PERSPECTIVES

Higher Education Faculty Versus High School Teacher: Does Pedagogical Preparation Make a Difference?

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Abstract: Higher education faculty are not held to the same standard of pedagogical preparation as primary and secondary teachers. This perspectives essay points out the difference in pedagogical preparations between higher education faculty and high school teachers. The essay highlights research indicating the importance of pedagogical training, offers suggestions on how to improve higher education teaching practices, and lists valuable teaching and assessment resources. Lastly, the essay encourages higher education faculty to seek pedagogical training and expend the necessary effort to become more effective instructors.

Key Words: Teacher preparation, teacher effectiveness, assessment, pedagogy, teaching strategies

INTRODUCTION

In the discipline of biology, students vary widely in the emphases they pursue. One of these emphases is in education with the end goal of being a high school biology teacher. Although total credit hours required to graduate in each degree program are generally consistent, at many universities, credit hours specified by a major in secondary education are substantially greater than for other majors in the department. This is because these students must not only learn the subject matter, but must spend an equal amount of time immersed in pedagogical training. Their peers, on the other hand, who choose to pursue a graduate degree with the intent to become a college teacher and researcher, rarely require pedagogical training. Is teaching in high schools versus institutes of higher education really so different? After personal observations and involvement in both high school and college teaching, my conclusion is that the challenges teachers face at either level are very much the same. The difference is in teacher preparation and accountability, and high school teachers, on average, have more of both. Does pedagogical training make a difference?

WHAT IS THE DIFFERENCE IN PEDAGOGICAL PREPARATION BETWEEN HIGH SCHOOL AND HIGHER EDUCATION?

The U.S. federal government has put in place stringent requirements to become certified as a primary or secondary teacher. According to the Interstate Teacher Assessment and Support Consortium (InTASC), a national organization that works with states to set state standards for K-12 teacher licensure, three standards must be met: an understanding of the learner and the process of learning; an understanding of the content knowledge; and an understanding of appropriate and effective instructional practices (including how to plan lessons, strategies for implementation, and assessment of learning; InTASC, 2011). As a consequence, to become a high school teacher, minimum state standards require an average of 54 credit hours of subject-specific content (based on a comparison of secondary science education majors at 6 institutions across the country—see Table 1), approximately equivalent to any basic science major, with typically an additional 16 to 24 credit hours of pedagogical training, and 12 plus credit hours of student teaching, which translates to a minimum of ten weeks of full-time teaching in the classroom. This makes a secondary education major, on average, 33 credit hours more than a standard science degree (e.g., biology, physics, or chemistry), sometimes requiring a master's degree. The pedagogical training typically includes courses in child and adolescent development, multicultural and special needs education, cognitive psychology, behavioral theories, classroom management, the use of technology in the classroom, and curriculum design. Certainly some of these courses are necessary pre-requisites to teaching children. However, even those who will teach high school are required to learn about the development of the intellect. As higher education faculty, what qualifications are required? A masters and/or doctoral degree in the subject being taught (i.e., content knowledge) is all that is required at most undergraduate institutions. Although this statement may be over-generalized, and certainly most institutions of higher learning require a demonstration of teaching ability prior to hiring, it is

Table 1. Credit hour requirements for standard biology degrees and biology degrees with an emphasis in secondary education at six universities across the nation.

Institution	Major	Approximate Major Credit Hours (content-specific hours for Biology Education Majors)
Arizona State University		
	Biology	72
	Biology Education	96 (53)
Baylor		
	Biology	66
	Biology Education	90 (66)
Brigham Young University		
	Biology	65
	Biology Education	82 (53)
Johns Hopkins University		
	Biology	59
	Biology Education	98 (59; Requires an M.S.)
Purdue University		
	Biology	66
	Biology Education	84 (50)
University of North Carolina		
	Biology	56
	Biology Education	68 (43)
	Average Biology Degree	53
	Average Biology Education Degree	86 (54)

certainly not commonplace for pedagogical training or "on the job" teacher training to be a "mandatory" part of a graduate experience. You may ask, "So what? Does it make a difference?"

DOES THE RESEARCH SUPPORT THE IMPORTANCE OF PEDAGOGICAL TRAINING?

Several peer-reviewed studies have produced evidence that pedagogical training leads to improved student outcomes. Postareff *et al*. (2008) showed that college professors who participated in at least one year of pedagogical training practiced more student-centered teaching and had a greater sense of self-efficacy than those who did not participate. Lawson *et al*. (2002) found that reformed teaching as a result of participation in the Arizona Collaborative for Excellence in Preparation of Teachers (ACEPT), a program focused on providing pedagogical training to college professors who teach major's and nonmajor's college courses, strongly correlated with improved student achievement on the course final exam. Pfund *et al.* (2009) found that participation in a pedagogical training program (the Summer Institute, sponsored by the National Academies) improved undergraduate teaching practices; participants reported, by survey, significant gains in their understanding of scientific teaching and their intention to implement such practices in their classroom. A follow-up survey revealed that 96% of alumni reported that they were continuing their efforts to improve their teaching. In addition, Martin and Lueckenhausen (2005) found that the more sophisticated one's understanding of teaching and learning is, the more likely an individual is to adjust their teaching strategies based on evidence of effectiveness. Perhaps this is because one is better able to assess effectiveness, if the process of learning is truly understood. Even at the primary and secondary level, the evidence shows that teachers who obtain a traditional teaching certificate lead to better student performance on standardized exams than those who do not (Fuller and Alexander, 2004; Greenwald *et al.*, 1996).

DO ADVANCED DEGREES AND YEARS OF EXPERIENCE MAKE FOR BETTER TEACHERS?

The simple, evidence-based answer to this question is that, at least at the primary and secondary levels, advanced degrees in specific science/math content area make little impact on teaching quality. Research comparing secondary student performance on standardized exams and degrees obtained by their teachers shows that having a bachelor's degree in the subject taught, at least in math and science, is a significant predictor of student performance on subject tests; however, graduate degrees had no additional effect (Darling-Hammond, 1999). Assessing the effect of advanced degrees on teaching in higher education is a much more difficult scientific endeavor. Since the attainment of an advanced degree is a pre-requisite to becoming a higher education faculty (at most institutions), an adequate control group is difficult to obtain. However, since the attainment of advanced degrees is often the only requirement to become a higher education faculty member, and since research shows that advanced degrees in a science content area have no effect on teaching quality at the primary and secondary level, this minimal requirement may be of concern at the college/university level. Certainly more research is needed to assess the impact of advanced degrees by higher education faculty on student learning. Nonetheless, evidence is lacking that it has any positive impact.

Does experience alone make for a better teacher? Postareff *et al.* (2008) compared the amount of teacher experience (in years) of higher education faculty with approaches to learning (assessed using the Approaches to Teaching Inventory) and found no significant shifts from teacher-centered to student-centered teaching practices based on experience. What they also found was that one's sense of self-efficacy does significantly improve with experience. This should be a cause for concern: regardless of actual effectiveness (which most likely has gone unmeasured; see Table 2 for suggested ways to measure student learning), one's confidence and self-perceived success increase over time! And many faculty members have been doing this for a very long time, utterly convinced that a teacher-centered approach is effective, an approach that has been shown to be highly resistant to change (Gibbs and Coffey, 2004; Lindblom-Ylänne *et al.*, 2006).

IS THERE EVIDENCE TO SUGGEST THAT A LACK OF TRAINING IS REALLY A PROBLEM?

That is a difficult question to address. According to the research listed previously, it would appear that, yes, without training, teachers have lower student achievement. However, assessing the effectiveness of a teacher has proven to be a complicated and problematic task. At the primary and secondary level, it has been attempted by evaluating the success of students on standardized tests of ability and achievement, determined by each state (e.g., The Utah Basic Skills Competency Test [UBSCT], the Arizona Instrument to Measure Standards [AIMS], or the Maryland High School Assessment [HAS]) or by national norm-referenced tests such as the Iowa Test of Basic Skills [ITED], the TerraNova, the SAT and ACT. Although fraught with controversy, and in no way perfect, at least an effort is being made to hold teachers accountable for teaching practices. Many norm-referenced exams exist for college-level assessment (e.g., the GRE subject tests, the Major Field Tests [by the Educational Testing Service]). However, their use to assess teaching quality is not commonplace and their ability to accurately assess student conceptual understanding is questionable.

Many higher education faculty, especially at Carnegie Research I Universities (e.g., Harvard,

Table 2. Instruments for assessing teaching practices and student outcomes. Constructs being measured by each instrument are listed along with the source where the instrument can be found.

Instrument	Construct Measured	Citation
Instruments for teacher assessment		
Approaches to Teaching Inventory	Teaching approach: conceptual change/student-focused approach versus information transmission/teacher-focused approach	Prosser and Trigwell, 1999
Reformed Teaching Observation Protocol (RTOP)	Teaching approach: degree to which teaching is reformed to meet the national science and mathematics standards	Piburn *et al*., 2000.
The measure of self-efficacy beliefs	Sense of self-efficacy in teaching practices	Trigwell *et al.*, 2004
Instruments for student learning assessment		
Student Assessment of their Learning Gains (SALG)	Learning outcomes for a wide range of courses	Access at http://www.salgsite.org
Introductory Molecular and Cell Biology Assessment (IMCA)	Understanding of basic biological concepts	Shi *et al.*, 2010
Biology Concept Inventory (BCI)	Understanding of basic biological concepts	Klymkowsky and Garvin-Doxas, 2008
Biology Attitudes, Knowledge, and Skills Survey (BASK; currently 3 versions)	Basic biological conceptual understanding and scientific reasoning ability	Lawson (currently available at http://www.public.asu.edu)
The Classroom Test of Scientific Reasoning (LCTSR)	Scientific reasoning ability based on Piagetian stage theory including concrete, formal, and post-formal levels	Lawson, 1978
Nature of Science Surveys (NOS & VNOS)	Understanding of the nature of scientific inquiry	Lederman *et al*., 2002; Oehrtman and Lawson, 2007

* Other valuable resources: Angelo and Cross, 1993; Huba and Freed, 1999

Princeton, Yale, Columbia, Stanford) are evaluated by research outcomes, prominently visible in the form of publications and grant dollars. Although most colleges and universities will confirm that faculty members are accountable for teaching quality as part of their qualifications for tenure, the evidence of such quality is most often assessed by student evaluations, a controversial, difficult to interpret, non-standardized instrument (Emery *et al.*, 2003; Mason *et al*., 2002; Wright, 2006). A call for more direct assessment of student outcomes is warranted and would most likely be beneficial. Table 2 provides several sources that can be used by individual higher education faculty to directly assess the effectiveness of their teaching.

ARE HIGHER EDUCATION FACULTY IN CHARGE OF TEACHING FUTURE TEACHERS?

Some higher education faculty are directly responsible for teaching content-specific pedagogy to secondary education pre-service teachers as part of the teacher preparation program. For those teachers, pedagogical training is an obvious necessity. But, do those faculty members, whose primary focus is on research in a biological discipline, have an impact on future teachers? Their responsibility is to teach biological content in a way that students will gain conceptual understanding. Most primary and secondary education programs have requirements for general science courses. Those students, who will be future teachers, will experience biology for the first time, but also observe how to *teach* it, from biology faculty. What kind of an example is being set? The ACEPT showed definitive evidence that pedagogical training led to reformed teaching practices that increased undergraduate student achievement (Lawson *et al*., 2002). In addition, it led to improved achievement of the junior and senior high school students whose teachers were enrolled in an ACEPT reformed class as part of their pre-service training (Adamson *et al*., 2003).

Consider the effect that college and university faculty have upon graduate students. A survey in 2006 indicated that in the United States, roughly a third of graduate students ended up in faculty positions (Cyranoski *et al.*, 2011), many of them without inclusion of a pedagogy course during their training. Although the offering of a future faculty training program is being more widely offered at many universities [e.g., the Center for the Integration of Research, Teaching, and Learning (CIRTL), an NSF-sponsored training program, or Preparing Future Faculty (PFF) programs that exist in over 295 participating universities], it is rarely a requirement for obtaining an advanced degree. So, where do *they* learn how to teach? As a graduate advisor, your responsibility is two-fold: instruct graduate students on how to be a successful researcher, but also instruct them on how to be an effective educator. As Adamson *et al*. (2003) affirmed, “Teachers teach as they have been taught” (p. 940).

In light of the evidence previously described and Kevin Carey’s recent article in *Democracy* (2010) describing the lack of accountability for teaching quality at America’s colleges, higher education faculty should re-evaluate their teaching methodologies, hold themselves accountable for student learning, and re-dedicate their efforts to improve the profession of teaching.

BE A PART OF THE SOLUTION

If high school teachers spend half of their professional preparation learning how to teach, shouldn’t higher education faculty take some responsibility for their own professional teaching preparation? Many faculty are so overwhelmed by scholarly and citizenry duties that teaching becomes a diminished priority. Moreover, at many institutions of higher education, research productivity is weighted significantly more heavily than teaching performance in merit pay evaluations and tenure and rank advancement decisions. However evidence supports the importance of teaching quality for student learning and should motivate an increase in attention and effort to improving teaching practices. So, how does one know if their teaching methods are successful and if not, how do they improve? Outlined below are some suggestions and resources to take an active approach to improving education.

TAKE AN EVIDENCED-BASED APPROACH

Since most scholars are driven by scientific research, taking an evidence-based approach to teaching strategies may in fact be relevant and motivating. Educational research is a thriving scientific field where innovations are being tested and implemented regularly. For many, it is a new and unexplored opportunity for research. Most colleges and universities have departments and faculty members dedicated to educational research. Take advantage of collaborations with these individuals. Educational research can be, and in most cases has become, just as objective, controlled, and scientific as other scientific research, e.g., systematics, ecology, developmental biology. This is especially so if those individuals trained and practiced in traditional biological sciences become active participants in the endeavor.

FIND OUT WHAT THE RESEARCH HAS ALREADY SHOWN

There is a plethora of evidence already available showing the effectiveness or ineffectiveness of different teaching strategies. Table 3 outlines some of the most well studied strategies and lists resources that can guide you in their implementation.

Seek out studies that might be applicable to your specific classes (i.e., teaching evolution to non-science majors, teaching introductory biology for majors, teaching microbiology or population ecology, etc.). There are several on-line search engines for finding scholarly articles in educational research (e.g., The Educational Resources Information Center [ERIC], www.eric.ed.gov; Google Scholar, http://scholar.google.com; Education Full Text, by WilsonWeb, http://vnweb.hwwilsonweb.com; The Gateway for Educational Materials [GEM], www.thegateway.org). In addition, many professional organizations specialize in disseminating educational research materials (e.g., ACUBE, NSTA, SCST, NARST, AERA) and many traditional scientific organizations have an education emphasis (e.g., ASM, SSE, AAAS, ASCB). Consider joining one or more of these organizations and taking advantage of member benefits from published educational journals, professional development workshops, and professional meetings on education.

SEEK PEDAGOGICAL TRAINING

Many professional development opportunities are available. Many professional societies in the life sciences now offer workshops on pedagogy and even present research on education (e.g., ASCB, ASMCUE, AAAS). In addition, many professional societies specialize in improving undergraduate education and hold annual conferences for this sole purpose (e.g., NABT, NSTA, AAC&U, ACUBE). In addition, a variety of training workshops are available such as the ABLE workshops (www.ableweb.org), the HHMI/NAS Summer Institute (www.academiessummerinstitute.org), the POD network conferences (www.podnetwork.org), and workshops sponsored by SCST (www.scst.org/conferences).

Pedagogical training does not have to be extensive or even formal in its acquisition. Resources abound. The National Research Council has compiled a review of significant research findings and suggested ways to link the research findings to actual classroom practice in their report, *How People Learn: Brain, Mind, Experience, and School* (Bransford *et al*., 2000). This is a valuable resource with which all educators should become acquainted. In addition, the NRC has called for an increased emphasis on inquiry instruction. How many have heard of “inquiry”? Probably most. But, how many can properly define it and appropriately implement it in the classroom? The NRC (2000) published *Inquiry and the National Science Education Standards* to serve as a guide for teachers. Other resources are listed in Table 3.

TAKE ADVANTAGE OF AVAILABLE RESOURCES

There is no sense in trying to reinvent the wheel when so many curricular materials are tried and tested, developed and planned, and readily available. Following is just a short list of available resources for developing effective lesson plans: BEN BiosciEdNet Digital Library managed by AAAS, Scitable by Nature Publishing Group, BioEdOnline.org by Baylor College of Medicine, The Biology Project by the University of Arizona, BioInteractive by the Howard Hughes Medical Institute, and the World Lecture Hall managed by the University of Texas at Austen.

Table 3. Teaching strategies that have been tested in college science classrooms. Student outcomes affected by each strategy with accompanying citations for effectiveness data are listed. Resources to help in the implementation of each strategy are also listed.

	Evidences of learning	Resource(s) for implementation
Inquiry—teaching science as science is practiced		
	Increases conceptual understanding, reasoning skills, and attitudes toward science over traditional expository teaching (Haury, 1993; NRC, 2000)	*Inquiry and the National Science Education Standards* (NRC, 2000); *Science Teaching and Development of Thinking* (Lawson, 2002); *Teaching Science as Inquiry* (Bass *et al*., 2008); NSTA’s *Handbook of College Science Teaching* (Mintzes and Leonard, 2006)
Formative Assessment—prompting students to evaluate their own learning		
	Increases conceptual understanding (McDonald and Boud, 2003; Nelson *et al*., 2009; Nicol and Macfarlane-Dick, 2006)	*A Practical Guide to Alternative Assessment* (Herman *et al*., 1992)
Collaborative Learning—allowing students to work in groups		
	Increases student achievement, positive attitudes toward STEM subjects, and persistence in STEM majors (Johnson *et al*., 1998; McKeachie *et al*., 1986)	*Cooperative Learning: Theory, Research, and Practice* (Slavin, 1990); *Active Learning: Cooperation in the College Classroom* (Johnson *et al*., 1991)
Active Learning—involving students in doing and thinking		
	Increases conceptual understanding and student engagement (Hake, 1998; Handelsman *et al*., 2007; McClanahan and McClanahan, 2002)	*Scientific Teaching* (Handlesman *et al*, 2007); *Active Learning: Creating Excitement in the Classroom* (Bonwell and Eison, 1991)

DISCUSSION

This perspectives essay is not meant to be discouraging or to paint a grim picture of the paucity of teaching excellence at undergraduate and graduate institutions. Many are outstanding teachers who have inspired and successfully educated hundreds and even thousands of students. For some, this essay may simply serve as a compliment to your already ongoing efforts to improve your teaching and as a welcome list of potential resources. For others, it may serve as an awakening and a realization that your advanced degrees and years of experience do not definitively qualify you as excellent educators. It takes dedication, self-reflection, and amenability to be great educators, and to adequately serve the students we have been appointed to teach. Fortunately, the road to improvement can be relatively easy, intellectually stimulating, and immensely rewarding. Resources abound, research is flourishing, and success is attainable. All it requires is dedicated effort, accompanied by appropriate training and support; and when teachers successfully instill in their students the same passion for learning and discovery that led them to their profession, the effort will be worth it.

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