Professionalizing College Science Teaching: Training a New Type of Science Academician

Linda L. Tichenor
Department of Science and Mathematics
University of Arkansas - Fort Smith
Fort Smith, AR 72913.
e-mail: lticheno@uafortsmith.edu

Abstract: Traditional graduate programs in science are not always appropriate for training future faculty desiring jobs in non-research institutions where teaching undergraduates is the primary mission. What the author proposes is a specific biology Ph.D. program to train professional academics who will have a strong science background and systematic training to teach at the undergraduate level. The newly graduated would be intent on improving undergraduate curricula and programs through evaluation, assessment, and classroom level research.

Key words: graduate students, college science teaching, innovative graduate program, restructuring graduate education.

DEFINING THE PROBLEM
The traditional research training model has been retained over the years as adequate preparation for a college science teaching/research career. Two of the reasons for this are the lack of research on undergraduate learning outcomes in higher education and lack of Ph.D. program outcomes assessment. A different concept in training doctoral students to be professional educators and pedagogical researchers in college science teaching is one that needs to be considered (Richlin, 1995; Tice, 1997; Golde, 1999; Nyquist, et al., 1999; Preparing Future Faculty listserv; Re-Envisioning the PhD Website, 1999; Nerad and Cherny, 2000; Murray, 2000; The Responsive PhD, 2001). The idea is not new, but in view of recent recommendations for improving graduate education, we should begin to rethink how we are preparing future academicians. Borrowing from the words of Dr. Jerry Gaff, vice president for education and institutional renewal at the Association of American Colleges and Universities (AAC&U) and director of the Preparing Future Faculty program, "It is timely to develop doctoral programs that address the mismatch with hiring institutions and that address changing responsibilities of faculty members" (Gaff, et al., 2000). This call is a stark admission that the time is right for a change in graduate training. We need academicians who have been trained for discipline-based, college science teaching and who are qualified to produce new scholarship on learning in the science discipline.

Accepting new ideas for preparing doctoral students will require a paradigm shift from the German university training model, which has been the standard for many years. It can be argued that the traditional Ph.D. training program creates a mismatch between training and actual work experience of the academic. Ph.D. graduates in science earn their degrees in Research I universities and then assume faculty positions in liberal arts colleges and comprehensive universities. Only about 10% of newly graduated Ph.D.'s will actually find themselves in an academic setting similar to the one in which they were trained (Finkelstein, 1999). These newly graduated Ph.D.s do not have substantive experiences in teaching practices, knowledge of research on learning, nor familiarity with institutions with missions different than Research I universities. Will these new faculty members have the skills to cope with the plethora of demands in academia today? Some of the preferred experiences listed in the job announcements include recognizing and honoring different learning styles, dealing with the handicapped and disabled students, understanding diversity issues of gender, race, and religion, coping with educational technology, and participating in strong academic advising. Many agree that the traditional doctorate programs do not give sufficient or any training in these areas (Whitt, 1991; Boice, 1992; Sorcinelli, 1992; Olsen, 1993; Rice, 1996; Tierney and Bensimon, 1996; Tierney, 1997; Olsen and Crawford, 1998; Golde, 1999).

The important question that needs to be asked is why do we not professionalize teaching in doctoral programs as we have research training? After all, as faculty, we do both. Most science departments are limited to offering degrees within highly specialized disciplines whose purpose is to train research scientists. Since these specialized research degrees may not always be most suitable for a graduate who desires to work in non-research institutions (AAAS, 1990; Sigma Xi, 1990; NSF, 1997), would it not be far-sighted to prepare at least some science faculty for these
institutions in which their professional expertise would be required for undergraduate science teaching and service to the institution?

This paper discusses a new type of doctoral program that addresses the above concerns. By offering broad content training in biological subdisciplines, plus training in educational research, the Ph.D. Biology--Science Education program attracts students who desire terminal degrees but will seek employment in non-research undergraduate institutions. This paper serves as a potential model for any science discipline that wishes to broaden its existing doctoral programs to include more than one type of graduate training.

**WHAT NATIONAL REPORTS TELLS US**

Major constituencies of doctoral education have called for programs of study that support a more inclusive definition of academic work (Finkelstein, 1999). The National Academy of Science, National Academy of Engineering, and National Institute of Medicine jointly reported that a new Ph.D. degree program is needed--one that develops a full-range of career skills for the program participant. The American Association of Universities, which produces over one-half of all doctoral degrees, reported in 1998 that graduate curriculum needs to be redesigned to address all student career interests (Gaff, et al., 2000).

The report entitled, *Building the Faculty We Need*, (Gaff, et al., 2000) summarized findings from several important national research studies on doctoral education. The surveys concluded that nearly one-third (30%) of graduate students were dissatisfied with the way their doctoral programs were organized. Doctoral students reported that they only felt prepared to do research whereas many of them were interested in a wide range of faculty roles. 25% of the doctoral students reported that they would like to have had courses in other departments (Nerad and Cherny, 2000). All findings of the national graduate student surveys can be grouped into global recommendations that provide information to justify the worthiness and to define the objectives of the new Ph.D. Biology--Science Education program discussed herein. These recommendations are enumerated in Table 1.

**Table 1. Summary of Recommendations Based on Graduate Student Studies**

<table>
<thead>
<tr>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater breadth of knowledge through interdisciplinary work should be emphasized during graduate training,</td>
</tr>
<tr>
<td>Greater emphasis should be placed on teaching and teacher training during graduate school,</td>
</tr>
<tr>
<td>Opportunities to work for potential employers should be a part of the training program,</td>
</tr>
<tr>
<td>Socialization of doctoral students to life in the academy needs to be addressed, and</td>
</tr>
<tr>
<td>Emphasis needs to be placed on developing various skills necessary for success in the academic profession in its entirety not exclusively on research.</td>
</tr>
</tbody>
</table>

**WHAT THE JOB MARKET TELLS US**

Since the present academic job market is slow, the time could actually be favorable for the creation of new doctoral training programs. The reason is that faculty searches are attracting large numbers of applicants, and institutions are being more selective for applicants who can offer some evidence of teaching efficacy. Many job announcements require that the applicant teach in two or more subdisciplines of biology and have skills with distance or on-line education.

According to reports (Finkelstein, et al., 1998; Finkelstein, 1999), the academic work force (n=1,033,966) is in a state of great change. The number of part-time faculty is increasing, while a number of faculty members are non-teaching professionals such as librarians and counselors. The data demonstrate that only one-half of the total academic work force is full-time teaching faculty (n=514,976). This fact does not discourage but rather encourages the timeliness of a new type of doctoral preparation program. The reason is because as many as 40% of the full-time teaching faculty will be replaced in the next decade. This means that the number of new doctoral graduates entering academe could be as high as 250,000 during the next 10 years. Therefore, the hiring potential for the new graduate will only be increased. New training standards in doctoral education could supply the demands for excellent teachers, *i.e.*, faculty who can perform assessment of their own teaching and curricula, conduct classroom research, produce research on pedagogy, and participate sooner in service to the institution.

**ABOUT A NEW PH.D. PROGRAM IN BIOLOGY**

**Program Description and Objectives**

The Ph.D. in Biology--Science Education is a doctoral degree that is not less rigorous than a traditional Ph.D., but is an alternative training program that emphasizes teaching effectiveness in science through educational research and breadth of disciplinary content. The graduate students will become content experts in biology as well as experts in educational theory, pedagogy, and research. The new program was designed in collaboration with the Department of Curriculum and Instruction in order to...
provide greater depth and focus on research techniques unique to education. Since education research is based on social science methodologies, the biology graduate student must learn a new set of research skills that are often different than those used in biological science.

In addition, students of this program will have "practiced" and assessed their academic performance through internship components detailed below. The teaching internship potentially familiarizes the students with different types of higher education institutions. Many institutions require that new faculty participate in community outreach, faculty governance, search committees, and/or student advising even in the first year of employment. Not having had practice with service requirements adds an extra burden to new faculty who are just beginning to put their first courses together and starting research/scholarship programs. The service internship gives graduates experience with the nonacademic portions of their job.

The intent of the new doctoral program is not new. The Ph.D. Biology-Science Education is similar to the Doctorate of Arts (D.A.) degree implemented in 1967 with the support of the Carnegie Foundation. The D.A. training program was adopted at ten major universities for preparing faculty as postsecondary educators in several fields, mathematics and sciences included. However, the D.A. programs in biology have dwindled to two, one at Idaho State University and the other at Northern Colorado State University.

The program designed for the biology department at the University of Arkansas has substantive differences than the D.A., mostly in the approach to the program evaluation through assessment. (See the section on assessment of the program below.) The following summarizes the objectives outlined for the new graduate program. These objectives were based on a literature review of teaching future undergraduate science faculty (Smith, 1974; Stockdale and Wolchok, 1974; Allen, 1976; Krockover, 1980; Monaghan, 1989; Cruikshank, 1990; Lawrenz, et al., 1992; Lumsden, 1993; Druger, 1997).

**Table 2. Expectations of graduates of the new program.**

<table>
<thead>
<tr>
<th>Expectations</th>
</tr>
</thead>
<tbody>
<tr>
<td>be able to synthesize a broad range of concepts in biology and communicate these concepts effectively both orally and in writing,</td>
</tr>
<tr>
<td>have produced significant, original contributions to the field of science teaching/learning through rigorous evaluation/assessment,</td>
</tr>
<tr>
<td>possess skills and attitudes to teach undergraduate biology in a variety of higher education institutions with missions different than research universities, and</td>
</tr>
<tr>
<td>obtain knowledge and skills involved in the academic culture by participating in academic service components at the institutional, national, and community levels.</td>
</tr>
</tbody>
</table>

**How Degree Program Objectives Are Achieved**

The major difference between the traditional Ph.D. training model and the new program is the deliberate teacher preparation with objectives more explicitly set forth. Through formalized internships, education-focused dissertation, required courses in education and breadth of content expertise, instead of "less," the student gets "more" training without the addition of extra years to the terminal degree program. Since the learning objectives are stated, the program must and should be assessed for efficacy of preparation.

The trainees are derived from applicants who have already completed a Ph.D. or M.S. research thesis in the sciences. This assures that the graduates of the program will understand scientific process. The course work will be determined in part by a diagnostic examination that assesses content knowledge in a core of biology content in addition to selected topics from educational theory. Diagnostic examinations may serve as pre-tests in assessing outcomes of the program. The candidacy exam and final written examination will serve as post-tests. Upon completion of the dissertation, the student will give a public seminar.

The teaching internship is a supervised pedagogical activity that provides for the development of skills in traditional and/or innovative teaching methods. Under the supervision of an experienced faculty member, the intern will develop instructions for an undergraduate course at the home institution or other college. The service internship is a supervised activity that provides for socialization of graduate students into the role as faculty. This experience will allow students to explore roles in committee work, administration, and/or service to the community at large (for example, outreach to K-12 teachers). A learning agreement or contract will be drawn up between the intern and supervisor that specify the tasks to be performed. Students will be expected to document the outcomes of the two internships. These documents will be used for program assessment.

The research component will be oriented toward undergraduate science education. All students must complete an original research-based dissertation in science teaching/learning, or design an undergraduate biology curriculum or manufacture some artifact to be
used in undergraduate instruction that represents a significant and original contribution to the field of science teaching/learning.

Assessment of the Program

The new program will be formally evaluated with the help of the Office of Research in Measurement in Education in the College of Education and Health Professions. One major goal of the evaluative component intends to assess the effectiveness of the program in producing graduates who are successful in the areas of educational research and biological science instruction at the college level. Specifically, assessment of the program effectiveness will be based on quantitative objective measures of student technical skills, participation in faculty service and administrative committees, and production of research, in addition to perception assessments of student abilities by faculty and employers. Additional information will be obtained for addressing student perceptions of strengths and weaknesses of the program, including evaluations of course work and training components, for the improvement of the delivery of education within the new program. Longitudinal databases will be created for the purposes of assessing change across time for cohort groups within programs, in addition to allowing for comparisons of traditional and non-traditional program participants.

The evaluation plan is divided into four phases. The first two phases provide for the creation of a longitudinal student database for evaluating program participants and non-participants on the selection of cognitive, academic, and interpersonal characteristics that are hypothesized to be related to the unique training provided by the new program. The third phase provides for the creation of a cross-sectional database that will provide a program assessment component as assessed by potential employers. The fourth phase is the creation of a longitudinal database for assessing program participants and non-participants' early career performance and long-term success as perceived by their employers and the graduates themselves. A summary of the evaluation plan is given in Table 3.

<table>
<thead>
<tr>
<th>GOALS</th>
<th>OUTCOME EVALUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthesis of broad range of content concepts which can be effectively communicated</td>
<td>1. Comparison of written and oral examinations, project proposals, and dissertations by biology faculty member for both traditional and new program cohorts</td>
</tr>
<tr>
<td>Educational research/original and significant contribution to the field Pedagogical skills in undergraduate teaching</td>
<td>2. Faculty survey</td>
</tr>
<tr>
<td>Knowledge of academic culture</td>
<td>3. Course work comparisons (performance and breadth of content)</td>
</tr>
<tr>
<td></td>
<td>Number and types of publications, presentations, grants, and scholarly activities from both cohorts</td>
</tr>
<tr>
<td></td>
<td>1. Teaching evaluations</td>
</tr>
<tr>
<td></td>
<td>2. Teaching effectiveness/observational measures</td>
</tr>
<tr>
<td></td>
<td>3. Student surveys of perceived proficiency of educational delivery</td>
</tr>
<tr>
<td></td>
<td>4. Reported use of research in the classroom for guidance in pedagogical practices</td>
</tr>
<tr>
<td></td>
<td>5. Internship reports</td>
</tr>
<tr>
<td></td>
<td>1. Level and types of participation in institutional, national, and community service activities</td>
</tr>
<tr>
<td></td>
<td>2. Service internship reports</td>
</tr>
</tbody>
</table>

SUMMARY

There have been few alternatives to the traditional research training model for preparing future faculty. Two reasons for this are the lack of research on undergraduate student learning outcomes in higher education and lack of Ph.D. program outcomes assessment. Because well-established institutional habits are difficult to change, it will not be easy to convince colleagues that examining traditional practices is worthwhile. After all, the system seems to work. Hopefully, we can begin to break away from more narrow models of graduate training, which are reported to be inadequate in the complex academic milieu today. With more explicitly designed doctoral programs which include a number of different experiences, we can begin to prepare future faculty with skills and experience necessary for meeting challenges of the entire academic profession. The key to a successful program is the “design,” however, with program objectives stated as well as methods of assessment planned before the inception of the program. Perhaps the data will suggest that there is a better way of preparing college science teachers.
REFERENCES
Gaff, Jerry G.; Anne S. Pruitt-Logan; Richard A. Weibl; and PFF participants. 2000. Building the Faculty We Need: Colleges and Universities Working Together. Association of American Colleges and Universities and The Council of Graduate Schools.
Preparing Future Faculty. Listserve. <PFFNET@CDINET.COM>
The Responsive PhD. 1001. An initiative to improve doctoral experience in the arts and sciences. <www.woodrow.org/responsivephd>

Tice, Stacey L. (1997). *The Relationships Between Faculty Preparation Programs and Teaching Assistant Development Programs: A series of occasional papers*. Preparing Future Faculty Program (No. 4, October).


---

**Call For Resolutions**

The Steering Committee of ACUBE requests that the membership submit resolutions for consideration at the 2004 Annual meeting to the Chair of the Resolutions Committee. Submit proposed resolutions to:

Brenda Moore, Truman State University, Division of Science, MG3062, Kirksville, MO  63501, bmoore@truman.edu Phone (660)785-7340

---

**Call for Nominations**

**Bioscene Editorial Board**

We are soliciting nominations for four (4) *Bioscene* Editorial Board positions (term through-2007). Board members provide input concerning the publication of *Bioscene* to the Editors. Board members provide rapid review of manuscripts as requested. Board members are expected to assist in the solicitation of manuscripts and cover art for *Bioscene*. Board members are expected to provide assistance in proofing the final copy of *Bioscene* prior to publication. If you are interested in serving a three-year term on the Editorial Board, please e-mail the editors

Ethel Stanley -- stanleye@beloit.edu

Timothy Mulkey -- mulkey@biology.indstate.edu