

Rethinking the Dissertation in Science

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There has been much discussion of late about the need to reexamine the way we educate graduate students in science. The need to rethink how we train students comes about because of the convergence of a series of trends within the broad fields of science and impinging on the scientific enterprise generally. The dissertation is only one part – albeit a central one – of graduate education but cannot be discussed productively without considering the broader context. In the first case, there is some discrepancy between the underlying approach to graduate education and the eventual career paths taken by today's students, and that may mean that we are not doing a very good job providing students with the education they need. All available evidence suggests that over 60% of new Ph.D.'s in science in the United States will not have careers in academic research, yet graduate training in science has followed the same basic format for almost 100 years, heavily focused on producing academic researchers. This system has served most stakeholders well to this point, including the broad scientific enterprise, the research institutions that train students, and the federal agencies that help provide support for graduate education through either research fellowships or research assistantships tied to research grants. The one, and most important, stakeholder who might be much less well served is the graduate student herself. The situation does vary somewhat by discipline and institution, but as a generality, a very large proportion of students will not go on to academic research careers. So, is our current model of graduate education in science the right one?

Another trend affecting graduate education emerges from an evolution in the way science is being done. Historically, science was a relatively solitary enterprise. Individual scientists worked in their own laboratories with perhaps a few graduate students as apprentices. But over time, science has become much more a team activity. Many of the most interesting and important scientific questions require multidisciplinary approaches to tackle them, and virtually no single individual has all the needed expertise. Therefore, it is essential that modern scientists be able to work productively in teams, and that they have some experience doing that before they go off into the field themselves. Graduate schools need to find some way to integrate those experiences into the curriculum.

What do these kinds of trends mean for the dissertation? Why do we have dissertations in science anyway? The dissertation was initially designed to ensure that future academic researchers had proved themselves able to be significant contributors to the scientific knowledge and theory base. Put another way, they had to prove they could be like their mentors. That fundamental concept still drives the majority of dissertation formats required by graduate programs, although there is substantial variation in what constitutes a dissertation in the various fields of science and across universities. Some universities require the same form of dissertation that they required 50 years ago – usually a long, expositive tome that includes a long introductory section that meticulously builds the case for testing an important theory or hypothesis and then a series of studies described in great detail to do the testing. This is followed by an extensive discussion section that

speaks both about the manifold implications of the work and discusses all the potential flaws or other problems that could diminish the work's impact. These can run to hundreds of pages, and the question is regularly asked whether anyone other than the student and his/her committee bothers to read or otherwise use the dissertation. Other institutions require mostly that the student has conducted a series of publishable experiments and then, in effect, the student can submit a relatively straightforward compilation of those papers or studies. The dissertation is subjected to scrutiny by a committee of the faculty and then the student needs to "defend" the dissertation, usually in an oral format.

Whichever format is used within a field or institution, it is time to ask just how well the dissertation is serving the training needs of today's students – or even serving the advancement of our scientific enterprise? Asking those questions is, of course, complicated by variation across fields and the diverse career goals and career paths students are pursuing, but we need to have those discussions. I offer some core issues for consideration.

- In the context of today's science and graduate education, is there still a need for a "culmination of training" project or final test that a graduate student has been appropriately educated (let's call it a "dissertation" for simplicity's sake)?
 - If so, what's the best format? Should there be a universal format or variation by discipline and institution?
- What do we really want the student to be showing or proving through the dissertation? Is the format attuned to that goal?
 - E.g., Is the goal to make a substantial contribution to the discipline and/or to prove one can behave like the student's mentor(s)?
- By the time students get to the dissertation stage, their career goals will be fairly clear. Should the format of the dissertation be tailored to the student's goals or should the format be uniform? If it should be tailored, who gets to decide the focus and direction?
- How much of a student's training should be directed at that project or test as opposed to other activities or experiences?
- How can the dissertation be adjusted to reflect the fact that science is much more being carried out in teams?
 - How can we best evaluate a student's ability to work in a team?
 - If the work is done in teams, how can we measure the contributions of the individual?

These kinds of questions surely have been considered within institutions and likely within disciplines. Moreover, only some are specific to science; others are generic to graduate education. Nonetheless, a national dialogue on these issues, I believe, would serve both graduate education and the scientific enterprise well.