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Teaching Strategies that Promote Science 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 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."**

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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.

[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."

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 monograph shares results of our inquiry into pedagogical strategies that infuse career awareness into science lessons. We first identify four cognitive building blocks of career development, and four promising approaches for raising awareness of science careers. We then provide a typology of ten replicable teacher practice strategies, with accompanying examples of each. These findings are part of a larger exploration into the potential for secondary science teachers to increase student awareness of, and interest in, science careers, and are intended to contribute to field-building efforts that address how to best support the STEM pipeline at the high school level.[7]

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.[8] 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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[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] The accompanying report, *The Emerging Role of Science Teachers in Fostering STEM Career Awareness* can be downloaded at: nwabr.org/education/teaching-STEM-career-awareness.pdf

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

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.

One science educator summarized this multi-faceted career exposure as analogous to an oil painting.

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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.

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, "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 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.

[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.

Career Strategy Area and Replicable Teacher Practices

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

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.[13] 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

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[13] *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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[14] 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

Methodology

The findings in this monograph are derived from an investigation into the emerging role of science teachers in fostering STEM career awareness.[15] The inquiry 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.[16] 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.

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[15] The full report, The Emerging Role of Science Teachers in Fostering STEM Career Awareness, may be downloaded at: nwabr.org/education/teaching-STEM-career-awareness.pdf

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

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*

MANUSCRIPT REVIEW

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John Gargani
President
Gargani + Company, Inc

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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.

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/science-careers-teaching-strategies.pdf

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