

Creating opportunities for science PhDs to pursue careers in high school education

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ABSTRACT The United States is confronting important challenges at both the early and late stages of science education. At the level of K–12 education, a recent National Research Council report (*Successful K–12 STEM Education*) proposed a bold restructuring of how science is taught, moving away from memorizing facts and emphasizing hands-on, inquiry-based learning and a deeper understanding of the process of science. At higher levels of training, limited funding for science is leading PhDs to seek training and careers in areas other than research. Might science PhDs play a bigger role in the future of K–12 education, particularly at the high school level? We explore this question by discussing the roles that PhDs can play in high school education and the current and rather extensive barriers to PhDs entering the teaching profession and finally suggest ways to ease the entrance of qualified PhDs into high school education.

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In many K–12 classrooms, science is presented as a series of textbook facts; students are not exposed to scientific methods of inquiry and lose interest in science. At the very opposite end of the science training pipeline, life science PhDs and postdocs in the United States are experiencing difficulties in finding university jobs, a situation that will likely persist in the coming decade if research funding fails to grow; we cannot expect all PhD graduates to become principal investigators (PIs) at academic institutions.

Might these two problems add up to a solution (or at least a partial solution)? Is there a place for graduates of PhD training programs in teaching K–12 science, particularly at the high school (HS) level (the focus of this article)? We argue that the answer is “yes” and that more PhDs, even if their numbers are small compared with the entire teaching pool, could have a catalytic effect on reinvigorating precollege science education. This topic is not new; the National Research Council (NRC) issued two thoughtful reports on attracting science and math PhDs to secondary school

education more than a decade ago (Committee on Attracting Science and Mathematics Ph.D.s to Secondary School Teaching, National Research Council, 2000; Committee on Attracting Science and Mathematics PhDs to K-12 Education: From Analysis to Implementation, Division of Policy and Global Affairs, National Research Council, 2002). Their recommendations were not implemented, however, and the reports have largely been forgotten. Little has changed since then; the roadblocks, both in perception and logistics, that discouraged a PhD from becoming a HS teacher in the year 2000 still exist. Since the NRC reports were released, the topic of a HS teaching career option for a PhD has rarely been discussed or debated in our scientific community. We feel that it is time to reopen this discussion. The focus of this article is on PhDs entering the high school system, but much of this discussion also pertains to graduates of science master degree programs and to individuals with scientific training becoming involved in all levels of K–12 education. Our goal is to make students, postdocs, and senior scientists aware of the value of high school teaching for certain individuals as well as for our nation’s educational system. We also consider how changes at the local level (including the perception of K–12 teaching within research universities), as well as at the policy level of teacher accreditation, might facilitate this career path.

IS THERE A NEED AND ROLE FOR PhDs IN HIGH SCHOOL SCIENCE TEACHING?

A HS science teaching position requires a BA or BS degree. This requirement makes sense but raises a host of questions for PhDs. Are PhDs overqualified for a HS teaching position? Does a PhD

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Abbreviations used: GK-12, NSF Graduate Stem Fellows in K-12 Education; HS, high school; IRACDA, Institutional Research and Career Development Award; NIH, National Institutes of Health; NRC, National Research Council; NSF, National Science Foundation; PI, principal investigator; SEPA, Science Education Partnership Award; STEM, science, technology, engineering, and mathematics.

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degree make one a better HS teacher? Is it worthwhile for a school to hire a PhD often at higher cost? Can one apply aspects of what one learns during PhD training to teaching at the HS level, and are these elements appropriate for HS students?

In our opinion, encouraging the right type of PhD to enter into HS teaching makes sense, and high schools benefit in the end. Many organizations (e.g., the National Academy of Sciences) and educational leaders advocate for more inquiry-based learning in the K–12 science curriculum (National Research Council, 1996; Committee on Developments in the Science of Learning and Committee on Learning Research and Educational Practice, 1999; Committee on Development of an Addendum to the National Science Education Standards on Scientific Inquiry, Center for Science, Mathematics, and Engineering Education, National Research Council, 2000). Scientific inquiry is difficult to teach without having had an experience of trying to solve an unknown scientific question oneself. Offering research opportunities for HS science teachers (or students in training to become teachers) is one way to provide HS teachers with a deeper understanding of science inquiry. Graduate education in science, however, is predicated upon solving an original research problem, and thus a PhD who enters a HS teaching profession has a strong foundation of understanding research and the processes of scientific thinking.

Furthermore, it is possible to translate many experiences from PhD training into a HS environment, such as the skill of how to set up an experiment. This skill, and a general understanding of experimentation, is sometimes lost with prepared lab kits that do not require students to think about controls and other parameters of their experiment. Many lab kits also are not flexible enough for students to adjust variables of the experiment, which is an important aspect of experimental science. Furthermore, even sophisticated labs that are now available to HS teachers do not always involve inquiry and therefore become more of a recipe for students to follow. A second valuable skill is the knowledge of how to read a scientific paper. Although there are resources that explain how to read primary literature, these do not substitute for the experience of using papers for furthering one's research and writing scientific papers (Gillen, 2007). In addition, scientific papers that are carefully chosen and explained properly can be understandable and enjoyable and no less difficult than reading a challenging novel. PhDs also can instill a sense of wonder about the many important things that remain to be discovered in the sciences and the discoveries that are being made right now. Furthermore, as concluded by the 2000 NRC report (Committee on Attracting Science and Mathematics PhDs to K-12 Education, 2002), PhDs can provide a bridge to scientific centers, as they are more willing to seek opportunities for students to tour research labs or connect students to research projects.

Some may argue that PhDs will be disappointed by HS teaching and are better off teaching more advanced biology in college. However, many individuals enjoy working with HS students at this influential stage of their lives. Furthermore, there are many opportunities for innovation and creativity in HS science teaching in which PhD training could be beneficial, particularly in developing ideas to make science interesting and introducing scientific thinking into the classroom. Thus, education in HS can be as challenging and interesting as bench science for the right type of person. A survey conducted by the NRC in 2000 also revealed that a surprising 30% of respondents (graduate students and postdocs in the biological sciences) were interested in and had considered a career in secondary education (Committee on Attracting Science and Mathematics Ph.D.s to Secondary School Teaching, 2000).

This poll should be reconducted, but since the “holding tank” of postdocs seeking jobs has grown larger in the past decade, it is likely that current interest remains high. Although PhDs are aware that the salary scale for a high school teacher is lower than that for other occupations, the 2000 NRC report identified several positive perceptions of teaching in a secondary school, which included “attractive working hours, a work schedule similar to their children's school day, and time for research or other activities during the summer” (Committee on Attracting Science and Mathematics Ph.D.s to Secondary School Teaching, 2000).

CATALYZING CHANGE: IMPORTANCE BEYOND NUMBERS

Even if PhDs can provide value to high schools, their numbers will always be small, a mere drop in the very large pool of HS teachers. Some might argue that such a small group does not warrant special attention. We counterargue that impact and change are not always driven by sheer numbers of people. Instead, it is important to identify circumstances in which a few individuals can make important differences to a system. A PhD who has a significant understanding of scientific research and learns to become a great HS teacher would have an unusual opportunity of seeing kids enter their classroom “hating” science and leave with an attitude that science is “okay,” maybe even “awesome.” As a bonus, a few students may want to pursue a science-related career (many science professionals can remember a HS science teacher who affected their career decision). In addition, beyond their own classrooms, good teachers with a deep understanding of science can influence many more students by sharing ideas with and assisting their peer teachers. Through their influence on curriculum development, teachers could reach even more students and teachers in their districts or beyond. A subset of scientist–HS educators also may later become administrators in schools or school boards, where they could have a broader impact on the science curriculum, as discussed in a recent editorial by Alberts (2011).

WHAT ADDITIONAL SKILLS DO PhDs REQUIRE TO TEACH IN HIGH SCHOOL?

The 2000 NRC report concluded that PhDs lack the general skills needed to become an effective teacher (Committee on Attracting Science and Mathematics PhDs to K-12 Education, 2002). Indeed, a PhD graduate is not trained to manage a class of teenagers with raging hormones, deliver learning material in a HS curriculum, or necessarily understand and relate to kids of this age group. In addition, teaching methods have changed since the time when a recent PhD graduate would have been in high school. In addition to traditional assessments and lectures, an excellent HS teacher needs to be able to implement methods that include self-reflection, formative assessment, rubrics, lesson planning, classroom management, and awareness of different abilities and learning styles, as well as many other skills. The crux of the matter is how to teach PhDs effectively and efficiently so that they have sufficient skills to confidently enter a high school classroom, a topic to which we return when we discuss teacher accreditation.

WHAT BARRIERS IMPEDE PhDs FROM ENTERING K-12 EDUCATION?

The NRC report estimated that only 0.8% of PhDs work in K–12 education, a stark contrast to the earlier-noted >30% potential interest in such an occupation (Committee on Attracting Science and Mathematics Ph.D.s to Secondary School Teaching, 2000). Although the K–12 teacher salary can dissuade many PhDs from entering the

K–12 profession, many remain interested but face several barriers in transitioning from research into teaching at secondary schools, as noted in the following sections.

Negative perception of becoming a high school teacher

Is K–12 teaching an acceptable career outcome after a PhD degree? The answer to this question is not obvious. In contrast to countries like Finland, where K–12 teaching is a highly respected occupation (Sahlberg, 2011), high school teaching is generally perceived as a low-stature occupation in the United States. That perception is further magnified in the higher academic circles. There is an unspoken perception in the graduate school community that becoming a HS teacher after obtaining a PhD represents a failure, a last resort after other options have not panned out. It is not something that one pursues as an active choice. This perception is expressed in a blog by a PhD HS teacher:

I often feel like the world looks at this choice we've made as some sort of failing condition. Once in a while I get a student asking me, carefully, why I'm not teaching college if I've got my doctorate. The assumption often seems that it's because I couldn't make it as an academic so now I'm stuck teaching high school.... If only graduate schools valued and encouraged returning to (or entering) K12 practice as an outcome for the PhD (DOCZ, 2012).

Jeff Shaver (personal communication) also expresses similar views:

I knew I wanted to be a high school science teacher since I was a sophomore in high school. This career aspiration was the result of having outstanding high school teachers and a history of teaching in my family. However, I haven't always felt supported in my decision to teach high school and often got questions like, "If you have a PhD, why are you teaching high school?" With that said, many students and parents appreciated the fact that I had research experience that enabled me to provide opportunities for students that they would not have otherwise gotten.

The perception of HS teaching as a failure for someone with an advanced degree is damaging to graduate students who entertain the idea of such a career choice and to the culture of the scientific community. Many students would be hesitant about discussing becoming a HS teacher with their advisor or thesis committee, fearing that it will "disappoint" them. HS teaching is not discussed as career option in thesis committees and rarely at career workshops. Most PIs have little idea of what HS teaching involves or what is being or could be taught in HS.

Lack of classroom experience during PhD and postdoc training

Beyond the perception problem, additional barriers discourage PhD graduates from entering a HS teaching career. First, it is difficult for graduate students to have a significant HS teaching experience during their PhD training in order to decide whether they might like or might be good at it. Graduate students are busy with their own training and work and therefore have little time to spend in a high school classroom. In addition, this time away from lab might not be acceptable to their PI.

On the other hand, finding a way into a classroom is certainly possible for motivated grad students, and there are some good programs that help facilitate such classroom experiences. The National Institutes of Health (NIH) Science Education Partnership Award (SEPA) Program partners graduate students with high schools in

order to elevate the curriculum at the schools (National Institutes of Health, 2013a). The National Science Foundation (NSF) Graduate STEM (Science, Technology, Engineering, and Mathematics) Fellows in K-12 Education (GK-12) Program provides training for graduate students through collaborations with K–12 classroom teachers (American Association for the Advancement of Science, 2013). Both the SEPA and the GK-12 programs are designed more to enrich K–12 classrooms than to provide a route to a teaching profession for the graduate student. In addition, the NSF-sponsored Robert Noyce Teacher Scholarship offers scholarships to graduates of STEM programs and professionals who enroll in certificate programs (National Science Foundation, American Association for the Advancement of Science, 2013). This scholarship requires teachers to work in underserved schools for 2 years for every year of support (~4 years), which may not always be the right fit for an individual. Another program that provides training in college classrooms for postdocs is the NIH-sponsored Institutional Research and Career Development Award (IRACDA; U.S. Department of Health and Human Services, National Institutes of Health, 2013b). This program focuses on connecting postdocs with mentor-teachers at institutions (not high schools) that focus on underrepresented groups. The aforementioned programs are helpful in providing PhD trainees or postdocs with an initial experience in the classroom, but they do not provide a pathway to certification, and many of them restrict the types of schools at which they can teach.

Difficulty in becoming a high school teacher after obtaining a PhD

The requirement of a teaching certificate provides the greatest barrier of all for PhDs who want to teach in public schools. The accreditation process often necessitates 2 additional years of training, a significant burden of time and potentially money for someone who has already completed a lengthy PhD training program. Owing to a need for STEM teachers, some states have instituted alternate certification programs to streamline this process for individuals with advanced degrees. The requirements for these programs vary greatly by state, but they generally require that the candidate pass a subject test and enroll in classes on pedagogy, class management, and lesson design. Some of these programs have restrictions, such as requiring candidates to work in rural underserved communities for a given amount of time or that the candidate already be used by a school district.

CAN WE PROVIDE A BETTER ENTRY PATH FOR PhDs TO TEACH HIGH SCHOOL BIOLOGY?

As discussed here, PhDs who are interested in secondary school teaching find themselves in a "no man's land," not being encouraged by the research community or by the K–12 educational community. In the following, we discuss ideas for how this overall path might be facilitated.

Expose PhDs to the possibility of high school teaching

Most PhDs who are currently teaching HS science arrive at this choice in spite of, rather than because of, a good mentoring system. Quite notably, HS teaching is frequently omitted from among the many nontraditional career tracks currently being advocated for PhDs (e.g., patent law, public policy, business or nonprofit administration, college teaching, science writing). This situation can be changed, however, by inviting PhD high school teachers to talk at career workshops aimed at graduate students and postdoctoral fellows and making this career option more visible at national meetings. Having clear information about how to get jobs in this sector

also is essential. Most PhDs are poorly informed, and information on the Web is complicated and often state specific. The differences between public and private school jobs could be explained and presented more explicitly to PhDs, and perhaps a national job board (e.g., for private schools seeking PhD-trained teachers) could be organized.

Before they make commitments to pursue HS teaching paths, it would also be useful to give interested PhDs more opportunity to see what HS teaching is like. All PhDs have experienced HS, but it is hard to imagine what it is really like to be on the other side of the classroom. The NSF's GK-12 program gets PhD students into classrooms. In addition to such formal mechanisms, however, it would be relatively easy to institute low- or no-cost partnerships with local high schools that are tailored to students interested in the possibility of a high school teaching career. For example, a 2-week "shadow" of a high school teacher might give PhD students or postdocs a sense of whether they could imagine themselves teaching several classes per day, 5 days per week

Restructure a certification program for PhD STEM educators

Public schools are losing out. The most prestigious and selective private high schools in the country hire PhDs to their faculty without a teaching credential. Private schools allow these teachers to pick up important teaching skills through professional development opportunities and/or mentor programs within their school. And it is working; in most cases, PhD hires become outstanding private school teachers. Public schools, with their tedious teaching credential requirements, cannot compete effectively with private schools for a newly minted PhD seeking a job.

In our view, a pipeline of PhDs entering private schools is not in the best interest of our overall educational system. Furthermore, the complete lack of training/certification for entering private schools is not in the best interest of a PhD seeking to become an effective teacher. There is a great need to develop tailored programs that efficiently train PhDs to enter and become effective teachers in either public or private school, recognizing that their backgrounds and years in training differ from those of someone with a bachelor's degree. The current accreditation system is not effectively meeting this goal. We recommend the creation of intensive certification courses (~6–10 weeks) designed specifically for PhDs that teaches pedagogy and high school level teaching methods coupled with a short teaching internship. Even if the cohort was small (e.g., 50 fellowships per year), it could have a powerful effect. The NRC report identified "a prestigious national fellowship that provides training and placement, and covers living expenses" would cause PhDs to consider secondary school teaching (Committee on Attracting Science and Mathematics PhDs to K-12 Education, 2002). In addition to providing an attractive entry point to teaching, such a program would send a message that PhD trainees have a place in the HS system.

Implementation of such a program is nontrivial, since some entity (state or federal government or private) would need to administer and fund it and help to place PhDs in school systems. If run at a national level, individual states would need to accept such training for certification to teach in their schools. In 2002, the NRC Phase II report proposed such a national level training program for PhDs to enter K–12 education. In this case, the proposed national program was to provide 2 years of support of PhDs, structured as a postdoctoral program, to train and intern in a school. Unfortunately, the NRC recommendations were not followed up by the U.S. government. At the present time, the NSF would be well positioned to link such a new PhD teacher training program to

their existing efforts (GK-12) that enable PhD trainees to have experiences in K–12 classrooms. Alternatively, a philanthropic organization with combined missions in research and K–12 education (e.g., Gates Foundation, Carnegie Foundation, Howard Hughes Medical Institute) could make a major impact by establishing a first-of-kind program to facilitate the transition of PhD graduates into HS teaching. After placement in high school teaching, a possible added feature would be to include a summer stipend for science curriculum development (perhaps for a limited time of a few years). In addition to augmenting teachers' salaries, such a summer program would provide opportunities for creativity and innovation that could attract energetic PhDs toward HS teaching.

Networking PhD K–12 educators

Improved networking of PhD-trained K–12 educators, both locally and nationally, could stimulate recruitment and career development. Because their numbers are small, PhDs involved in K–12 education rarely encounter one another to share experiences or ideas for the classroom. Such interactions with one another (and with PhDs in higher education) could have a powerful effect on their professional development and have a positive impact on STEM education overall.

One way to foster a sense of community among PhD educators would be through the creation of a website that would serve as a source of information (e.g., how to get jobs, job postings, curriculum ideas) and social networking. The cohort of PhD HS teachers could also interact at a national meeting, where they could present their efforts and share notes on science curriculum development, as well as meet senior guest scientists and educators.

CONCLUDING REMARKS

Our scientific and educational communities cannot wholeheartedly advocate bringing real science into K–12 classrooms and yet discourage or make it difficult for trained scientists to enter the precollege teaching profession. Small changes, however, can alter the status quo. These include developing better local and national awareness of career paths in K–12 education and expediting/publicizing training programs that will allow PhDs to find jobs and be prepared to enter precollege classrooms. Given the coincident problems of insufficient number of jobs for new PhDs and the need to bring more exciting science rather than facts to K–12 education, the time is ripe for serious thinking on implementation. It also is a good time to break down traditional barriers that prevent more interactions and partnerships between "scientists" and "educators." Critically, any new program aimed at introducing PhDs into K–12 education must be developed with the help and guidance of K–12 schools. Only in this way can we build an education system that can truly bridge K–12 and graduate institutions and introduce scientist-teachers at all levels of our educational system.

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