowledge of Science Careers

> "If I don't understand how fields of STEM merge together, I am reticent to encourage kids in careers."

> "It would be cool to know what those different fields are, and I could say, that is what a biostatistician would do."

Classroom teachers, professional development providers, and other key informants all underscored the challenge of keeping abreast of rapidly changing science careers and pathways. When asked in a focus group "How do you keep up on STEM careers?" several teachers stated that they are simply not able to do so, or that they get their information from the same popular media sources as their students, i.e., newspapers, the Internet, and television. One science educator, referring to teacher ability to support science career awareness, said, "I would think one of the biggest obstacles is teacher content knowledge about careers. How do they get their information?" Another interviewee confirmed, "We don't know the possibilities ourselves."

Interviewee comments are backed up by research. A 2008 evaluation report on various STEM initiatives in Southwest Washington commissioned by Clark College and the Southwest Washington Workforce Development Council notes both teachers and counselors lacked proper career information: "While many STEM efforts included some career exploration component, many interviews noted a lack of comprehensive information about careers, especially newer job titles. A common response was '....I can only explain what I know: it would be nice to be able to have more up-to-date career tools'. "[13]

Several of the interviewees identified career/industry collaboration and support for connecting teachers and students to STEM career experiences as a key factor in keeping teachers informed.

[13] Scruggs, P., and Morgan, M. (2008). *Interview & survey findings of Southwest Washington STEM Initiatives*. Davidson, NC: Scruggs & Associates, LLC Retrieved April 24, 2011, from http://www.swwdc.org/docs/STEM/STEM Interview- Survey Findings 2008.pdf.

> "Science teachers have the best chance to impact students. But they are not up-to-date on what is out there in careers. I would love to see science teachers go into industry and do some things there or at the university in research."

> "Instructors need experiences in business and industry in the summer time; they need to be in the real world themselves."

Others amplified these sentiments, stating that their own opportunities to work in science settings are critical to their ability to inform students. As one teacher said,"I only know about science careers because of opportunities to be in labs so much, and I am able to share that with students." Another added, "Wherever you have been working in science, if you can get first-hand experience, it's easier to bring that personal experience back into the classroom and embed the information into what you do every day."

In addition to worksite experience, other multi-pronged solutions were suggested: fostering opportunities for teachers to engage in "continuous networking" with both fellow teachers and research scientists; and providing both funding and release time to participate in internships, sabbaticals, job shadowing, and professional development sessions.[14] One key informant noted a potential for innovations sponsored by partnerships and civic organizations, resulting in, for example, a newspaper series on careers aimed for classroom use.[15] Teachers also asked for funding to access the latest research in online science journals. Finally, they requested paid time to transfer their newly gained knowledge to other teachers in their schools.

Classroom Resources

> "I need help with navigating the Web. It is a nightmare. I need help getting pointed in the right direction, and being able to decipher good resources from trash."

Teachers were asked, "In general, what kinds of resources would be useful to you as a classroom teacher to enhance student awareness of science careers and knowledge of how to prepare for STEM careers?" Perhaps most striking, a plea that echoed through the interviews was to provide classrooms with the science equipment needed to adequately prepare students to enter science careers.

Teacher requests for classroom materials and support included the following:

- Accessible curriculum materials that teachers can pull out and use as needed, such as lessons that highlight the "career of the day"; and PowerPoint slides, video clips, or interviews that profile people in different science careers, including scientists from underrepresented populations.

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[14] This finding is also echoed in the 2008 study Commissioned by Clark College and the Southwest Washington Workforce Development Council. Scruggs, P., and Morgan, M. (2008). *Interview & survey findings of Southwest Washington STEM Initiatives*. Davidson, NC: Scruggs & Associates, LLC. Retrieved April 24, 2011, from http://www.swwdc.org/docs/STEM/STEM Interview- Survey Findings 2008.pdf. A key theme among the findings was a shortage of time, capacity, and opportunities to build STEM career awareness efforts into their classrooms; respondents expressed that there is a "lack of professional development time for teachers to fully integrate the array of STEM information available to them." (p. 4)

[15] For example in 2010, *The Seattle Times*, through its Newspapers in Education project, partnered with the Seattle King County Workforce Development Council to produce the "Map your Career" newspaper series. One of the six sectors was "Career Paths in Biomedical Careers+Technology". http://www.mapyourcareer.org/pdf/LifeSciencesMap2010.pdf

- A STEM career database so students can access information on different jobs under the umbrella of science, how much schooling is involved, median pay, and that "says something about why that person likes that job."
- A list of 25 jobs that University of Washington biology graduates have entered.
- A series of posters about the range of jobs a student might enter, grouped by academic degrees; "something that would show the kids that there are hundreds of careers."
- Access to diverse speakers who know how to speak effectively to an audience of high school science students. This might include a state-wide database of speakers, and a coordinator to facilitate the encounter because teachers often don't have time to coordinate speaker arrangements during the school day.
- Technical support for communicating with scientists electronically. Two teachers mentioned that they had been able to connect with organizations such as the National Aeronautics and Space Administration (NASA), but required outside help in setting up videoconferencing capabilities. Suggestions included having students interview scientists or see a worksite via videoconference.[16]

Supporting Student Access to Science Professionals and Worksites

> "What is most effective is what happens outside of the school building, especially through taking field trips and connecting them to people working in the field. That is powerful. If they don't get this opportunity through school, they miss it altogether."

Key informants repeatedly commented that a critical role for teachers to engage students in science careers is to act as conduits by introducing students personally to scientists, their worksites, and their work. Study interviewees called for meaningful worksite experiences, a clearinghouse of internship opportunities, and funding to take students to lectures and science events. One informant said:

> "Anytime you can get students out of the classroom and into industry, they talk about it for a long time after they come back. That would be first and most powerful in my opinion whether it is via job shadowing, field trips, or internships. Then, they can see themselves—or not—in that work environment."

Teachers described barriers they face in bringing both professionals into the classroom and students to professional settings. One barrier is geographic access. While teachers from Seattle spoke of inviting speakers from the Fred Hutchinson Cancer Research Center and the human therapeutics company Amgen into their classrooms, those who are far from an urban hub found it difficult to help their students connect with biomedical organizations. This creates an equity issue, especially as some rural areas also have significant populations of students underrepresented in the sciences.

Access can be a challenge even when the local area is well-resourced. A Seattle-area teacher related having to cancel a very special—and free—opportunity for her students at the Fred Hutchinson Cancer

[16] A recent publication, *Connecting Students to STEM Careers: Social Networking Strategies*, (Cole, Camille, published by International Society for Technology in Education [ISTE], 2011), describes use of videoconferencing and Web 2.0 tools to raise STEM career awareness.

Research Center because she didn't have the $30 per student needed for transportation and related field trip costs. Several teachers mentioned the limited number of tour slots available at these institutions as a barrier. One teacher revealed that she had to take a sick day in order to have the "time off" to take her students on a field trip.

Identified resources that would support special opportunities for students outside of the classroom included:

- A comprehensive clearinghouse of student opportunities to participate in summer internships, job shadowing, career fairs, and lab tours.
- Funding to support student career exploration activities. Funds could be used for transportation, or for paying for substitute time so the teacher could take interested students to special events. The latter was especially requested by rural teachers.
- A clearinghouse/website with information on how to apply for existing funds, or how to set up an easy funding structure that enables community members to support these activities.

SECTION 4:

Implications for Policy and Practice

> "The best career counselor is the science teacher—they have daily contact, understand the kids, know what they know and need, and can differentially raise awareness in the classroom."

A recent study of STEM programs in Washington state notes, "Most schools have career/guidance counselors and career centers, yet research and hands-on experience tell us that student interest in STEM careers begins with their teachers (and parents) and then is supported by counselors and others."[17] Our exploratory study findings indicate an opportunity to encourage student interest in science and STEM careers in general, by providing support and resources to science teachers. Acknowledging and validating this emerging role for teachers has implications for both policymaking and educator practice. Key questions include:

To what extent do science teachers—as well as their principals and district leaders—view this role as part of their job description? In what ways might taking on this role become an accepted norm for science teachers? What policies and practice changes will support this critical role? Areas to consider for both policies and teacher practice are noted below.

Equity: Raising Career Awareness for All Students

Science teachers have the potential to play a particularly significant role in raising career awareness for students from populations underrepresented in STEM careers. While not all high school students have access to career counselors, or the social networks that may expose them to career opportunities, all are in contact with at least one science teacher. Furthermore, classroom teachers are uniquely positioned to connect with students regularly, and in a variety of formal and informal ways.

However, not all students are exposed to career possibilities in science classrooms. In our purposeful sample, career-related lessons were most likely to be reported for classes offered for Career and Technical Education (CTE) credits (also known as occupational/vocational courses), or in advanced science classes. Some teachers specifically noted that they did not include career awareness in their introductory biology courses. Even teachers who routinely infuse career lessons in their CTE courses reported that they did not have time to do so in their introductory biology courses due to pressure to conform with required curriculum and to prepare students for Washington State's end of year exam. One teacher who provided stellar examples of the career lessons she developed for her advanced/CTE accredited class said, "I don't feel as driven in my biology class, there they are just building a knowledge base; career lessons are more for the upper level classes.....In upper level courses, career lessons are part of a career tech program, it is an applied class (biotechnology). Biology is not an applied science. I feel an imperative to cover careers in biotechnology, not in biology."

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[17] Scruggs, P., and Morgan, M. (2008). *Interview & survey findings of Southwest Washington STEM Initiatives*. Davidson, NC: Scruggs & Associates, LLC. Retrieved April 24, 2011, Ffrom http://www.swwdc.org/docs/STEM/STEM Interview- Survey Findings 2008.pdf.

Our findings suggest that it may be particularly important to focus on policies that infuse career lessons into all introductory-level biology classes in order to reach students from populations under-represented in the sciences, and who may enroll only in those courses. As one interviewee said, "If you look at the data, [you will see] that science after grade 10 is not inclusive."[18] Waiting until later in high school also makes it very difficult for students who have not prepared themselves academically to catch up if they discover a STEM career interest.

State and District-Level Policymaking Opportunities

Interviewees noted that state and district-level policy changes could support STEM career awareness. Several of the teachers said that career awareness is not accorded much weight in the Washington state standards.[19] As one noted, "You are evaluated based on what's on the state test, and there are no career questions on the state test." Another said, "We are following state standards for the biology class and will have the end of year biology exam next year, and they will test on state standards and there are no state standards that deal with careers. If we deviate to include careers, it will be at the expense of meeting existing state standards."

Other polices, including at the district level, can make a difference as well. For example, one teacher noted that textbook selection is a district-level decision, and a district could chose to make inclusion of career lessons a criterion for textbook adoption. As shown in the first strategy listed in Exhibit 1 (Utilize Career Materials in Science Texts, pg.16), certain science textbooks are known for their exemplary incorporation of career lessons.

Strengthening Pre-Service Education and Ongoing Teacher Professional Development

Pre-service education and ongoing professional development experiences can encourage teachers to infuse career awareness into curriculum. Pre-service education may be most significant, as this is where norms around teacher expectations are developed. In one focus group, the entire group of over 20 teachers unanimously exclaimed that instruction relating to careers had never been addressed in their pre-service preparation.

One science educator, commenting on a Master of Science in Biology for Teachers program, noted that the program addresses the "big picture" by supporting science teachers in understanding how to help students make connections between science and society and appreciate the civic relevance of science. The interviewee provided an example of how an awareness of this big picture can lead students to value

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[18] This interviewee also said that the molecular and genetic engineering curriculum are "not inclusive, they are elitist." He called for moving the content down to 9th and 10th grade biology classes, and at the same time to offer more classes of accessible and high interest to all students through 12th grade.

[19] In Washington State, Essential Academic Learning Requirement (EALR) 3 states: "Application includes the ability to use the process of technological design to solve real-world problems, to understand the relationship between science and technology and their influence on society, and to become aware of the wide variety of careers in scientific and technical fields." Although EALR 4 does address work preparation, it does not clearly address career awareness ("Understand the importance of work and finance and how performance, effort, and decisions directly affect future career and educational opportunities").

the importance of science knowledge in relation to careers, for instance that attorneys who practice environmental law need a science background. However, career awareness is not a distinct piece of this program. Furthermore, at least in Washington, an understanding of science careers isn't required for a biology endorsement.[20] One issue that came up during teacher interviews and focus groups is that both teachers with a science career background, and those who had significant experience in a science expressed the most comfort in talking to young people about science careers. This implies that including a science research practicum as part of a pre-service requirement could strengthen the confidence of teachers as they talk about science careers.

Another avenue to support effective infusion of career awareness may be through programs that empower CTE-accredited science teachers to develop curriculum and prepare other teachers through pre-service education and continuing professional development. As noted earlier, CTE courses offer high level science lessons and at the same time, embed career awareness into their curriculum. CTE teachers interviewed for this study described a wealth of creative and thoughtful strategies for infusing career understandings into science lessons, and their examples and experiences may be instrumental in supporting other high school science teachers.

Key informants also advocated forging a stronger role for business and industry in engaging in teacher pre-service education and ongoing professional development. As one key informant said, "Business and industry need to step up and provide paid experiences for teachers....Business and industry need to serve on advisory committees for science teachers....help them stay up-to-date on curriculum."

Policies and practices that break down silos can encourage new ways to disseminate career information among school professionals. These could include supporting science teachers in sharing occupational knowledge beyond their classrooms, for example by serving as a resource to career counselors, as well as creating new funding streams to support teacher learning from, and interaction with, scientists.

Finally, it may also be worthwhile to examine the practices of other countries in addressing the same issue. For example, a recent study of the STEM Subject Choice and Careers Project funded by the United Kingdom Department of Education describes how schools, applying a variety of interventions, have raised awareness of STEM careers. It includes a framework for developing school policy and practice on STEM careers, and provides an overview of six case studies. Among the outcomes achieved are: "Observable changes in confidence and attitudes of science and math teachers and other staff towards careers awareness as part of the teaching and learning process."[21] The report also includes a rubric to help assess teacher awareness of STEM careers.

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[20] In Washington State, the Professional Educators Standards Board (PESB) has the authority to set policies and standards for teacher endorsements and certifications. PESB also responds to directives from the state legislature. For example, in 2011, the legislature passed HB2160, requiring the board to revise science teacher endorsements relating to STEM education. This directive, however, did not address career awareness.

[21] Centre for Science Education and Babcock Research. *STEM subject choice and careers lessons learned (Part 1)*. Sheffield, UK: Sheffield Hallam University. Retrieved April 23, 2011, from http://www.shu.ac.uk/_assets/pdf/cse-stem-lessons-learned-report.pdf

SECTION 5:

Conclusions and Next Steps

The United States is experiencing a pressing need for new entrants to STEM careers and, in response, dedicates a significant amount of funds to STEM education. A recent report from the National Science and Technology Council found that federal government annual STEM education expenditures totaled $3.4 billion in FY2010. Of this total about 60% was directed to K-12 education. Teacher effectiveness was "a primary or secondary objective of 49 percent of all Federal STEM education investments." However, federal K-12 STEM expenditures represent only a fraction of total education spending in the U.S., just 1%.[22]

We hope these initial findings will spur a series of deeper inquiries and inform near-term action. Potential areas for investigation include but are not limited to the following:

- Verification and expansion of these initial findings, especially regarding teacher perceptions of their own roles in inspiring STEM career motivation, and their level of preparation to impart accurate career information.
- Development of one or more compendiums of effective approaches to infuse career awareness and motivation. These resources might include best practices in the following: middle and high school science classes; collaborations among science teachers, career counselors, and school librarians; and innovations in public/private/civic sector partnerships. These efforts could also include strategies to coordinate access to existing resources.
- An investigation into the necessary conditions at the school or district level, and in teacher preparation and professional development programs, to encourage infusion of career awareness into all levels of science courses.

The findings of this exploratory study indicate an unrecognized potential to leverage STEM education investments. As one expert consulted for this inquiry noted, "Teachers are in an excellent position to connect students to STEM careers, yet most don't. Why not? What if they did? Could we increase the number of qualified students entering STEM fields as professionals?"

[22] The Federal Science, Technology, Engineering, and Mathematics (Stem) Education Portfolio, A Report from the Federal Inventory of STEM Education; Fast-Track Action Committee, Committee on STEM Education, National Science and Technology Council, December 2011

Methodology

This investigation used a case study approach and was conducted over an 18-month period in 2010 and 2011, relying on data collected through qualitative interview and focus group methods. Interview and focus group data were supplemented by an open-ended survey of Bio-ITEST program participants prior to a reunion in May 2011, as well as information gathered in discussions with teachers during classroom observations.

This exploratory study used semi-structured protocols for both individual interviews and focus groups, tailoring questions as appropriate to particular interviewees based on their professional roles or expertise. The protocols were informed by a scan of academic literature and relevant reports available on the Internet for information about career development and the role of science teachers in fostering student career awareness. Interview topics included perceptions of typical student sources of career information, teacher perceptions of their roles in fostering career awareness, ways that teachers incorporated career information into lessons, and challenges they faced in doing so.

We identified a purposeful sample of science and career educators, and other key informants involved in teacher education, workforce development agencies, and science education initiatives.[23] Participants from the Bio-ITEST workshops were selected based on a variety of criteria. All of the 2010 pilot teachers who indicated that they implemented the Bio-ITEST lessons were included in the first set of interviews. We also identified teachers for structured interviews based on comments they made during our full group focus group sessions that indicated they had "more to say" on the subject. Finally, a few of the interviewees were identified by project staff as CTE-certified teachers, who would be able to share knowledge of career infusion strategies. The majority of participants came from Washington state, the location of the workshop. Most teachers taught in urban and suburban public high schools, but private and rural schools were also represented in the sample. A list of interviewees is provided in Exhibit 2.

We also conducted focus groups with three sets of Bio-ITEST participants: 2009 curriculum developers (n=9); 2010 Summer Workshop participants (n=26); and 2011 Summer Workshop participants (n=23).

In analyzing the data gathered from these sources, we developed a typology of the strategies used to engage students in career exploration as it emerged from teachers' descriptions of their formal and informal practices. The presentation of findings is intended to represent a full range of perspectives in response to the study questions.

[23] For background on purposeful sampling, see Patton, Michael Quinn. *Qualitative Research and Evaluation Methods*, Sage Publications, 2002, p. 45- 46

Exhibit 1: Teacher Examples of Career Strategies and Relevant Career Development Concepts (1-10)

Career Strategy Area and Replicable Teacher Practices

1. Utilize career materials in science texts / journals / articles

- Use career information materials, often found as supplements in textbooks (e.g., *Insights in Biology: An Introductory High School Biology Curriculum, (EDC)*; and Prentice Hall's *Biology* (Miller and Levine). One teacher ties the job description to science content, asking students, "How would you tie this person's job to what you read about on p. xx?"
- Adapt materials from professional publications, for example, the National Science Teachers Association (NSTA) Journal, *The Science Teacher*, which features a career each month.
- Incorporate supplemental readings from books and news articles that show students how those working in STEM careers make a difference in ways that can affect students' own lives (e.g., *Pretty Is What Changes: Impossible Choices, The Breast Cancer Gene, and How I Defied My Destiny*).
- Have students write up personal reflections related to lessons. For example, reflections connected to engaging with elements of the Bio-ITEST unit, *Using Bioinformatics: Genetic Testing* (e.g., BLAST searches, the NCBI database, and *23andMe*).

Career Development Concepts	✓ Awareness	✓ Relevance	Self-Efficacy	Engagement

2. Integrate experiential activities in the classroom

- Set up a role-playing activity where students assume various lab positions (e.g., Principal Investigator (PI), post-doctoral scientist or graduate student). This helps students understand the duties of each position in the research setting and "connect the dots" between what they are learning and how it can be used in real life.
- Students work in groups to design a research poster based on a classroom lab activity, present it, and ask questions.

Career Development Concepts	✓ Awareness	Relevance	✓ Self-Efficacy	Engagement

3. Incorporate authentic research

- Engage students in authentic research. Several Bio-ITEST teachers have also implemented a curriculum funded by the National Institutes of Health where students conducted authentic research on smoking behaviors and genetics.[24] Students were involved in the study design and genotyping. "The curriculum guides them to realize that this is what scientists do" (study PI). Students become interested when they have the opportunity to choose the research questions and analyze the data in new ways that no one else has done.

Career Development Concepts	✓ Awareness	✓ Relevance	✓ Self-Efficacy	✓ Engagement

4. Invite guest speakers

- Include a variety of careers; examples included the county crime scene investigator (CSI) director, a person with a disease who can speak about all the scientists who have helped them, a mortician, and a forensics expert.
- Ask all guest speakers to share their own educational and career pathways.
- Invite parents engaged in any STEM field to speak.
- Task advanced students to work in teams to arrange guest speakers themselves.

Career Development Concepts	✓ Awareness	✓ Relevance	Self-Efficacy	Engagement

(continues on next page)

[24] *Exploring Databases: Conducting Authentic Research Using the Smoking Behavior Database*, developed by the University of Washington Department of Genome Sciences and College of Education.

Exhibit 1: *continued*

5. Research science careers / map out career paths

- Assign homework that requires researching different science-related careers or mapping out a personal career plan so that students can see the required educational trajectory, the multiple possible paths and entry points to careers, as well as interesting related careers in other fields such as art.
- Have students document their skills (e.g., pipetting, DNA gel electrophoresis) through creating resumes (resume writing is an assignment in the Bio-ITEST curriculum).
- Incorporate reflection and exploration. Students journal about all the careers covered in the curriculum and then research one, answering questions such as: Where could you go to school to become qualified for this profession? Do you need an advanced degree? What are the career avenues? They then share their findings with each other in small groups and post them on the wall or the class website.
- Assign students to search online to find a biotech company and research information on one job that is currently open at that company including job duties, level of education required, prior experience needed, and salary range. Students also write a description of what they think is fun or interesting about that job, sharing findings with the class.

Career Development Concepts	✓ Awareness	✓ Relevance	Self-Efficacy	Engagement

6. Support inclusion of science careers in school career fairs

- Use personal contacts to invite scientists who can represent a wider range of science opportunities.
- Set up a science-oriented career fair and have students prepare a resume and "interview" for different science jobs, with parents or other adults serving as interviewers.

Career Development Concepts	✓ Awareness	Relevance	✓ Self-Efficacy	Engagement

7. Weave career Information informally into lessons

- Talk informally, while students are working on a classroom lab activity, about what it would be like to do that kind of work for a job. For example, one teacher related that when she showed a film on the Hantavirus prior to conducting an immunology lab, she made a point to discuss what it would be like to work in a Biosafety Level 4 lab, what training would be needed for that job, and what would attract someone to that line of work.
- Engage students in a discussion about the scientist who started a study that the lesson is based on. For example, one teacher, using a DNA electrophoresis kit[25] to determine if ivory is being poached from certain herds of elephants, led a discussion about what the scientist had to do before he could get to the point of being able to identify the ivory and what doing that kind of work would be like.
- Discuss the individual jobs relevant to each unit. For example, in studying the cholera epidemic in London in the 19th century, one teacher set the tone by telling her students that "they would all be epidemiologists for the next two days."

Career Development Concepts	✓ Awareness	✓ Relevance	✓ Self-Efficacy	✓ Engagement

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[25] This kit is made available to teachers through the Science Education Partnership, Fred Hutchinson Cancer Research Center.

Exhibit 1: continued

8. Share personal experiences

- Share on-the-job experiences with students as a way to engage students and show the relevance of biology content. Several of the teachers interviewed were able to share their experiences in either science fields prior to entering the teaching profession, or from summer opportunities to work in the sciences. Students see an adult they can identify with, demystifying the work that scientists do.
- Attend professional development workshops such as Bio-ITEST and bring the information back to students.
- Share personal decision-making processes in choosing a science career. One teacher noted that her students read a book of interviews with scientists, in which one interviewee struggled to decide between a career as a scientist or a concert pianist. The teacher then shared her own dilemma in choosing between music and science. Three students facing similar decisions chose to write a reflective paper on this issue.

Career Development Concepts				
	✓ Awareness	✓ Relevance	Self-Efficacy	Engagement

9. Expose students to worksites and outside opportunities

- Leverage student learning at scientist worksites with targeted preparation, not only studying in class what kind of work happens in the lab but also working with students to develop questions for scientists they will encounter. Students see scientists and others in STEM careers as real people in the context of where they work and learn about local job opportunities.
- Require group research and presentations about the site prior to the visit.
- Seek funding to take students to career and science fairs. This strategy has been useful for a teacher in a rural area, whose student population is 70% Hispanic, and who would not otherwise have access to these opportunities.
- Organize Saturday field trips so that students can have an all, or half-day, experience without interrupting school time.
- Arrange for students to get involved with relevant local initiatives. For example, one teacher's students organized a blood drive at school and, in return, were invited to observe an open-heart surgery and tour hematology and pathology labs at a hospital. Students develop confidence in their own abilities by making a contribution that will have a real impact on others in their communities.

Career Development Concepts				
	✓ Awareness	✓ Relevance	✓ Self-Efficacy	✓ Engagement

10. Be a mentor / advocate

- Mentor students whether formally or informally. This might entail seizing an opportune moment to comment to a student who is interested in a career, "You can do this, but you will need to take algebra next year."
- Engage in networking, taking the names of science professionals wherever encountered, including in workshops. When students mention a particular career, contact the appropriate person to see if s/he can advise on how to help that student.
- Support students in seeking out funding opportunities (e.g., in applying for the Washington Award for Vocational Excellence [WAVE] scholarships). Identify and nominate students for specific opportunities as they surface through teachers' own networks or other sources, such as school counseling offices.

Career Development Concepts				
	✓ Awareness	✓ Relevance	✓ Self-Efficacy	✓ Engagement

Exhibit 2: List of Interviewees and Expert Reviewers by ITEST Participation

PILOT TEACHERS-2010

Tami Carabello
Science Teacher
Snohomish School District, WA

Jennifer Duncan
Science Teacher
Port Angeles High School, WA

Heidi Kirk
Science Teacher
Olympia High School, WA

Mary Marsh
Science Teacher
Redmond High School, WA

Amanda Rainwater
Science Teacher
Bothell High School, WA

Miranda Roth
Science Teacher
Seattle Academy of Arts & Sciences, WA

Susan Russell
Science Teacher
Lynnwood High School, WA

WORKSHOP-2010

Tami Carabello
Science Teacher
Snohomish School District, WA

Wanda Bryant
Science Teacher
Detroit Public Schools, MI

Randy Dix
Science Teacher
Olathe High School, KS

Devin Parry
Science Teacher
Lakeside Upper School, Seattle, WA

Susie Ridgeway
Science Teacher
Union High School, WA

MINI-SESSION-2011

Connie Kelley
Science Teacher
Shorewood High School, WA

Judy Shaw
Science Teacher
Riverside High School, Auburn, WA

Michele Wolksi
Science Teacher
Arlington High School, WA

KEY INFORMANTS

Helen Buttemer
Director, Biology Program for Teachers
University of Washington

Pam Darling
Director, *Washington Network for Innovative Careers*

Pat Ehrman
Associate Director,
Center for Inquiry Science
Institute for Systems Biology, Seattle, WA

Nancy Hutchison
Director, Science Education Partnership
Fred Hutchinson Cancer Research Center

Larry Lashway
Director, Program Support
Professional Educator Standards Board, State of Washington

Maureen Munn
Director, Genome Sciences
Outreach Program
University of Washington, Seattle, WA

Sue Shields
Director
Puget Sound Skills Center, Burien, WA

Dana Twight
Member, *Washington State Board of Education, 2002-2006*
Chair, *Seattle School District CTE Dept General Advisory Committee, 2009-2011*

Cheryl Vermilyea
Director, Center for Career Connections
Bellevue College, Bellevue, WA
Co-PI NSF Stem to *Stern Project*

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Maureen Munn
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BIO-ITEST

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This product was produced by Carolyn Cohen, Cohen Research & Evaluation, LLC, (cohenevaluation.org) and Davis Patterson, Ph.D., Evaluation Consultant, as part of their external evaluation of the Bio-ITEST project. Its contents are solely the responsibility of the authors and NWABR, and do not necessarily represent the official views of the National Science Foundation.

For further information on the evaluation, contact Carolyn Cohen at cohenevaluation@seanet.com.

Additional copies of this monograph may be downloaded at: nwabr.org/education/teaching-STEM-career-awareness.pdf

The Bio-ITEST Project

The Northwest Association for Biomedical Research (NWABR), a non-profit dedicated to promoting understanding of biomedical research and its ethical conduct, leads **Bio-ITEST:** *New Frontiers in Bioinformatics and Computational Biology*, a program funded by the National Science Foundation's Innovative Technology Experiences for Students and Teachers (ITEST, Grant No. DRL 0833779), designed to bring the exciting discipline of bioinformatics to high school teachers and students. The Bio-ITEST program is a model designed to provide secondary science teachers with the knowledge, skills, and resource materials to engage their students in the newly developing fields at this intersection of biology and information technology, ensuring that students will be able to participate in these important new workforce areas. Project leadership includes Jeanne Ting Chowning, MS, Bio-ITEST Principal Investigator and NWABR Director of Education; Sandra Porter, PhD, Bio-ITEST Co- Principal Investigator and President of Digital World Biology; Karen Peterson, MEd, Bio-ITEST Co- Principal Investigator and CEO of the EdLab Group; and Dina Kovarik, MS, PhD, Bioinformatics Program Manager, NWABR.

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