# Student Perspectives on Developing More Relevant Ph.D. Programs in STEM Disciplines through Professional Skills Training

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## Introduction

Graduate study, in an attempt to produce experts, has traditionally encouraged doctoral students to delve deeply into a narrow area of specialization over the course of their research [1,2]. While recognizing the value of concentrated analysis and expertise, Ph.D. students themselves have expressed frustration at the inherent problem of compartmentalization of knowledge in doctoral programs [3] and what they perceive to be an "extreme specialization in their studies"[4(p.47)]. As a result, some are left with what has been described as disconnected and narrow areas of expertise [1,5] at a time when the changing marketplace is demanding workers who have well-rounded and integrative skills that balance breadth and depth, as well as experience with interdisciplinarity, leadership, and communication skills [2,5–8].

Critics have determined that this disconnect is creating an unacceptable number of doctoral students who feel "ill-prepared for, and under-informed about, jobs outside of research universities" [1(p. 24)]. Even graduates who find work within the academy struggle to transfer their disciplinary training and knowledge to meet the broader demands of their new employment and are finding themselves largely unprepared to teach classes or serve administratively in academic departments [1]. Consequently, researchers and employers are now urging contemporary Ph.D. students to acquire what they refer to as "generic," "transferable," or "professional development" skills—especially the capacity to lead, work well with others, and communicate knowledge to audiences across disciplinary borders—in addition to an area of academic expertise [8–13]. As students have diverse motivations for pursuing a graduate degree, varying expectations about how the degree will prepare them for the future, and different experiences related to career development opportunities, there is yet much to be learned in this area.

The misalignment between the professional skills contemporary employers expect and the actual skills with which many doctoral-level STEM programs are equipping doctoral students needs to be better understood. This research explores the degree to which students perceive that their doctoral programs are providing them with skills that will make them employable in the current job market. Using a mixed methods approach, this study employed both a written survey and focus group interviews with several groups of Ph.D. students currently involved in STEM doctoral programs at a large Midwestern university. The intent is to learn more about the ways in which Ph.D. students in these fields prepare themselves for careers in a demanding and fluctuating job market, and to discover their thoughts on how their departments and graduate programs could better assist in these efforts.

## Background

The last few decades have witnessed an assortment of rapid and transformative changes in the needs of society and in the institutions created to respond to these needs [13,14]. As the economy shifts from one based on the production of goods to one based on the production of knowledge

and information it creates a demand for new types of learners and innovators in every profession [15]. Consequently, employers and administrators in every sector now report that they expect doctoral programs to create well-rounded disciplinary experts who have the ability to be leaders in their fields and are capable of creating real-world value from knowledge and discovery[1,16–18].

Employers also report that they are seeking graduates who possess a myriad of skills not traditionally included in many STEM-focused programs, such as entrepreneurial experience [3], leadership skills [13,19], the ability to adapt to and manage shifting goals [20], and effective collaboration and communication skills with individuals both inside and outside of their areas of specialization[7–13,17]. It has been said that "today educated people and the knowledge they produce and utilize have become the keys to the economic prosperity and well-being of our society" [21(p. 11)]. In spite of these economic realities, universities—and doctoral programs specifically—largely continue to view Ph.D. training as a means of reproducing the status quo [1,2,7,22,23].

Given the disparity between the narrow disciplinary skills traditionally acquired in doctoral education and the growing pressure for STEM graduates to have more transferable professional skills in the contemporary economy, many have questioned whether the current highly-specialized form of research-dominated graduate education is still capable of responding to the needs of both students and of society [4,24]. These concerns emphasize the increasing significance of transferable skills training for the employability and career readiness of all graduate students [17,25], as well as the growing necessity for a more self-regulated and professionally flexible graduate education that equips Ph.D. students with the ability to adapt their education to meet a broad set of needs as they become proficient lifelong learners in a variety of occupations.

Recent examinations of doctoral education and graduate career paths show that even after acquiring advanced degrees in a disciplinary field, most Ph.D. graduates never secure jobs at research universities—and yet the training of graduate students continues to be geared almost exclusively toward such positions [26,27]. Approximately half of all students who begin a doctoral degree report wanting to pursue a career as a professor in a tenure track position [19], and the results of several national surveys conducted over the last decade indicate that around fifty percent of doctoral graduates will end up employed in business, government, and nonprofit sectors[9,19,24,28]. Findings emphasize that only a minority of graduate students will be able obtain employment which directly applies the academic content of their doctoral education [29].

In spite of these data, the traditional expectation for Ph.D. students to become tenure-track faculty members has been maintained in the midst of abundant statistics documenting the continuing decline of available jobs in academia [23,30–32]. Several factors over last few decades have dramatically decreased the number of tenure-track jobs in many academic disciplines in what looks to be a now-permanent structural imbalance [23]. This means that if Ph.D. programs continue to proceed in the traditional manner, many knowledge communities may be training doctoral students at great length and expense for jobs they will never obtain [2,30,32,33].

Research also shows that even those graduates who eventually do land a job in academia are finding themselves to be lacking general professional skills and are largely unprepared to work cooperatively with other faculty, participate in interdisciplinary projects, or serve administratively as leaders in academic departments [1,13]. Many career skills not typically situated

within traditional Ph.D. coursework - including the ability to cope with change, possessing a mindset capable of recognizing opportunities, and the ability to innovate across disciplines—have become essential professional and life skills that students need regardless of their chosen fields of study [34,35].

In summary, the acquisition of a broader set of transferable professional skills, in addition to a technical specialty, can provide students with the capacity to recognize opportunities for innovation and the generation of economic and/or social value more quickly[36]. In the new economy, the ability to nimbly direct one's learning towards desired outcomes, coupled with an awareness of the utility of possessing broadly-applicable professional skills, has become the key to quickly assessing market conditions and creating new opportunities rather than a waiting to find a reliable ladder to the top [29,37–39]. Overall, a more comprehensive perspective about the career options open to all Ph.D. students—and STEM students in particular—combined with exposure to transferable professional and lifelong learning skills would augment workforce readiness and employability, leaving multiple career paths open for doctoral graduates [40].

**Purpose and Research Questions**

Quantitative data have been gathered in previous studies that document the existing incongruities between the disciplinary skills acquired during doctoral education and the professional skills contemporary employers are demanding[9,28,41]. Researchers studying the roles of postsecondary education in career preparation have commonly relied on questionnaires and surveys as the predominant means of determining Ph.D. graduates' assessments about how well their former doctoral programs prepared them for their current careers [5,22,23,42].

What is noticeably absent in the literature up to this point, however, are the voices of the students—beyond what can be expressed in a survey with limited response options—who are currently engaged in the higher education-career preparation process. In order to fill this gap and better understand the expectations and perceptions of contemporary STEM doctoral students surrounding the acquisition of relevant professional skills during graduate school, by answering the following questions:

1) What are Ph.D. students' career objectives?
2) How do Ph.D. students perceive the relevance or focus of their programs?
3) Which professional skills are students interested in acquiring?
4) How do Ph.D. students feel their programs could be improved?

**Research Methods**

This exploratory study uses a mixed methods approach involving a quantitative survey with focus groups. The purpose of the quantitative survey was to gather demographic data from participants as well as gauge interest in various aspects of professional development. Focus groups were chosen because of their ability to uncover deeper facets of understanding that often remain hidden when employing surveys alone to gather data [43]. Numerous topics can be discussed and many insights can be gained, particularly with regard to the variations in student behavior in comparable situations. This proves useful in studies such as this one when seeking to

triangulate data to better understand how the experiences, behaviors, and skills acquired by similar types of students produce different levels of career readiness despite being educated in a seemingly common learning environment.

### *Participants*

To date, the study has recruited the participation of 44 students who are currently enrolled in STEM-related Ph.D. programs at a large Midwestern university. In addition to being doctoral students in a STEM discipline, a secondary level of participant stratification was added and each of the four focus groups was populated by assembling participants who also shared another common characteristic [44,45]. These commonalities included: foreign students who are sponsored financially by their national governments; students who are sponsored financially by a company; students who work in a research position as part of an integrated university/industrial research park community; and students who have previously participated in a professional development course or workshop offered through the university.

### *Research Design and Data Collection Procedures*

Each of the four focus groups consisted of roughly 8-10 participants who were asked to individually fill out a consent form and a 20 question survey upon arrival at the focus group site. The survey consisted of questions designed gather general demographic information, as well as numerical rating scales intended to elicit more specific information about the student's career goals, expectations about being prepared for the job market during graduate school, perceived proficiency in various professional skills, interest in gaining additional supplemental skills training, and opinions about what formats would make transferable skills training most accessible to them (see Appendix A).

The focus group interviews were approximately 90 minutes in length and moderated by a team of researchers who employed a flexible interviewing structure in an effort to foster a conversational atmosphere and collect genuine responses from the participants during the interviews [46]. The moderator team used a list of potential focus group questions organized around topics pertinent to the research questions as prompts to stimulate group discussion. The researchers elected to use this questioning guide as a non-verbatim and non-linear topical outline, employing it more to focus on covering important areas of research relevance and provide prompts for introducing new topics and for segueing between topics as the discussion progressed than to address specific research questions in a particular order.

### *Data Analysis Procedures*

Qualitative analysis of the information collected from the focus group interviews was initiated by performing multiple readings of the information in its entirety to become familiar with the compiled data sets. After this process was completed, phrases, ideas, reactions, suggestions, and opinions that were repeated throughout the focus groups were highlighted to uncover and summarize common themes within the data. Initial coding was then performed to sort data into manageable chunks relating to these themes. Finally, connections, relationships, and larger

patterns within or between themes were extracted and examined to ascertain whether these fit with any of the current theories that exist in available research on this topic [47,48].

Analysis of the quantitative survey results consisted of comparing the mean scores and standard deviations of the responses. Survey items asked participants to rank the types of jobs they will seek after completing their degrees and how informed and prepared they feel for their respective careers. The survey also asked students to describe their proficiency in professional skills and the likelihood they would participate in additional training in those same skills if it were provided. Students also indicated how much time they would be willing to spend per week to learn those skills. The results of the survey were compared with the results of the focus groups and are shown in the results and discussion sections.

**Results**

The main themes discovered during the analysis of the focus group data are presented here in an effort to address the research questions posed by this study. Further examination of these themes seeks to develop a better understanding of student perceptions about which skills will be most useful in their future careers, and which factors affect their learning and career preparation behaviors and influence the kinds of knowledge and skills they actively seek to acquire during graduate school.

***1) What are Ph.D. students' career objectives?***

Despite the traditional association of a Ph.D. with a job in academia [19], or the belief (as one student put it) that getting doctoral degree in a STEM field means choosing a career as a research scientist, participants in this study not only reported an interest in multiple career paths but also the desire to become consultants, entrepreneurs, and social activists. The survey asked participants to indicate their interest in each of 5 different career paths (tenure-track faculty, research scientist in academia, research scientist in industry, research scientist in government, or other) on a scale from 1 to 5 with higher numbers indicating more interest. The results are summarized in Tables 1 and 2 below.

Table 1

| Path | Mean Rating | Standard Deviation |
|---|---|---|
| Tenure-Track Faculty | 3.5 | 1.4 |
| Research Scientist – Academia | 3.3 | 1.4 |
| Research Scientist – Industry | 3.7 | 1.4 |
| Research Scientist – Government | 2.9 | 1.5 |
| Other | 1.9 | 1.6 |

The mean scores show that these students slightly preferred the prospect of doing research in industry over tenure-track and research academic careers. The standard deviations demonstrate the large variance in the career goals of the participants.

| Table 2 | | |
|---|---|---|
| **Path** | **Percent of participants indicating this career path as being MOST desirable (with a score of 5)** | **Percent of participants indicating this career path as being LEAST desirable (with a score of 1 or 0)** |
| Tenure-Track Faculty | 27% | 30% |
| Research Scientist – Academia | 27% | 25% |
| Research Scientist – Industry | 34% | 30% |
| Research Scientist – Government | 16% | 36% |
| Other | 18% | 84% |

One student expressed the opinion that you end up in the career for which you are trained:

> *"[It] depends on your PI (principal investigator or advisor) and your department. So, my PI, most of his students have gone into industry. Now he's trying to get students into academia. There are [some] labs in the department [where] they all go into industry, and different ones are more [geared] toward becoming faculty. So, I think it just depends on who you work for really."*

Many participants also reported that their career goals had changed as a result of their participation in a Ph.D. program. Some participants attribute their changing career goals to observations that changed their opinions about the nature of academic work life:

> *"I'm open now to other [career] options. I thought [before] about only staying in academia, but I realized here at [the university] that there are other options."*

Other participants described how, by focusing solely on the technical skills required by their academic disciplines and neglecting any formal training in general professional skills, they believe that their Ph.D. programs limited their career options. One student said:

> *"I think one of the big things people say is, well, once you get your Ph.D., then you can manage people, and so, I [thought] that's something that I would have – [however,] I have absolutely no idea how I would do that if I were to go into a management position, and so, actually I [just] say I don't want a management position. That's not what I want, or I don't care about that aspect at all, and so, probably if I felt like I had that skill set, I would be more apt to move that direction, but right now, as I said, I think I would be a terrible manager."*

In some cases participants felt that being assigned to work on certain research projects can lead students to gain esoteric or irrelevant skill sets, leaving them almost exclusively with experience in highly theoretical work or research without any present day applications:

> *"My project is fundamental physics, far away from applications. It's in the field of computing, so it's pretty far away from what industry is doing right now, and it's just why I would go pursue – maybe academia" and "I feel that some of the content of the facts that we learn is kind of out of date. So, there is a big*

*difference in the requirements between what we learn and the requirement of the industry."*

***2) How do Ph.D. students perceive the relevance or focus of their programs?***

Several participants expressed what they perceived to be a problem in conflicting objectives between possible career paths, making it difficult for Ph.D. students with atypical career goals in some programs to learn the skills that are relevant to their specific goals. Many participants expressed the belief that different fields often expect employees to do things differently, and that most Ph.D. programs only focus on teaching skills for certain types of careers. For example, one participant said:

*"There's a disconnect between the way you do research as a Ph.D. and the way that you would be doing research in industry. Generally in a Ph.D., you're doing fairly fundamental research, really understanding why this thing works. When you're in industry, they don't really care why it works. They just want it to work. They need to sell it, and so that fundamental understanding is not as important. It's more empirically based. It's more statistically based."*

Some of the participants who were nearing the completion of their Ph.D. program and getting involved in the job search process described a growing awareness of a "mismatch" between the skills they have been encouraged to develop and the ones potential employers are looking for:

*"I wasn't exposed to [general professional skills] a lot – but from what job search I have done, my experience and specifically my [Ph.D.] project is not going to prepare me directly for a job in the sense that I cannot get a job in what research I have done."*

When asked during the survey how well they thought their doctoral programs were preparing them for their future careers, the mean score on a scale from 1 to 10 was 7.7, indicating that participants were fairly optimistic about how their program was preparing them. That optimism, however, decreases as students get closer to graduation. Across all participants, they were likely to respond 1 point lower for every 3 years spent in their program.

Finally, some participants said that in doing everything that was required of them over the course of their Ph.D. program, they just never realized how isolated their skills were becoming:

*"I think you live in a shell when you're doing your PhD. You're so busy trying to answer this one question that you lose track of everything else, and when you wake up, you're just about to graduate, and there's very little time to network and find anything else, because the PhD just keeps you so busy that you have no time for anything else, and you're just doing one question."*

One participant summarized these thoughts by saying:

*"Sometimes I think that the problem is that we don't know if we need [other skills], because if I am entirely interacting with [others just like me] – I don't know anything else."*

***3) Which professional skills are students interested in acquiring?***

The STEM Ph.D. students who participated in this study were asked to describe an "ideal skill set" that they believed would best prepare them for both their job search after graduation and for their future careers. Communication skills and interpersonal or "people skills" were mentioned often by respondents:

*"It's not a matter of knowledge. It's a matter of being able to communicate;"*

*"In academia or in industry you're going to have to deal with other issues that are not just your research or your topic. It's going to be with people, it's going to be budgets, it's going to be talking with administrators."*

Participants also frequently expressed a desire to learn better leadership and management skills as part of their Ph.D. training. They reported that they hoped to "learn how to manage students, manage projects, and you can then be – maybe at least a little bit more adept [at] coming into an environment and leading a research project instead of just being a part of one." Other students described the perceived expectations potential employers have:

*"I think that what is expected from a Ph.D. regardless if it's industry or academia – you are expected to be more than a technician or someone who executes the research. You are expected to be a leader, you are expected to– I don't know – take control of a project and not only the technical aspects."*

*"There are a lot of Ph.D. [graduates], so if you want the job, you better have management skills, you better have some communication skills that you can also bring to the table."*

***4) How do Ph.D. students feel their programs could be improved?***

Although nearly all of the participants in this study agreed that they are extremely busy, students indicated that they would be willing to spend, on average, up to two hours per week involved in some type of supplemental professional skills development. They stated that they would be willing to participate as long as they feel that it is interesting, well-designed, and relevant to them and their career goals. The format the proposed training should take was not perceived to be as important to students as was its relevance:

*"Regardless of [it being] workshop or a class or whatever, it should be important that it's connected to reality. For instance, if you want to learn to write a proposal, write it for real, not for just a class. Talk with your advisor and find a real proposal and do it. Or with anything – like entrepreneurship – really create*

*this new industry. Do that part for real, not just as an imposed exercise that is not connected [to real life]."*

Students emphasized that relevance made training more interesting and something they were more likely to pursue:

*"The closer [it is] to your real life, the better. If you can apply it for your proposals, for your thesis, for your company or whatever it is, the better."*

*"If it's really interesting, then I'll give up other stuff to do it."*

Other participants indicated that they would prefer more flexibility in customizing which professional skills would best suit their needs, and some worried that graded courses and mandatory professional development requirements would result in "one-size-fits-all" models that were not actually useful for many students. What eventually resulted from discussions on mandatory versus optional supplemental skills trainings was a general consensus on the usefulness of a hybrid of flexible formatting options:

*"You have to pick one out of a list – an elective from this group. Or what if as an option you had a mandatory number – you had to do like three credits in professional development, and you could choose from a pool of classes to fill that three credits however was most beneficial to you."*

An interesting and unanticipated development in the research concerning what formats and types of training would be most useful for career preparedness was the amount of student responses that centered around the desire for better mentorship and guidance from their advisors. One participant said:

*"I think [the university] provides us with a wonderful platform for us to develop ourselves. So, we have most wonderful faculty, and we have all kinds of resources back in the lab – all these kinds of courses, and we have wonderful alumni, but the problem is we don't know how to utilize these resources. I think that's the biggest problem. We need some guidance about how to utilize this so that we can become better. Not just in research but also in our personal development."*

Other participants responded that what they desired most as they prepared for life after graduation was the advice from their advisors on topics other than their research about how they could better prepare themselves for the job market:

*"I meet with my advisor probably for half an hour at least every two weeks, but it's always focused only on the research. So, I think he knows a lot of my skills, because obviously I'm communicating with him and presenting to him. I think he has some ideas, but I think to have a formal discussion, maybe once a semester that says, 'What are your career goals?"*

> *"Usually with our advisor we mostly talk about the research work. I think once a semester we could schedule a time slot talking about 'I think that this is where I want to head out, and this is what other things I want to work on that can help me in the future,' because I would like to be someone like my advisor, at least in terms of the skill set that he has. So I would like to extract those qualities from him"*

Although the professional development of Ph.D. students cannot be placed entirely upon the shoulders of already overburdened university faculty members, one participant suggested that if emphasis were placed on assuring that students acquired good interpersonal, communication, and management skills early on in the doctoral process, both students and their advisors would be more capable of creating the type of mentoring relationships that would facilitate student preparations for life after graduation.

**Discussion**

One interview participant gave a seemingly conflicting statement that, upon further analysis and comparison of the survey data with the focus group transcripts, appeared to be a common theme among many participant responses:

> *"I think we are doing fine, I think, or at least I'm doing okay or fine maybe, but other minor things – as I said, we are usually overworked. We are not exposed to other groups. We are not learning how to manage our life, how to manage our career, and many other things that I think [would] help us to be happier [and] more successful after the PhD."*

As one participant pointed out while discussing career preparedness, "the program you are in is not [completely] responsible for these kinds of things. It basically provides an ecosystem, and we have to learn how to survive it. So, basically, it doesn't do a lot to help you, but that's also your own responsibility While it may be true that students at this level are ultimately responsible taking the initiative to determine what skills they need most and seeking these skills out, it may also be true that they would be more likely to do this if they were given the tools and flexibility necessary to self-regulate (i.e., identify problems, innovate potential solutions, judge how well the attempts are solving the problem/aiding in obtaining the desired goal, and readjust/regulate to overcome obstacles or try other solutions to get back on track). Many students have not yet learned the skills needed to recognize innovative opportunities for skill development or to overcome the various barriers within the graduate school culture that affect their ability to self-regulate their learning and flexibly change strategies or behaviors as they relate to their motivations and desired outcomes.

Despite the growing need for STEM students to develop a variety of transferable skills that confer access to diverse strategies of self-regulation, the available literature and the findings outlined in this paper suggest that barriers exist within many doctoral programs that limit the ability of Ph.D. students to increase their motivation, self-efficacy, and empowerment in the face of economic uncertainty by selecting their own expected career outcomes or setting personally relevant skills-acquisition goals [3,4,6,7,22,49,50]. In the current apprenticeship-model of doctoral education, it is consistently reported that "the training doctoral students receive is not what they

want, nor does it prepare them for the jobs they take" [23(p. 3)]. Often the skill set a student expects to acquire by enrolling in a Ph.D. program is significantly different than the skills they are formally urged to obtain before graduation [40,51–53]. As Brown et al. describe it, "The general strategies for intuitive reasoning, resolving issues, and negotiating meaning that people [need for negotiating] everyday activity are superseded by the precise, well-defined problems, formal definitions, and symbol manipulation of much [of] school activity"[51(p.35)].

Many institutions may soon find themselves compelled to re-evaluate their graduate curricula in order to more fully equip students with the current knowledge and professional skills necessary for a broader array of careers[4–6,18,19,54–56]. Accelerating current efforts to infuse transferable professional skills into every student's discipline in academia as they seek their Ph.D.s will create a new standard for engaged and socially relevant universities who provide graduates with the skills they need to lead, innovate, and overcome challenges both in academic and non-academic contexts [57]. In seeking solutions for facilitating this process by offering potential solutions for closing the transferable skills gap, the final section of this paper gives suggestions for integrating the findings of this study with research that examines the possible benefits of integrating courses that teach the principles of entrepreneurship into STEM-related Ph.D. programs as a means of delivering relevant and flexible professional skills, encouraging self-efficacy and the capacity to become lifelong learners , and making STEM students in all disciplines more employable before graduation.

## Conclusion

With the nature of jobs in the current market for STEM graduates permanently transformed by a changing global economy, graduate education now finds itself with an opportunity to reinvent itself as well. Contemporary Ph.D. students are beginning to realize that their training must change and are demanding that universities provide graduates with the skills necessary to operate professionally within the new economy [1,29]. Previous research on graduate students, including the STEM-field Ph.D. students who participated in this study, emphasize that while the technical and disciplinary-specific training received during doctoral programs is useful, they are missing basic professional skills that are essential in the contemporary economy. The findings of this study suggest that many STEM students in doctoral programs are not only aware that they are lacking these skills, they are willing and looking for flexible, interesting, efficient, and relevant ways to develop them over the course of their graduate programs.

## Bibliography


1. Murray, B. The growth of the new PhD. *Monit. Psychol.* **31,** 24–27 (2000).

2. Shea, A. A. It's time for graduate science programs to get real. *Chron. High. Educ.* **59,** 31 (2013).

3. Creed, C., Suuberg, E. & Crawford, G. Engineering entrepreneurship: An example of a paradigm shift in engineering education. *J. Eng. Educ.* **91,** 185–195 (2002).

4. Roseth, R. Stakeholders in higher education re-think the Ph . D . *Northwest Sci. Technol.* **Autumn 200,** 47 (2000).

5. Wulff, D. H. *et al.* National surveys and studies on doctoral education. in *2000 Conf. Panel Natl. Surv. Stud. Dr. Educ.* (2000). at <http://depts.washington.edu/envision/project_resources/2000_conf_pages/2000_panel_surveys.html>

6. The Association of American Universities. *Committee on graduate education report and recommendations*. (1998).

7. Taylor, M. C. Reform the PhD system or close it down. *Nature* **472,** 261 (2011).

8. Nerad, M. The PhD in the US: Criticisms, facts, and remedies. *High. Educ. Policy* **17,** 183–199 (2004).

9. Nerad, M., Rudd, E., Morrison, E. & Picciano, J. *Social science phds — Five + years out: A national survey of phds in six fields--highlights report*. (2007).

10. COSEPUP. *Reshaping the graduate education of scientists and engineers. Acad. Med.* **70,** 1–208 (National Academy Press, 1995).

11. Gilbert, R., Balatti, J., Turner, P. & Whitehouse, H. The generic skills debate in research higher degrees. *High. Educ. Res. Dev.* **23,** 375–388 (2004).

12. National Academy of Science. *Facilitating interdisciplinary research*. (National Academies Press, 2004).

13. Nyquist, J. A tapestry of change for the 21st century. *Change* **34,** 12–20 (2002).

14. Duderstadt, J. New roles for the 21st-century university. *Issues Sci. Technol.* **16,** 37–44 (1999).

15. Duderstadt, J., Wulf, W. & Zemsky, R. Envisioning a transformed university. *Issues Sci. Technol.* **22,** 35–42 (2005).

16. Benenson Strategy Group. *The American workforce survey (Springboard Project)*. 1–44 (2009).

17. Etzkowitz, H., Webster, A., Gebhardt, C. & Terra, B. The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Res. Policy* **29,** 313–330 (2000).

18. Wendler, C. *et al. The path forward: The future of graduate education in the United States*. (2010).

19. Nerad, M. in *Dr. Educ. Fac. Futur.* (Ehrenberg, R.) (Cornell University Press, 2009).

20. McCook, A. Rethinking the phd. *Nature* **April,** 280–282 (2011).

21. Duderstadt, J. Preparing future faculty for future universities. in *Annu. Meet. Am. Assoc. Coll. Univ.* 1–14 (2001).

22. Nyquist, J. & Wulff, D. H. Recommendations from national studies on doctoral education. *Re-envisioning PhD Proj. by Pew Charit. Trust.* (2000). at <http://depts.washington.edu/envision/project_resources/national_recommend.html>

23. Golde, C. & Dore, T. *At cross purposes: What the experiences of today's doctoral students reveal about doctoral education.* 1–58 (2001).

24. Nerad, M., Aanerud, R. & Cerny, J. in *Paths to Profr. Strateg. Enrich. Prep. Futur. Fac.* (Wulff, D. H. & Austin, A.) 137–58 (Jossey-Bass, 2004).

25. Dees, J. G. The meaning of social entrepreneurship. *Duke Univ. Fuqua Sch. Business, Cent. Adv. Soc. Entrep.* 1–5 (2001). at <http://www.caseatduke.org/documents/dees_sedef.pdf>

26. Magner, D. Critics urge overhaul of Ph.D. training, but disagree sharply on how to do so: How graduate school alters students' career plans. *Chron. High. Educ.* **46,** 19 (2000).

27. Carnevale, A., Rose, S. & Cheah, B. *The college payoff: Education, occupations, lifetime earnings*. 1–34 (2011).

28. Sadrozinski, R., Nerad, M., Cerny, J. & La, S. *PhDs in art history--Over a decade later*. (2003). at <http://depts.washington.edu/cirgeweb/wordpress/wp-content/uploads/2008/02/arthistory_report.pdf>

29. Fallows, S. & Steven, C. Building employability skills into the higher education curriculum. *Educ. + Train.* **42,** 75–82 (2000).

30. Salisbury, M. W. Better education required. *Genome Technol.* **12,** 17 (2011).

31. Hacker, A. & Dreifus, C. *Higher education?: How colleges are wasting our money and failing our kids--and what we can do about it*. (St. Martin's Press, 2011).

32. Cyranoski, D., Gilbert, N., Ledford, H., Nayar, A. & Yahia, M. The phd factory. *Nature* **472,** 276–279 (2011).

33. Mason, M. A., Goulden, M. & Frasch, K. Why graduate students reject the fast track. *Academe* **95,** 11–16 (2009).

34. Kauffman Foundation. *Entrepreneurship education comes of age on campus: The challenges and rewards of bringing entrepreneurship to higher education*. 1–28 (2013).

35. Streeter, D. H., Jaquette, J. P. & Hovis, K. University-wide entrepreneurship education: Alternative models and current trends. 1–42 (2002).

36. Network for Teaching Entrepreneurship. *Grow the global economy: Entrepreneurship education for all youth*. 1–19 (2013).

37. Wang, L. Closing the skills gap. *Chem. Eng. News* **90,** 49–51 (2012).

38. Volkmann, C. *et al. Educating the next wave of entrepreneurs: Unlocking entrepreneurial capabilities to meet the global challenges of the 21st century*. 1–184 (2009).

39. Watson, P. Transferable skills for a competitive edge: Mastering the " soft " skills can convince prospective employers of your potential. *Nat. Biotechnol.* **21,** 211 (2003).

40. Zimmerman, B. J. Becoming a self-regulated learner: An overview. *Theory Pract.* **41,** 64–70 (2002).

41. Nerad, M. & Cerny, J. *PhDs--Ten years later*. (1997). at <www.cirge.washington.edu>

42. Duderstadt, J. Preparing future faculty for future universities. *Lib. Educ.* **2,** 24–31 (2001).

43. Liamputtong, P. *Focus group methodology*. (Sage, 2011).

44. Krueger, R. A. & Casey, M. A. *Focus groups: A practical guide for applied research*. *Rev. Lit. Arts Am.* **22,** (Sage, 2009).

45. Patton, M. Q. *Qualitative evaluation and research methods*. (Sage, 2002).

46. Harrell, M. C. & Bradley, M. A. *Data collection methods: Semi-structured interviews and focus groups*. 148 (2009).

47. Corbin, J. & Strauss, A. *Basics of qualitative research: Techniques and procedures for developing grounded theory*. (Sage, 1998).

48. Onwuegbuzie, A. J., Dickinson, W. B., Leech, N. L. & Zoran, A. G. A qualitative framework for collecting and analyzing data in focus group research. *Int. J. Qual. Methods* **8,** 1–21 (2009).

49. Bandura, A. *Self-efficacy: The exercise of control*. (W.H. Freeman, 1997).

50. Bandura, A. Social cognitive theory: An agentic perspective. *Annu. Rev. Psychol.* **52,** 1–26 (2001).

51. Brown, J. S., Collins, A. & Duguid, P. Situated Cognition and the Culture of Learning. *Educ. Res.* **18,** 32–42 (1989).

52. Zimmerman, B. J. in *Handb. self–regulation Theory, Res. Appl.* (Boekaerts, M., Pintrich, P. R. & Zeidner, M.) 13–29 (Academic Press, 2000).

53. Bandura, A. *Social foundations of thought and action: A social-cognitive theory*. (Prentice Hall, 1986).

54. Fry, G. Toward excellence in graduate education: A mixed methods and interdisciplinary study. *Nagoya J. High. Educ.* **8,** 217–241 (2008).

55. National Association of Graduate and Professional Students (NAGPS). The 2000 National Doctoral Program Survey. (2001). at <http://survey.nagps.org/>

56. The Woodrow Wilson Foundation. *The responsive PhD: Innovations in doctoral education*. (2005).

57. Beckman, G. D. & Cherwitz, R. A. Intellectual entrepreneurship: An authentic foundation for higher education reform. *Plan. High. Educ.* **37,** 27–36 (2009).

Appendix A

**PhD Focus Group Participant Information Survey**

Name: _____ Email: _____

**I voluntarily agree to participate in this research focus group and provide my consent to have my personal comments recorded. These comments may be used in reports or for publications with the understanding that my name and identifying characteristics will not be used or associated with them.**

_____ _____

**Signature** **Date**

**PLEASE COMPLETE THE FOLLOWING:**

1. College in which you are enrolled (please circle):

| | |
|---|---|
| Agriculture | Management |
| Education | Pharmacy |
| Engineering | Science |
| Health and Human Sciences | Technology |
| Liberal Arts | Veterinary Medicine |

Other (please describe0: _____

2. Department or academic program for your PhD: _____
3. Faculty Advisor(s): _____
4. Month/Year you started your doctoral training at Purdue: _____
5. Anticipated date of completion of your doctoral training: _____
6. Previous degrees and institutions where you received them:

| Degree | Institution | Year Received |
|---|---|---|
| | | |
| | | |
| | | |

7. Gender (please circle): female male

8. Age: _____

9. Are you an international student (please circle)? yes no

10. Nationality: _____

11. Ethnicity (if a U.S. Citizen):

____ White
____ Hispanic or Latino
____ Black or African American
____ Native American or American Indian
____ Asian / Pacific Islander
____ Other, please describe: _____

12. What is the source of funding for your doctoral degree:

____ Research grant/assistantship from Purdue faculty
____ Third party (e.g., government, military), please describe: _____
____ My own personal funding
____ Other, please describe: _____

13. Previous work experience:

| Position | Company/Organization | Dates |
|---|---|---|
| | | |
| | | |
| | | |

14. What type of job will you seek after you complete your PhD? (Please rank your preferences 1-5)

| | Not interested at all (1) | | | | Extremely interested (5) |
|---|---|---|---|---|---|
| Tenure-track faculty position | 1 | 2 | 3 | 4 | 5 |
| Research scientist in academia | 1 | 2 | 3 | 4 | 5 |
| Research scientist in industry | 1 | 2 | 3 | 4 | 5 |
| Research scientist in government | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| Other ( please explain) | 1 | 2 | 3 | 4 | 5 |

15. On a scale of 1-10, how informed are you about the prospects of being hired into your chosen career field?

    Not well informed at all - 1 2 3 4 5 6 7 8 9 10 - Extremely well informed

16. On a scale of 1-10, how well is your PhD program preparing you to be successful in your future desired profession or career path?

    Not well prepared at all - 1 2 3 4 5 6 7 8 9 10 - Extremely well prepared

17. On a scale of 1-10, please rate your proficiency in the following professional skills outside of your major area of study?

| | Not proficient at all (1) | | | | | | | | | Extremely proficient (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| Leadership | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Managing people | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Program administration | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Project management | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Grant writing | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Communication | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Negotiation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Interpersonal skills | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Time management | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Ability to work collaboratively | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Career preparation and planning | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Intellectual Property Management | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Entrepreneurship | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Ethics | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Social responsibility | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Teaching | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Educational assessment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

18. On a scale of 1-10, please rate how likely you would be to participate in training related to the following professional skills, if it were made available to you as part of your doctoral program.

| | Unlikely (1) | | | | | | | | | Extremely likely (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| Leadership | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Managing people | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Program administration | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Project management | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Grant writing | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Communication | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Negotiation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Interpersonal skills | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Time management | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Ability to work collaboratively | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Career preparation and planning | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Intellectual Property Management | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Entrepreneurship | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Ethics | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Social responsibility | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Teaching | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Educational assessment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

19. Are there other skills you are interested in acquiring while obtaining your PhD? (please describe)

20. Please indicate how many hours per week would you be willing to devote to professional skills training per week?

    ____ No time available
    ____ 1 hour
    ____ 2 hours
    ____ 3 hours
    ____ 4 hours
    ____ More than 4 hours