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*Forming Interdisciplinary Scholars:*
*An Evaluation of the IES Predoctoral Interdisciplinary*
*Training Program*

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Final Version Presented on November 6, 2017

**Context for *Forming Interdisciplinary Scholars: An Evaluation of the IES Predoctoral Interdisciplinary Training Program***

The Committee on Revitalizing Graduate STEM Education for the 21st Century contracted Jennifer Lebrón to conduct an analysis on selected interdisciplinary training programs in STEM, the Institute of Education Sciences (IES) Predoctoral Interdisciplinary Research Training Program in the Education Sciences (Training Program). This evidence-gathering activity was commissioned as a part of the committee's charge to identify "policies, programs and practices that could better meet the diverse education and career needs of graduate students in coming years." Specifically, the purpose of this analysis is to:

- Assess the extent to which fellows who completed the Predoctoral Interdisciplinary Research Training Program over the past decade believe they possess and make use of skills necessary to produce research that is rigorous in method as well as relevant and accessible to practitioners and policymakers.
- Assess the extent to which fellows who completed the program believe they possess the characteristics and skills the program intends to imbue, including subject-matter and methodological knowledge and skills, research experience and collaboration with practitioners and policymakers, written and oral communication skills, research administration skills, and grant-writing and management skills.
- Identify strategies that can be undertaken by IES and universities to attract and attain more students from underrepresented for participation in the program.

The committee charged Lebrón to conduct an analysis by coordinating with relevant IES program officers and staff to obtain the contact information of prior program participants, as well as data from programs' annual and grant-completion reports. Work included coordination with former and existing Training Program contacts at institutions to obtain relevant data. NASEM staff worked with to obtain an IRB for Lebrón's work. The analysis will incorporated available data from institutions and prior program participants, as well as existing published literature.

The committee used the multiple presentations of the preliminary findings and final analysis as one of many evidence-gathering activities to inform the development of the report. The committee acknowledged that each of the individual training sites were allowed to create their own evaluations, making a portfolio-level analysis challenging. The committee understood the constraints and referenced the findings and analysis appropriately in their deliberations.

**Statement of Task**

An ad hoc committee, under the auspices of BHEW (Board on Higher Education and Workforce) and COSEPUP (Committee on Science, Engineering, and Public Policy), and liaising with GUIRR (Government-University-Industry Research Roundtable) and TAC (Teacher Advisory Council), will lead a study of STEM graduate-level education in the U.S., revisiting and updating a similar COSEPUP study completed 20 years ago.

Specific tasks will include:
- Conduct a systems analysis of graduate education, with the aim of identifying policies, programs and practices that could better meet the diverse education and career needs of graduate students in coming years (at both the master's and Ph.D. levels—understanding the commonalities and distinctions between the two levels), and also aimed at identifying deficiencies and gaps in the system that could improve graduate education programs.
- Identify strategies to improve the alignment of graduate education courses, curricula, labs and fellowship/traineeship experiences for students with the needs of prospective employers--and the

reality of the workforce landscape--which include not only colleges and universities but also industry, government at all levels, non-profit organizations, and others. A key task will be to learn from employers how graduate education can continue to evolve to anticipate future workforce needs.

- Identify possible changes to federal and state programs and funding priorities and structures that would better reflect the research and training needs of graduate students.
- Identify policies and effective practices that provide students and faculty with information about career paths for graduates holding master's and Ph.D. degrees and provide ongoing and high quality counseling and mentoring for graduate students.
- Identify the implications of the increasingly international nature of graduate education and career pathways, reflecting both the numbers of foreign students who enroll in U.S. graduate schools and the increasing global migration of U.S. STEM graduates.
- Investigate the many new initiatives and models that are influencing graduate education, including MOOCs, other digital learning programs, increasing numbers of alternative providers of master's and Ph.D. degrees, and opportunities to secure credentials through multiple sources.
- Create a set of national goals for graduate STEM education that can be used by research universities, Congress, federal agencies, state governments and the private sector to guide graduate level programs, policies and investments over the next decade, and ensure that this "blueprint" for graduate education reform is revisited and updated on a periodic basis to reflect changing realities.

The products of this study will be an interim report and a final report that is widely disseminated for analysis and adoption of new programs, policies, and practices that enhance STEM graduate education. This may include dissemination activities on campuses, at professional society meetings and in other venues to share the report's findings and recommendations and to engage stakeholders in discussions around implementing new strategies, programs and models.

**Forming Interdisciplinary Scholars:**

**An Evaluation of the IES Predoctoral Interdisciplinary Training Program:**

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*Submitted to:*

**Committee to Revitalize Graduate STEM Education in the 21st Century**

Board on Higher Education and Workforce

National Academies of Science, Engineering, and Medicine

## Introduction

The desire to reform graduate education to meet new challenges in research has been part of the higher education landscape for some time.  The 1995 National Academies report, *Reshaping Graduate Education of Scientists and Engineers,* identified the importance of increasing both the number and quality of graduates to advance scientific and technological knowledge in the future. Since that time, a web of investments in both individual doctoral students and in doctoral-granting institutions by government, research organizations, nonprofits, and others has improved the quality and access of graduate education around the United States. For example, the creation of the Integrative Graduate Education and Research Traineeship (IGERT) program in 1998 by the National Science Foundation and the reformation of the National Research Service Awards at the National Institutes of Health beginning in 1974, have been used to support predoctoral training to better meet challenges in research and discovery of the future (Gamse, Espinosa, & Roy, 2013; Martinez et al., 2006; Pion, 2001).

Similarly, the Institute of Educational Sciences (IES) recognized the growing need to improve doctoral training and the capacity for applying high quality educational research to meet growing challenges in the field.  In 2004, IES introduced the Predoctoral Interdisciplinary Research Training Program to "to train a new generation of education researchers to carry out methodologically rigorous research that is relevant and accessible to education practitioners and policymakers" (IES, 2011).  This program, now in its third iteration, has provided funds to create interdisciplinary graduate education programs at 20 institutions of higher education, funding over 600 doctoral students who are committed to applying their doctoral research to a variety of education problems (IES, 2011).

The purpose of this study is to understand the goals, activities, and impact of the IES Predoctoral Interdisciplinary Research Training Program on both institutions and fellows who have been supported by the program since 2008. This study seeks to determine this program's replicability and relevance to efforts to advance graduate education in the STEM fields as commissioned by the National Academies of Sciences, Engineering, and Medicine's committee on *Revitalizing Graduate STEM Education for the 21st Century.* As such, this analysis uses literature related to doctoral student socialization and interdisciplinary education as a framework and situates the purposes and outcomes of the IES program within a continuum of research on graduate training programs. This report first provides an overview of the IES program and situates it within a conceptual framework of interdisciplinary doctoral student socialization. Next, relevant literature in the field of graduate education, with attention to nationally funded interdisciplinary graduate training programs, is provided before an overview of this study's design and methods. Finally results from document analysis and interviews are presented along with recommendations for future research and practice.

## IES Predoctoral Interdisciplinary Training Program

**Program Scope and History**

Since 2004, the Institute of Education Sciences has worked to strengthen research training in education by funding the IES Predoctoral Interdisciplinary Training Program, a multiyear grant to universities to "increase the number of well-trained PhD students who are prepared to conduct rigorous and relevant education research that advances knowledge within the field and addresses issues important to education leaders and practioners" (IES, 2014). In total, 36 awards have been distributed by IES to 20 institutions of higher education since 2004. Program awards range from $3 million to $5 million over a period of 5-years. As of 2011 (the

last year for publicly available data) 529 doctoral students have received funding through the training program.  An additional 10 awards have been distributed to universities during the 2014-2015 academic year, the most recent award year, accounting for a potential 100 to 200 more doctoral students receiving funding; although, there is no publicly available data to confirm the total number of individual fellows currently receiving support.

**Previous Evaluation Studies**

In 2008 and in 2011, IES conducted an evaluation of the Interdisciplinary Predoctoral Training Program to determine aggregate activities across institutions which received funding in 2004 and 2008 and collect survey responses from fellows about their program experience.  The final report in 2008 (IES, 2008) focused on the research productivity, employment, future research plans, and general program satisfaction among fellows.  The 2011 report mirrored the previous report, providing updated information on number of Fellows and awards (IES, 2011).  Results from these program reports found that a large majority of the fellows were academically stronger than peers, published significant numbers of peer reviewed papers and presentations, submitted or planned to submit grant applications to IES, and had obtained employment in higher education or related education fields upon completion of the PhD (IES, 2008, 2011).  Both reports also found that IES fellows were less likely than other social science doctoral students to be from minority or underrepresented minority backgrounds.  For example, in 2008, fellows with minority background comprised on 18% of students, while social science doctoral students in general were approximately 45% minority.  These findings led to a revision of the request for applications (RFA) in 2014 to support minority recruitment to the program.  Since 2011, no other publicly available program evaluation has been completed, and no studies

specifically researching the IES predoctoral training programs have been published in the academic literature.

## Current Program Parameters

In the most recent RFA in 2014, IES required training programs to have three specified components: an ongoing lectures or seminars for fellows (proseminars), the development of an educational sciences certificate signifying completion of all program components, and a specific plan to recruit underrepresented minority students into the doctoral program. In addition, the 2014 RFA required institutions to ensure fellows received training in the following areas:

1. Subject-matter and methodological knowledge and skills
2. Research experience and collaboration with education practicioners
3. Communication skills
4. Grant-writing skills
5. Research administration and grant management skills
6. Career development

Proposals for research training in 2014 were also required to include at least one research topic area and one research goal from the following IES supported areas. Through the IES program, participants are expected to complete a disciplinary PhD program in a social science field (e.g. economics, education, psychology) as well as an interdisciplinary program of content and methodological coursework, experiential and applied learning, and research training culminating in the Education Sciences Certificate. In addition, fellows' dissertation research must be related to an educational topic.

## Conceptual Framework

In many ways, the IES Predoctoral Interdisciplinary Training Program can be described as a set of curricula and experiences designed to *socialize* doctoral students into roles of interdisciplinary, methodologically rigorous, education scholars. Doctoral student socialization

is process that describes the ways in which "individuals gain the knowledge, skills, and values necessary for successful entry into a professional career" (Weidman, Twale, & Stein, 2001, p. iii). Through socialization, graduate students become integrated into their profession, typically as members of the academy though in other professional research roles as well, through a dynamic, cultural process (Golde, 2010; Weidman et al., 2001). In this way, doctoral students interweave previous experiences, the values, norms, and practices of the institution they are attending, and the influences of faculty advising, peer networking, and professional associations into a new professional identity (Austin, 2011; Weidman et al., 2001). As the primary lens with which to understand the doctoral student experience (Golde, 2010), studies have used socialization to link doctoral preparation to professional requirements of faculty roles, such as researcher (Austin, 2002a; Gardner, 2008) and teacher (McDaniels, 2010; Wulff, Austin, Nyquist, & Sprague, 2004). Doctoral student socialization has also been used to understand how doctoral students are retained in their academic programs and ultimately the academy (Gardner, 2007, 2010, Golde, 1998, 2005).

Weidman et al. (2001) proposed that doctoral students are socialized through four stages: anticipatory, formal, informal, and personal. In the *anticipatory* stage students enter their graduate programs, seek out information, and form stereotypical role expectations. In the second, *formal* stage, students receive more structured information regarding norms and directly observe expected behaviors of faculty members in the field, but their view of professional roles are still idealized. The *informal* stage allows students to become immersed in the culture and learn more subtle and nuanced role expectations, such as the impact of institutional service on faculty performance. In the final stage, the *personal* stage, students' professional identity is created through deeper engagement in professional activities, research, and publication and

students' values and beliefs are adjusted accordingly. This process is not linear, as these stages represent a complex interaction of internal and external influences (Weidman et al., 2001). Moreover, as students' professional identities are formed, they in turn shape processes, values, and norms within their doctoral granting institutions, creating a two-way socialization process that influences students and universities simultaneously (Austin, 2011). Understanding how students are socialized, the elements and features of this process, and what changes occur among students and institutions as a result are key questions drawn from socialization theory to inform this study.

However, doctoral students are primarily socialized within academic disciplines (Golde, 2010), as they are expected to uphold the norms and standards of the disciplines for future scholars (Walker, Golde, Jones, Bueschel, & Hutchings, 2008). Academic disciplines within higher education are one of its most salient features — they impact nearly all of the values, structures, and forms of higher education institutions (Clark, 1987). However, there are increasing calls for students and faculty to overcome these silos and work *interdisicplinarily* in order to solve some of the most pressing challenges facing society today (National Academies, 2005). Boix Mansilla and Duraising (2007) defined interdisciplinary understanding as "the capacity to integrate knowledge and modes of thinking in two or more disciplines or established areas of expertise to produce a cognitive advancement…that would have been impossible or unlikely through single disciplinary means" (p. 219). Research grants, particularly in the sciences, and numerous reform efforts in higher education have worked to value interdisciplinarity in research by funding both institutions as well as graduate students with a focus on cross-discipline collaborations (Amey & Brown, 2004; Bridle, Vrieling, Cardillo, Araya, & Hinojosa, 2013; Gamse et al., 2013; National Academies, 2005; Strober, 2011)

Interdisciplinarity has been a key goal of institutional reforms as well; Stanford, University of Southern California, and other institutions are now including interdisciplinary research as part of their strategic plans (Strober, 2011). However, there are numerous organizational barriers that interdisciplinary research within institutions including tenure processes which value disciplinary contributions, faculty reward structures which are tied to departments, and financial systems of institutions that discourage faculty from crossing disciplines for collaborative research or teaching (Amey & Brown, 2004; Strober, 2011). Scholars within disciplinary communities also have difficulty speaking the same language when collaborating, as the definition of what is legitimate research and how it should be conducted can vary from discipline to discipline (Austin, 2002a).

Tensions in interdisciplinarity within higher education are also evident within the doctoral student socialization process. Disciplines play an important role to define how and when students become an experts and ultimately "stewards of the discipline" themselves (Walker et al., 2008, p. 11). Through their educational programs, "typical graduate students are being socialized to a particular discipline and department; they are also socialized to a culture of higher education as being *organized by disciplines*" (Boden, Borrego, & Newswander, 2011, p. 742). Disciplines become self-perpetuating as new doctoral students learn the cultures and values of their discipline, which can limit their ability to cross these borders in the future. As a result, doctoral socialization processes vary significantly based on the disciplines in which they are enrolled, resulting in different role expectations after graduation (Austin, 2002a; Gardner, 2007, 2010; Golde, 2010; Walker et al., 2008).

Understanding how to create a culture of interdisciplinarity in which faculty can engage and students can be socialized is an important focus of this study. Therefore, this research

frames an evaluation of the IES Predoctoral Interdisciplinary Research Training Program as a mechanism to support *interdisciplinary graduate student socialization*. Following the work of Boden et al. (2011), this study seeks to understand how a "culture of interdisciplinarity" can be formed within higher education institutions to support interdisciplinary doctoral student socialization. In the next section, research conducted on similar training programs and within interdisciplinary graduate programs more broadly will be reviewed to understand the opportunities and challenges presented by interdisciplinary socialization for students, faculty, and institutions.

## Literature Review

Much of the literature on interdisciplinarity in graduate education stems from investigations of the *Integrative Graduate Education Research Training* (IGERT) program sponsored by the National Science Foundation. The IGERT program has distributed funding to institutions of higher education since 1998 in order to educate PhD-level scientists to become leaders in their fields and promote changes in graduate education that foster collaboration and interdisciplinary. Similarly, the *National Science Research Award* (NSRA) administered by the National Institutes of Health provides, among other funding mechanisms, institutional awards to universities to support interdisciplinary graduate educational programs within closely related science and social science fields. Table 1 provides a brief comparison of the IES, IGERT, and NSRA program awards based on the most recent funding solicitations. While other programs at institutional levels exist to support interdisciplinary research, together, these programs represent a large financial investment by federal agencies to support interdisciplinary graduate education, totaling over $65 million in the last funding round(s). Yet, despite this investment, only the IGERT program has been studied within the literature on graduate education and higher

**Table 1**

*Comparison of Interdsciplinary Federal Funding Programs*

| | IES Predoctoral Training Program | Integrative Graduate Education Research Training | NRSA - Ruth L. Kirschstein Institutional National Research Service Award (T-32) |
|---|---|---|---|
| **Purpose** | To prepare individuals to conduct rigorous and relevant education research that advances knowledge within the field and addresses issues important to education policymakers and practitioners. | To catalyze a cultural change in graduate education, for students, faculty, and institutions, by establishing innovative new models for graduate education and training in a fertile environment for collaborative research that transcends traditional disciplinary boundaries. | To support graduate and postdoctoral research training to help ensure that a diverse and highly trained workforce is available to assume leadership roles related to the Nation's biomedical, behavioral and clinical research agenda |
| **Last Year of Funding** | 2014/2015 | 2013 | 2016 |
| **Funding limit per award** | $4 million | $3.3 million | $900k to $1.5 million or higher dependent on scientific focus |
| **Student Eligibility** | U.S. citizen | U.S. citizen | U.S. citizen or noncitizen national |
| **Support Duration** | 4 years | 4 years | 3-5 years |
| **Types of Student Support** | Stipend, tuition, travel funds | Stipend, tuition research fund, international travel grant, | Stipend, tuition, $750 in travel funds |
| **Required Student Activities** | Must complete educational sciences certificate and dissertation on educational topic | Must complete training program as outlined in proposal | Must complete training program as outlined in the proposal |
| **Program Elements** | Interdisciplinary coursework; seminars, workshops, career or internship activities | Coursework, career development, interdisciplinary research, teamwork | Coursework, mentoring activities, career activities |
| **Recruitment plan for diverse individuals** | Yes | Yes | Yes |

education more broadly. Evaluation reports of NRSA and the IES program created by federal agencies are the only documentation on these programs effects.

In addition to these funded programs, two additional initiatives were highly influential to understanding and reforming doctoral education in the last twenty years. The *Carnegie Initiative on the Doctorate*, sponsored by the Carnegie Foundation from 2000-2005, involved 84 participating departments across 44 institutions and was designed to support department's efforts to improve their doctoral programs using a process of reflection, dialogue, program changes, and assessment that was unique to each department (Walker et al., 2008). Similarly, *Preparing Future Faculty,* created in partnership between the Council of Graduate Schools and the Association of American Colleges and Universities between 1993-2003, worked to provide doctoral students: a) opportunities to understand the multiple roles and responsibilities of faculty members including teaching, research, and service; b) feedback and mentoring on each of these future roles; and c) an understanding of institutional diversity by creating opportunities to explore community colleges and teaching institutions as future employment sites. Each of these programs produced significant research on the attitudes, expectations, experiences, goals, and supports for doctoral students and furthered the literature on the importance of doctoral student socialization (Austin, 2002b; Walker et al., 2008). Taken together these major initiatives on doctoral student education worked to push PhD programs to rethink their curriculum and learning outcomes, provide better and more targeted student advising, offer experiences that enhance student skill development beyond research, and support a myriad of student career goals, including those outside of the academy. In the following, research related to these programs and initiatives is explored specifically to understand how these programs support

interdisciplinary doctoral student socialization, as well as the support and barriers to this process.

**Processes of Interdisciplinarity Socialization**

**Anticipatory.** Weidman et al.'s (2001) first stage of socialization focuses on the ways in which doctoral students anticipate or imagine their professional roles prior to encountering examples of this role in faculty mentors or others. Unfortunately, little research has focused on how students conceptualize interdisciplinarity prior to graduate training, although there are some investigations of student motivations to apply. Students who enrolled in interdisciplinary graduate programs were motivated by the ability to work with multiple faculty, the financial support such as stipends and free tuition, and the opportunities to work in specific professional fields outside of academia (Pion, 2001; Schmidt et al., 2012; Trautmann & Krasny, 2006). One key factor in participation in the IGERT program has been the financial support for graduate students, which can attract students who are not interested in pursuing interdisciplinary research and may distort students' intended research goals to meet the funding requirements (Boden et al., 2011). One IGERT student, for example, said "professors come up and say 'you need to do something to get funded in our department, so we'll do this and change our research and overall goals to get it '" (Boden et al., 2011, p. 748). In this case, students' research interests may have not aligned with interdisciplinary focus, which changes the nature of an integrated interdisciplinary community. Evidence suggests that institutions are able to recruit successful students into their interdisciplinary programs when they are transparent about the kind of student who can succeed: that is, students who have excellent social skills, have the ability to collaborate, have experience effectively communicating, and are able to integrate into the social network created by interdisciplinary programs (Boden et al., 2011)

**Formal and Informal.**  Weidman et al.'s (2001) next stages of socialization involve students' revising their understandings of what it means to be a scholar within a community based on experiences that are both implicit and explicit.  Explicit structures to support interdisciplinary socialization typically include program activities and curricular requirements. In a large study of successful IGERT proposals, there lacked a connection between learning outcomes, assessment, evidence, and learning experiences within these interdisciplinary graduate programs (Borrego & Cutler, 2010).  IGERT activities as proposed by program directors were often short-term, ad hoc, voluntary, and did not connect to form a larger effort to evaluate what students experienced holistically (Borrego & Cutler, 2010).  Moreover proposed activities focused on lower levels of skills such personal development, rather than application of skills such as presentations of results to multiple audiences (Borrego & Cutler, 2010).  Despite a focus on interdisciplinarity, the IGERT program also reinforces a privileging of disciplinary contributions. According to the request for proposals, ''Students should gain the breadth of skills, strengths, and understanding to work in an interdisciplinary environment while being well grounded with depth of knowledge in a major field'' (Carney & Neishi, 2010, p. 4).  As a result, significant tensions arise between success in the discipline vs success in interdisciplinarity within the grant.  For example, students completing graduate programs in IGERT funded department found it difficult to learn more than one disciplinary base of knowledge to the satisfaction of their discipline-based degree program and its faculty (Graybill et al., 2006; Schmidt et al., 2012). Additionally, there was a mismatch between faculty and student expectations, with student feeling that they had to lead their faculty mentors towards more interdisciplinary thinking (Schmidt et al., 2012).

Previous research on interdisciplinary student socialization has also found that the structural and organizational barriers that create tensions in interdisciplinary research for faculty extend to graduate students as well (Boden et al., 2011; Borrego, Boden, & Newswander, 2014; Borrego & Newswander, 2010; Golde, 2010).  Specifically, students enrolled in IGERT programs faced difficulty balancing the increased workload from IGERT with other program demands, experienced concern from faculty about the benefits of the IGERT program, were frustrated by communication between themselves and other students and faculty outside of their home departments, and experienced time conflicts when different academic departments scheduled required courses or activities in conflict with one another (Gamse et al., 2013; Martin & Umberger, 2003).   These issues demonstrate the need for strong mentorship and advising by faculty to guide students who may be viewed outside the norm of graduate preparation, particularly in departments which do not have faculty who model interdisciplinary research (Borrego et al., 2014; Gamse et al., 2013; Graybill et al., 2006).

However, in evaluation reports of the NSF IGERT program, researchers found numerous ways in which grantees supported interdisciplinary student socialization through formal programing including: requiring courses in multiple departments; interdisciplinary coursework that synthesized and integrated knowledge across disciplines; internships; team research; academic clubs; lecture series; and mentorship by faculty outside of the students' home department (Gamse et al., 2013).  For example, workshops designed to increase the familiarity and confidence in working with networked, interdisciplinary research in teams were found to be a successful part of the IGERT program (Read et al., 2016).  Although not explicitly studied, the disconnect between analysis of proposed activities and outcomes reported by IGERT students could demonstrate the transition between formal socialization to informal socialization, where

the implicit messages students receive about their expectations as interdisciplinary student

scholars become more valuable than the formal programming offered to support this process.

**Personal.** The final stage for interdisciplinary doctoral student socialization as defined

by Weidman et al.'s (2001) framework is the personal, in which doctoral students integrate their

old identities as students to their new identities as scholars. Research on IGERT and similar

interdisciplinary programs have found that students and graduates demonstrate more flexibility,

greater interpersonal skills, and are more open to other peoples' points of view than individuals

who have not had this specific educational experience (Gamse et al., 2013). Similarly, creativity

and critical thinking skills can also be enhanced through interdisciplinary graduate education

programs (Newswander & Borrego, 2009; Repko, 2008). In addition, graduates of

interdisciplinary programs reported that they had better leadership, technical, and communication

skills than similar peers (Carney & Neishi, 2010; Gamse et al., 2013; Martinez et al., 2006).

IGERT students attributed these skills to their interdisciplinary training because it helped them

obtain a breadth of knowledge and skills necessary in multiple disciplines, apply tools and

approaches from one discipline to others, and successfully communicate with individuals in

other disciplines (Gamse et al., 2013). Although focused on an older cohort of fellows, research

in NRSA behavioral science fellows who were supported through the NIH predoctoral program

were found to be more likely to continue in academia and obtain post-doctoral research or

tenure-track faculty positions immediately upon graduation (Pion, 2001). More recently, IGERT

students believed having access to a variety of faculty from multiple disciplines as research

supervisors and mentors was a key benefit to participation in the IGERT program (Boden et al.,

2011) and working on interdisciplinary teams was most helpful in securing employment after

graduation indicating a connection between their training and workforce demands (Carney &

Neishi, 2010).

Beyond student perceptions of their experiences, a key way to determine how successful

graduate students are in becoming interdisciplinary scholars is to measure the research output of

students during and after program completion.  Using data from the survey of doctorate

recipients, Millar (2013) found that doctoral students who indicated their dissertation research

was interdisciplinary were more likely to obtain employment within institutions of higher

education after graduation, but were also more likely, in the years used for analysis, to obtain

non-tenure track appointment.  Graduates who completed interdisciplinary dissertations also had

an increased number of publications, even after controlling for the type of position in which they

were employed (Millar, 2013).  Recent research has demonstrated that interdisciplinary

researchers often produce less but are cited more within academic literature (Leahey, Beckman,

& Stanko, 2017) which has consequences for graduate students pursuing tenure-track positions

after graduation. Van Noorden & others (2015) found that interdisciplinary science research has

less of an impact three years after publication, but citations rise considerably by ten years after

publication, although impacts of such research can extend beyond citations.  Borrego &

Newswander (2011) found that interdisciplinary job posting for faculty hires, particularly early

career hires, were rare and that positions that did emphasize interdisciplinarity were still housed

within single disciplinary department, representing a rebranding rather than a reorganization of

the hiring structures and practices.  As a result, it is unclear whether socializing graduate students

to become interdisciplinary is in the best interest if graduates want to enter into higher education

institutions in which their work is primarily evaluated by a single discipline.

**Institutional.**  Austin (2011) adds to conceptualizations of socialization by arguing that faculty, departments, and ultimately institutions are also shaped the doctoral student socialization process.  The existence of interdisciplinary graduate education programs on campus has been shown to have a positive effect on the overall number of PhDs awarded, as well as the number of doctoral degrees within the STEM disciplines specifically, holding other factors constant (Kniola, Chang, & Olsen, 2012).  While this association was weaker among minority and female graduate students, and among programs focused solely on STEM disciplines, the existence of a single interdisciplinary program, as well as the cumulative effect of multiple interdisciplinary programs on a single campus, support doctoral student completion and limit doctoral student attrition overall (Kniola et al., 2012).  In addition, institutions which received IGERT funding have reported that interdisciplinary innovations, including new coursework and funding models for graduate students, expanded beyond the original departments and graduate students, sustaining and expanding opportunities for graduate students to engage in interdisciplinary work (Martinez et al., 2006)

## Current Study

Given the process and outcomes of interdisciplinary doctoral student socialization evidenced primarily by the IGERT program, this study seeks to add to our understanding by reviewing the purpose, goals, and activities which shape the socialization process of the IES Predoctoral Interdisciplinary Research Training Program fellows and the institutions which support this program. The following research questions guide this study:

- To what extent do fellows who completed the Predoctoral Interdisciplinary Research Training Program over the past decade believe they possess and make use of skills the program intends to imbue including: subject-matter expertise; ability to carry out

methodologically rigorous research; ability to communicate with researchers, practioners, and policymakers; research administration skills; and grant-writing and management skills.

- To what extent and in what ways have the Predoctoral Interdisciplinary Research Training grants changed the institutions and graduate programs in which they are housed including: the purpose and focus of PhD programs, curriculum of graduate programs, interdisciplinary research activities, and quality of graduate students and applicants.

- In what ways is the fellows' graduate training, including interdisciplinary programming, course-taking, mentoring, or other program activities, socializing graduate students into interdisciplinary research and methodologies.

- In what ways do successful proposals and other institutional documentation identify strategies to attract and retain more students from underrepresented for participation in the program.

This independent assessment seeks to determine the IES program's applicability to advancements in graduate education in the STEM fields, as commissioned by the National Academies of Science.

**Methods**

Using a qualitative design, this study incorporates multiple data collection methods. First, publicly available program websites for all institutions who are currently operating a predoctoral training program were reviewed to understand recruitment and admissions criteria, program activities, required and available research experiences, and evidence of differentiated curriculum for fellows. In addition, individual program directors were contacted directly and asked to provide the *Training Program Narrative* portion of their grant proposal along with

connected appendices. Key portions of the websites and program narratives were reviewed for content, coded and thematically analyzed in order to answer the research questions above (Bowen, 2009).

Second, to compliment the document analysis, individual interviews and focus groups were conducted with program directors and current and former fellows. Program directors were emailed and asked to participate in a 30-minute phone interview which was recorded and transcribed. Current and former fellows were recruited for focus group via announcements distributed by the IES program officer using student and alumni listservs and LindedIn groups. In addition, program directors were asked to send out recruitment announcement to their specific institutions internal email lists. Focus groups were conducted via Skype with 2-6 participants, ranging between 45 minutes to 1 hour, although two alumni were interviewed individually for approximately 30 minutes via phone due to technical and scheduling issues. With permission of all fellows and alumni, focus group and individual interviews were audio recorded for later transcription. In addition, fellows were asked to fill out a brief online survey to capture biographic and demographic information. Interviews were coded primarily using evaluative and descriptive methods (Saldaña, 2016) with themes and recommendations generated from the data.

**Participants**

In total, eight program directors at six institutions participated in individual interviews. In addition, proposal narratives were obtained from five institutions. A list of institutional awardees and those program directors who were interviewed are listed in Table 2. In addition, 18 current or former fellows participated in either focus group or individual interviews. Because recruitment announcements were distributed on a IES fellows alumni listserv, individuals who enrolled in institutions which are no longer funded agreed to participate. No exclusionary criteria

were placed on respondents resulting in 12 fellows coming from institutions which are currently

funded and six fellows participating from institutions which received funding in earlier rounds.

A summary of fellow participation is listed in Table 3.   Fellows were demographically

representative of program participants based on previous IES program evaluations (IES, 2011):

five students were male; two were African American, one was Hispanic or Latino and one was

Asian.  In addition, five self-identified as first-generation college students.  Four participants did

not disclose their race, ethnicity, or status as first-generation college students on the demographic

survey.

**Table 2**

*IES Predoctoral Awards Since 2011*

| University | Program Title | Grant Year | Interviewed |
|---|---|---|---|
| Carnegie Mellon University* | Program in Interdisciplinary Education Research | 2015 | Yes |
| Harvard University | Partnering in Education Research | 2015 | Yes |
| New York University* | The New York University (NYU) Predoctoral Interdisciplinary Research Training Program in Education Sciences | 2014 | Yes |
| Northwestern University* | Multidisciplinary Program in Education Sciences | 2014 | Yes |
| Pennsylvania State University* | Training Interdisciplinary Educational Scientists (TIES) Program | 2015 | Yes |
| Stanford University* | Stanford University Predoctoral Training Program in Quantitative Educational Policy Analysis | 2014 | |
| University of Chicago* | Improving the Contribution of Schooling to Skills Required for Labor Market Success | 2014 | |
| University of Michigan | Predoctoral Training Program in Causal Inference in Education Policy Research at University of Michigan | 2015 | |
| University of Virginia* | University of Virginia Predoctoral Training Program in Education Sciences (PTPES) | 2014 | Yes |
| University of Wisconsin, Madison* | Interdisciplinary Training Program (ITP) for Predoctoral Research in the Education Sciences | 2015 | |

*Note:  * Indicates university has received funding in previous solicitation years.*

**Table 3**

**IES Fellow Participants**

|    | Gender | Status  | Institution                       | PhD Program | Current Position or Future Goals |
|----|--------|---------|-----------------------------------|-------------|----------------------------------|
| 1  | Male   | Alumni  | Carnegie Mellon Univ.             | Other       | Tenure track faculty             |
| 2  | Female | Alumni  | University of Wisconsin-Madison   | Other       | Policy/research                  |
| 3  | Female | Alumni  | University of Chicago             | Other       | Tenure track faculty             |
| 4  | Male   | Alumni  | Stanford University               | Education   | Post-doc/Tenure track            |
| 5  | Female | Alumni  | University of Chicago             | Other       | Post-doc/Undecided               |
| 6  | Female | Current | University of Wisconsin-Madison   | Other       | Undecided                        |
| 7  | Female | Alumni  | Pennsylvania State University     | Education   | Policy/research                  |
| 8  | Female | Current | University of Chicago             | Other       | Undecided                        |
| 9  | Female | Alumni  | University of Miami               | Education   | Policy/research                  |
| 10 | Female | Alumni  | University of Minnesota           | Other       | Policy/research                  |
| 11 | Female | Current | Florida State University          | Other       | Policy/research                  |
| 12 | Male   | Alumni  | University of Pennsylvania        | Education   | Policy/research                  |
| 13 | Male   | Alumni  | University of Washington          | Other       | Tenure track faculty             |
| 14 | Female | Alumni  | University of California Los Angeles | Education | Policy/research                 |
| 15 | Male   | Alumni  | University of Washington          | Education   | Policy/research                  |
| 16 | Female | Alumni  | University of Wisconsin-Madison   | Other       | Tenure track faculty             |
| 17 | Female | Alumni  | University of Pennsylvania        | Education   | Policy/research                  |
| 18 | Female | Alumni  | University of Pennsylvania        | Other       | Tenure track faculty             |

Note: In order to protect the anonymity of participants, limited program information is displayed. Other programs represented were sociology, communications, psychology, public policy, political science, and psychology.

**Strengths and Limitations of Study**

This study is the first to examine the IES Interdisciplinary Predoctoral Fellowship program through the lens of interdisciplinary doctoral socialization as developed from the literature. Specifically, this study goes further than previous evaluation reports to understand fellows' perceptions of their education and to understand perceptions of individual and institutional change as result of the training program. However, there are several limitations to this study. First, the nature of the research and research questions are exploratory as

interdisciplinary learning, particularly at the graduate level, is an emerging field within the literature.  A second limitation is the sampling strategy of the study as it uses publicly available information about programs and voluntary participation in data collection.  Due to the extensive and time consuming process to obtain privately held data and other confidential information such as program evaluation reports from IES through the Freedom of Information Act, these potential sources of information had to be excluded from the analysis.  Finally, participation in interviews was self-selected and therefore may be biased towards a more positive view of the IES program.

**Findings**

The ten institutions which received the IES Predoctoral Interdisciplinary Training Program grant proposed and implemented their programs with some significant variety.  Shared elements included interdisciplinary proseminars, which bring outside scholars to present to fellows or offer opportunities for fellows to present their work to each other, and statistical or content coursework, which exceeded academic requirements in any single PhD discipline. However, other program activities demonstrated clear differences.  Internships, for example, were required by all institutions, yet could be housed at a policy organizations, practioner organizations including K-12 classrooms or within university research centers depending on the institution; they could also vary in length from a summer term or single semester to a two-year experience.  Some universities require students to complete research assistantships outside of their home departments, others had no requirement for interdisciplinary research apprenticeships. While all programs are required to create an Educational Sciences certificate for fellows to earn, the requirements for a non-education PhD fellow vary considerably.  One institution framed the required coursework as just one additional course above what would normally be required of a graduate student; at another institution, the coursework added a full year to the fellows' doctoral

study.  Most institutions fall somewhere in the middle of these extremes with the additional

required courses dependent upon home department requirements.  Additionally, some institutions

prescribe specific courses, workshops, trainings, or other experiences to meet the requirements of

the IES fellowship, while others utilize a portfolio or advising process to track the progress of

fellows to ensure a well-rounded educational experience.  Given the variety of program

requirements, there is considerable distinction in the experiences of fellows and the perceptions

of program directors; yet common themes emerged from this analysis.  Based on interviews with

participants and faculty involved in the program, IES predoctoral fellows can be described as

skillful scholars and interdisciplinary thinkers; however, the disciplinary nature of institutions

creates challenges to recruit diverse fellows and socialize all IES fellows to become

interdisciplinary scholars.  Below, the perceptions of fellows' skills and attributes and the

institutional challenges faced in the coordination and implementation of the program are

described in detail.

**Skillful scholars**

  **Research.** Universally, fellows and program directors believe that the structure and

expectations of the IES programs support fellows' ability to carry out methodologically rigorous

research.  All participants described the strong quantitative training as the most salient feature of

the IES program.  One alumnus said that "you could see a big difference" between IES fellows

and non-fellows in the ways they approached methods.  Beyond understanding a variety of

techniques, other students discussed how the additional methods changed the way they

approached their research more broadly.  One current student said in a focus group:

> I think the program has really helped me think about why I use a particular method or
> why I use a particular design in a way that I wouldn't have asked myself, so, I *think* when
> I'm designing studies . . . Is this really the best method; is there another way I could do it;

would somebody else from another discipline do it differently? It gives me more
conviction.

Having the conviction to back up design choices helped fellows in their post-graduate lives. One

alumna connected her training to her researcher position in a policy firm: "The rigorous

statistical side of the IES pre-doc prepared me to make wise decisions as I was talking to policy

makers about what you can do with this information and what you can't do with this

information." Understanding the strengths and limits of methods was a recurrent feature of

students' experiences. As one program director described, "I think [fellows] are more

appropriately cautious about the conclusions and inferences that are being drawn from their

work" and attributed this caution to the fact that fellows, unlike non-fellows, "are exposed to

people who are critiquing their work from multiple perspectives." Other students summed up the

power of their methodological training as giving fellows a "systematic approach" to research and

a "more well-rounded research ability" that ultimately created a "high quality education"

experience.

Program directors consistently agreed that fellows demonstrated high level research

skills, deeper understanding of theories in multiple fields, greater ability to apply knowledge in

innovative ways, and increased sophistication in the methodological approaches to their research

than other graduate students in the program. Fellows echoed this belief in their own research

efficacy and broad skill set. One student said that being an IES fellow "showed that I had a

greater knowledge of education research more than people who come out of a discipline."

Another said about the program that:

> It effects the things I think I can bring to the table. It brings me confidence the types of
> conversations I could have in any type of situation. I'm not afraid to sit down with a
> sociologist, with a linguistic, with a public policy expert.

One alumna expressed that her work in a policy research center is "basically [IES] program but for the real world" and expressed the value her employer placed on strong methods and interdisciplinary perspectives. Another alumnus said: "Regardless of where I go, the IES skills will help me . . . I'll have a rigorous understanding of all these statistics across disciplines."   In addition to their publication and research records, program directors also described fellows as having increased engagement in the classroom, brought more depth and breadth of literature to ground their research, and enhanced the quality of the learning experience for other students in classes.

      **Communication.**  Most program directors believed that fellows have the ability to communicate with a variety of audiences, including practioners and policy makers, although whether that ability was a result of their graduate training or their personal experiences and dispositions prior to entering the program was unclear.  One program director spoke for most when he said that "Has it had a big impact? It is hard to say, in part because people who come to our program . . . they've already had some experiences in the field."  Certainly, program requirements are designed to support graduate students' ability to communicate with practioners. More than half of the fellows interviewed had conducted an internship in a school division, policy think tank, or other education setting outside of academia which provided specific opportunities to hone this skill. Alumni who worked externally described the internship as being a "good way to not just do research for its own sake" because it required fellows to "know how to talk their language" when pitching their work to practioners as well as trying to "figure out what it is [practioners] want to know" when conducting joint research projects.

      The connections and experiences of the internship helped current students conceptualize careers outside of the academy.  One current student described the impact of the internship:

> I think of what happens in sociology is automatically preparing me and socializing me for tenure track positions.  I think what I needed was this counterbalance, to say that like: here's a more expansive view of what your skills and what this PhD can do . . . so I think I'm getting a good balance of options for myself, and [it's] very practical because of the requirements generally and the internship specifically.

Other alumni described internships through their professional careers as well. One alumna who is a faculty member at a liberal arts college said it was hard to do high quality research expected on the tenure track in her current work environment, but the "connections in the outside world with some of the think tanks and applied research centers really helped me established a record of scholarship that I could build on now here and I think that is unique from my peers." One alumna described being "shook" out of her academic focus by talking with a first-grade teacher who put the problem she was researching into a real-world context. Collaborating with teachers made her broaden her perspective beyond psychological experiments on learning and influenced how she teaches undergraduates as a new faculty member in psychology.  One program director felt strongly about the importance of the internship requirement because it filled in "a missing component of what it means to be a researcher in these academic programs" and helped prepared students for "the real confines of being a researcher in the real world once they become independent faculty."  Other program directors echoed this sentiment, citing the internship experience as highly supportive of a variety of research skills for fellows.

A few alumni either gained experience only working in research centers on campus or completed more than one practicum experience which included on campus research. For these students, and for alumni who graduated from programs which are not included in the current round of funding, feelings of being unprepared to work with practioners which marked a clear difference among participants. One older alumna who is currently working for a policy organization said that "the ability to write clearly and simply and in plain language is very

important when communicating with non-researchers and we touched on that in our pre-doc but I think it could have been stronger." Another alumnus from an earlier grant said that one of the most meaningful experiences in her program was returning to the schools in which she conducted data collection to present the findings of her dissertation in the form of a professional development workshop for teachers. She wished "that kind of research to practice was required" for all fellows, as most current programs require that fellows present their research to academic peers, not to policymakers.

**Grants.** Grant writing skills had some of the most variation among participants and program directors. Because this skill was added to the most recent round of funding, program directors, particularly at institutions which had received previous rounds of funding, described grant-writing skills as being learned on a more ad hoc basis, rather than being part of the curriculum. One institution described the proposal process as a collaborative learning activity between faculty, students, and selected outside representatives, which they felt gave students more understanding of why grant proposals or research requests are not supported. Another described this experience as embedded into a single required course. Only six fellows interviewed described specific, concerted efforts to learn grant-writing skills through content coursework, proseminars, or short training sessions. One fellow from an institution grant-writing was emphasized over multiple semesters in the curriculum said: "[Program faculty] were absolutely brutal to us about the feedback - just getting that tougher skin, so that when you get a response from a real grant and they tell you your idea is trash, was so helpful." Another student, though, felt that the emphasis was not valuable because 'by the time we were going to be applying for money from IES to even be post-docs, the process had changed so much."

However, many students described writing grants with faculty or learning about the process by simply being around highly active research faculty.

**Interdisciplinary Thinkers**

While nearly all fellows believed that their research skills and efficacy has or will serve them well in their future goals, the role of interdisciplinarity in their research and thinking was more mixed. Fellows conceptualized interdisciplinarity in two ways. The first was described as being pulled inside another discipline; the second was described as being pushed outside of one's own discipline, or relatedly, outside of academia. Some students were pulled into other disciplines by their own motivations, which caused them to apply to the IES program specifically. As one alumni said: "I was looking for the feeling that I was doing research beyond my own disciplinary area." A few other alumni described how they rethought their scholarly identities as a result of their participation in the program, such as becoming a sociologist of education despite earning a PhD in education, or becoming focused on public policy after earning a degree in sociology. However, more common was fellows' description of being pushed out of their disciplines in some specific ways, particularly around coursework requirements. In most cases program requirements correlated to when fellows earned their degrees (and thus to the evolution of requirements from IES), rather than their specific institutional affiliation. The oldest alumni felt that their program was not particularly interdisciplinary, either because the program was dominated by students from a particular department or because their program requirements did not force them to take coursework or conduct research outside of their home department. More recent alumni described a considerable amount of flexibility around course-taking requirements, which allowed some students to take the majority of their coursework in their own discipline, particularly if the designated

methodological coursework was housed in their department. A few fellows who graduated most

recently described programs that required content courses in another discipline, typically two to

three courses.

In addition to course-taking, fellows described being pushed out of their discipline

through the interdisciplinary proseminars which offered them the opportunity to hear speakers

and discuss research "from multiple perspectives" and "in a really intimate setting" as two

fellows expressed.  Every student who was interviewed described the required proseminars as

critical to developing their interdisciplinary thinking and all but a few students found these

seminars fundamental to being an IES fellow.  As one student described "you heard these

conversations between these leading academics and [ideas] being debated with the [IES]

professors, and you could ask questions as well. That kind of interaction just kind of toughened

you up."  Other students talked about the proseminars as "comfortable and not intimidating"

places to learn from experts across the country, as well as an "opportunity to connect with other

graduate students in a way that I wouldn't have had otherwise."  A program director described

what makes the proseminars experience so powerful for fellows and faculty alike:

> The proseminar is extraordinary in my experience over the last 10 years for how eclectic
> the group is and how multiple disciplines really play a role in the Q & A sessions and the
> discussions and the way they interact with faculty or with students.  When you have a
> sociologist, you've got the psychologist and an economist and statisticians who all bring
> different perspectives to any given presentation - we try to make sure that is part of the
> broader experience.

Even for alumni who didn't find the experience to be transformative felt that the interdisciplinary

proseminars functioned as a PhD support group, where students could have their work critiqued

by other fellows from different backgrounds which enhanced their thinking.

Many of the fellows interviewed described interdisciplinary program as a way of challenging their own perspectives rather than situating themselves as interdisciplinary or cross-disciplinary scholars.  One student summed up what many shared in saying "the interdisciplinary training stopped at the level of my thinking. It helped me understand other researchers but my own research didn't cross any interdisciplinary boundaries."  Fellows described the ability to "translate" between the disciplines and understanding "how another discipline uses language or constructs a research question" in ways they couldn't have without the proseminars and other program activities.  One fellow described the proseminars as helping her through this disciplinary translation:

> This is the challenge but also value of learning to communicate across disciplines . . . so learning wait, what is that, I've never even heard that word and then you sort of realize that we are actually talking about the same thing but we call it two different things or talk about it in really different ways

Another alumna described her role as an interdisciplinary thinker as being "an ambassador from our field to communicate with other fields" and said that the IES program allowed her to learn "how we are discussing the same issues but using different language."   This experience of translation permeated many other self-perceptions of fellows, and was considered a critical aspect to developing their research skills.  One fellow described the value in this way:

> Interdisciplinary work does make you a better researcher. It forces you to develop higher level critical thinking skills because you get outside of a bubble.  A world of living with in one discipline and talking with people within your same discipline can often lead people to have a perspective on the world that is pretty narrow, so there are agreed upon theories and this is how it is and you don't question them as much unless you talk to people who are coming from a different perspective . . . . By engaging [interdisciplinarily] you have to be able to explain it and it forces you to really think about it. You get exposed to new ideas and it creates a challenge.

 Learning how to share their own research in ways that resonated across disciplines was a critical aspect of many fellows' development as interdisciplinary thinkers.

Yet the experiences of interdisciplinarity were not universal among participants and not universally agreed upon as positive. There were several cases in which fellows did not feel they had a particularly interdisciplinary experience. These alumni came from programs which are no longer funded by IES and described programs which were dominated by one discipline or that, in their view, were mismanaged when it came to the interdisciplinary requirements of the program. Some fellows who came from more recent programs also felt they had, as one fellow described, a very "uni-disciplinary experience" despite the fact that he is collaborating across disciplines by "co-authoring something with a sociologist who was in the program with me." Others simply said that they didn't have an interdisciplinary experience, "it wasn't a focus of my program," or that they wished they had more opportunities to practice interdisciplinary research.

There was also significant pushback from some fellows on the value of interdisciplinary research as a graduate student. One alumnus who is currently an economics faculty member described being pressed by search committees for tenure-track faculty positions about "why would you have wasted all of these courses" doing interdisciplinary work. He went on to relay: "There was, let's say, some skepticism. But at the same time, I can say where it opened up specific opportunities" by allowing him to apply to a broader range of faculty positions including those outside of his discipline. Another current student echoed this saying:

> There is a skepticism from people who put a high value on disciplinary knowledge because they wonder if you are spending time learning all these other things are you building up enough knowledge in your own discipline. . . . So it's like you have to do the baseline and you have to do more.

Here faculty are pushing back against the interdisciplinary work of IES fellows and questioning their disciplinary, and by extension, academic credentials. Another alumnus provided even more rationale for limiting interdisciplinary work in graduate school:

> If I want to be perfectly honest, I think programs should be careful of actually going too far and doing a disservice to their trainees. I have discovered that in many ways interdisciplinarity is a luxury of the tenured in some ways.  It's like, alright I've done my thing, I've proven my stuff, I got my you know my core in my own field and now I can be this dynamo who makes bridges and connections and contributes to another field. And while I think it is really cool to start that process early, I think you can kinda be left in the middle sometimes.  [. . .] Until there is a whole slew of jobs that are specifically labeled as interdisciplinary - *we still have to get jobs in disciplines* -  and so having this interdisciplinary training is a piece of what we do is really beneficial and can plant the seed that can grow into later career goals. But I think taking graduate students and having them be very, very interdisciplinary is a little bit dangerous territory.

Alumni who went on the job market described applying more widely in other departments beyond their own, and received interviews in some cases; of the fellows interviewed within this study, all ended up in faculty roles that corresponded to their PhD disciplines.  However, these concerns were exclusive to the fellows who are or were pursuing tenure-track faculty positions. Interdisciplinary knowledge and experience was perceived to be highly respected and sought after by policy and research organizations, and fellows in these environments felt they had the right interdisciplinary disposition to thrive in non-academic roles.

**Institutional Perspectives & Challenges**

The development of IES fellows as skillful scholars and interdisciplinary thinkers came as a result of how institutions adapted the program for their contexts, and at times despite the institutions' organizational structure and disciplinary norms of the faculty.  In fellows' view, the stipends for IES fellows were incredibly important to their success because it gave fellows time and space in which to engage in the variety of program activities.  Without funding, fellows described the pressures that would have been placed on their time by becoming teaching assistants or limiting their ability to complete internships.  Giving fellows time to conduct independent research, volunteer for projects, or attend the proseminars was facilitated by the stipends.  Additional travel funding was also cited as important for fellows' professional

development, allowing them to attend conferences outside of their discipline which they would

not normally have been able to and that subsequently enhanced their interdisciplinary thinking.

However, several program directors explained that because the funding levels for IES fellows

haven't risen since the inception of the program, stipends are becoming less of a motivating

factor for students to apply, and is beginning to pose a challenge for recruiting students.  At

several institutions, IES fellows' stipends are now equal to other assistantship appointments, but

carry more course requirements and expectations than alternative sources of funding. Program

directors at these institutions have attempted to offset the disadvantage by reframing the program

as offering significant non-financial rewards, namely the interdisciplinary and applied focus of

the curriculum.  Program directors interviewed for this analysis have been able to fill every

cohort slot despite these financial challenges.

Program directors also described institutional structures which create barriers to

recruiting students, particularly from underrepresented minority backgrounds.  Institutions

recruit fellows in two ways, either directly into a fellowship position during the admissions

process, or after fellows complete one to three years of coursework.  If the institution has a

school of education, and is recruiting doctoral students into an education PhD program, program

directors have control over the recruitment and admissions processes.  If the institution does not

have a school of education, or if program directors are hoping to bring in non-education PhD

students, they are limited by the admissions and recruitment practices of each department. As

one program director explained: "It's hard because we're on the yield side instead of the

recruitment side.  . . . It is hard to inform the recruitment process."  This has enormous impact on

the ability to recruit fellows from underrepresented minorities.  Simply put, if the economics or

sociology departments do not have a robust pool of minority PhD students, there is not a

mechanism for IES program directors to bring in more diverse students. However, one program

highlighted some evidence that having the IES program informed an overall recruitment strategy

for the institution. As she explained after attending a new student orientation:

> Several of the students of color said that one of the reasons I accepted [our] offer instead of another institution is because I knew of the [IES] fellowship program. And so, I think those efforts of trying to kind of amplify beyond the scope of students who are admitted has had some effect on who has actually who accepted the graduate program, period.

Utilizing proseminars and other scholarly activities housed in the IES program was a strategy to

lure students into applying for the program, but it was not shared explicitly by any other program

director interviewed. Current fellows and alumni who were interviewed for this study and who

are from underrepresented minority backgrounds cited disciplinary barriers to recruiting new IES

fellows that extended beyond initial offers of admission. From their perspective, IES programs

at their institutions exclude academic departments, particularly within education, that attract

more practioner-oriented and non-White students. In both cases, the departmental structures

and admissions procedures represented an institutional barrier to recruiting diverse candidates

into the program.

Program directors provided limited evidence that the design and structure of the program

changed administrative operations, cross-disciplinary research, or broader curricular changes in

other departments. While some programs required fellows to have faculty affiliated with the IES

program or faculty specifically outside of the fellows' home department on dissertation

committees, this requirement was not universal. However, by participating on dissertation

committees together, two program directors discussed that faculty had the opportunity to work

outside of their home department and engage interdisicplinarily through student research

interests. Program directors could not provide specific examples of interdisciplinary research

among faculty as a result of participating in the predoctoral training program, although a few

discussed the impact of the proseminars in creating a scholarly community in which faculty

could, and do, participate.

Instead, every program director provided examples of the ways in which the organization

of the university and the department structures limited interdisciplinarity. In one program found

navigating the different expectations of students in various departments to be challenging. The

director went on to say:

> If you are trying to be interdisciplinary, what we're learning is that every department has its own culture and expectations. We were thinking we have these pathways and we should be make it less of a burden for certain folks in sociology or anthropology to come into [IES program]. What we learned is that the culture is so different, that the faculty don't expect students to take classes in their first two years and we didn't understand that. It was kind of a culture shock for us. So a lot of the students were like 'this sounds great but it isn't a great fit for the way my department runs', and it was kind of interesting to hear that.

Collaborating with this department to enroll students into educational sciences coursework

during the first two years of their program created significant tensions between the program and

other faculty which had yet to be resolved. Scheduling and offering courses was also a challenge

across disciplines for program directors, and faculty from various departments had difficulty

participating in predoctoral programming because of internal department time conflicts. Despite

these challenges, program directors believe that students have an interdisciplinary experience

even if it requires, as one program director put it, that "the students lead the faculty in this

regard."

## Discussion and Implications

This study sought to understand the perceptions and experiences of IES Predoctoral

Interdisciplinary Training fellows and program directors concerning the content and quality of

the academic training. Key questions related to fellows' experiences involved fellows'

development of rigorous research and effective communication skills and fellows' experiences

and attitudes towards interdisciplinarity in scholarly work.  In addition, institutional supports and

barriers for the recruitment of diverse fellows and interdisciplinarity within the institution were

also examined.  Overall, IES fellows and program directors believed the program supported a

high quality and rigorous doctoral experience, offered unique training for a variety of skills, and

prepared fellows to think about research and design in ways that cross disciplines and are

valuable to policy makers, researchers, and academic fields.  The interdisciplinary socialization

process is discussed in more detail below.

Examining IES fellows' anticipatory socialization in the program demonstrates that

fellows applied to the program for three reasons in order of importance: 1) ability to be funded at

typically higher levels, without specific teaching assignments, for a full calendar year; 2) ability

to become strong quantitative methodologist through course-taking requirements; and 3)

interdisciplinary thinkers who had more opportunities for research apprenticeships and diverse

faculty mentors.  These motivations primed doctoral students to be attentive what is required to

become a quality researcher, how to make effective research design decisions, how to

incorporate multiple methods to strengthen the research, and how to communicate and translate

their research to multiple audiences.

The formal and informal socialization mechanisms in the IES program enhanced these

benefits by giving students specific ways to practice these skills in a variety of settings including

academic research centers, practioner organizations, and research or policy organizations.  The

requirements to engage with scholars from different disciplines, either in proseminars or in

research assistantships outside of their department, provided IES fellows confidence in their

research abilities.  Proseminars in particular were vital for fellows to gain an interdisciplinary

perspective by allowing them a supportive, yet exacting, environment in which to present their

research to cross-disciplinary scholars. While specific skills, such as grant-writing and non-

academic writing could have been emphasized more in their doctoral training, fellows were able

to draw upon a deep well of experiences that helped them understand their roles as emerging

scholars.

Finally, the personal stage of socialization demonstrated that most IES fellows did not

fully integrate the interdisciplinary scholar role into their research agenda or professional careers.

Here the pressures to conform to an academic job market that valued disciplinary knowledge, as

well as the flexibility in course requirements, created opportunities for fellows to be disciplinary

scholars and interdisciplinary thinkers. While alumni who went on the academic job market

ended up in disciplinary roles, they felt confident to apply to a wide range of positions, with

some moderate success, and in some cases continue to collaborate across disciplines or with

other practioners they worked with during their doctoral program. Conversely alumni who

entered into policy and research arenas were able to better able to integrate interdisciplinarity

into their professional identities, and found how they conceptualize problems across disciplines

and translate disciplinary language across team members to be particularly valuable. Moreover,

despite the additional program requirements, which in a few cases cost fellows an additional year

of coursework for their PhD program, fellows believed that the program provided a valuable

experience that has supported them throughout their current studies and post-graduate careers.

Institutionally, the IES fellows program had little effect in socializing faculty or programs

to collaborate across disciplines. Instead, university structures that were organized around

departments created barriers to recruiting and admitting underrepresented minorities into the

fellows program, a concern for all program directors interviewed in this study. IES program

directors continue to work to broaden the reach of their activities, particularly proseminars, beyond committed faculty and fellows, in order to engage their larger institutional communities. Through this engagement, program directors hope to attract more diverse applicants to departments, and ultimately to the fellows program itself.

### Recommendations

While fellows and program directors mostly agreed that the IES Predoctoral Interdisciplinary Training program socialized doctoral students to become strong quantitative methodologist, skilled communicators, and interdisciplinary thinkers, several key recommendations to improve the program emerged from this analysis. From current students and alumni there was a nearly universal desire to support cross-institutional and cross-cohort collaboration and discussion, facilitated through an IES fellows annual conference or other similar event. Older alumni were disappointed that fellows were no longer required to attend a joint conference, and all fellows wanted the opportunity to network beyond their institution. Given the requirements that fellows engage across disciplines, with policy-makers and practioners as part of their graduate programs, it is not surprising that fellows expressed an eagerness to continue that engagement with each other. Program directors' recommendations were more inwardly focused, concerning the logistical and financial arrangements of the grants, rather than the content or expected outcomes of the program. All program directors expressed concerns about their ability to sustain innovations created through the IES program without continued financial support. A few also believed that IES could provide more support in advertising the programs, particularly to underrepresented minority students.

In order to draw lessons from the IES program to other efforts to reform graduate education, policy makers should be attentive to the institutional cultures, norms, and values that

intersect graduate education.  Faculty who were educated in their disciplines and whose careers

are focused particularly on meeting the goals and rewards of academia may be ill prepared to

provide graduate students the skills necessary to become interdisciplinary scholars.  In particular,

writing for non-academic audiences, collaborating across disciplines, or integrating multiple

theoretical perspective into interdisciplinary graduate programs may require specialized

professional development and support.   Additionally, socializing graduate students into

interdisciplinary roles carries risks for graduate student careers, particularly if they seek a

position within academia.  Until institutions of higher education prioritize interdisciplinary

faculty positions, students who cannot situate themselves within a discipline or cannot

convincingly translate their work to a particular academic audience may be disadvantaged in the

academic job market.  Finally, the role of funding is paramount to encouraging interdisciplinary

graduate training and collaboration.  Supported graduate positions, funding for faculty to engage

in curriculum reform, and financial incentives that align with program goals are critical to

changing the nature of higher education institutions and socializing graduate students to become

interdisciplinary scholars.

**References**

Amey, M. J., & Brown, D. F. (2004). *Breaking out of the box: interdisciplinary collaboration and faculty work*. Greenwich, Conn: Information Age Pub.

Austin, A. E. (2002a). Creating a Bridge to the Future: Preparing New Faculty to Face Changing Expectations in a Shifting Context. *The Review of Higher Education*, *26*(2), 119–144. https://doi.org/10.1353/rhe.2002.0031

Austin, A. E. (2002b). Preparing the Next Generation of Faculty: Graduate School as Socialization to the Academic Career. *The Journal of Higher Education*, *73*(1), 94–122. https://doi.org/10.1353/jhe.2002.0001

Austin, A. E. (2011). The socialization of future faculty in a changing context: Traditions, challengs, and possibilities. In J. C. Hermanowicz (Ed.), *The American academic profession: transformation in contemporary higher education* (pp. 145–167). Baltimore: Johns Hopkins University Press.

Boden, D., Borrego, M., & Newswander, L. K. (2011). Student socialization in interdisciplinary doctoral education. *Higher Education*, *62*(6), 741–755. https://doi.org/10.1007/s10734-011-9415-1

Borrego, M., Boden, D., & Newswander, L. K. (2014). Sustained Change: Institutionalizing Interdisciplinary Graduate Education. *Journal of Higher Education*, *85*(6), 858–885.

Borrego, M., & Cutler, S. (2010). Constructive Alignment of Interdisciplinary Graduate Curriculum in Engineering and Science: An Analysis of Successful IGERT Proposals. *Journal of Engineering Education*, *99*(4), 355–369. https://doi.org/10.1002/j.2168-9830.2010.tb01068.x

Borrego, M., & Newswander, L. K. (2010). Definitions of Interdisciplinary Research: Toward

> Graduate-Level Interdisciplinary Learning Outcomes. *The Review of Higher Education*,
>
> *34*(1), 61–84. https://doi.org/10.1353/rhe.2010.0006

Borrego, M., & Newswander, L. K. (2011). Analysis of Interdisciplinary Faculty Job Postings by

> Institutional Type, Rank, and Discipline. *Journal of the Professoriate*, *5*(2), 1–34.

Bowen, G. A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative*

> *Research Journal (RMIT Training Pty Ltd Trading as RMIT Publishing)*, *9*(2), 27–40.
>
> https://doi.org/10.3316/QRJ0902027

Bridle, H., Vrieling, A., Cardillo, M., Araya, Y., & Hinojosa, L. (2013). Preparing for an

> interdisciplinary future: A perspective from early-career researchers. *Futures*, *53*, 22–32.
>
> https://doi.org/10.1016/j.futures.2013.09.003

Carney, J., & Neishi, K. (2010). Bridging disciplinary divides: Developing an interdisciplinary

> STEM workforce. *Abt Associates*. Retrieved from
>
> http://www.abtassociates.com/reports/ES_IGERT_SUMMARY_REPORT_October_201
>
> 0.pdf

Gamse, B. C., Espinosa, L. L., & Roy, R. (2013). Essential Competencies for Interdisciplinary

> Graduate Training in IGERT: Final Report. *Abt Associates*. Retrieved from
>
> https://eric.ed.gov/?id=ED553183

Gardner, S. K. (2007). "I heard it through the grapevine": Doctoral student socialization in

> chemistry and history. *Higher Education*, *54*(5), 723–740.

Gardner, S. K. (2008). Fitting the mold of graduate school: A qualitative study of socialization in

> doctoral education. *Innovative Higher Education*, *33*(2), 125–138.

Gardner, S. K. (2010). Contrasting the Socialization Experiences of Doctoral Students in High-
and Low-Completing Departments: A Qualitative Analysis of Disciplinary Contexts at
One Institution. *The Journal of Higher Education*, *81*(1), 61–81.
https://doi.org/10.1080/00221546.2010.11778970

Golde, C. M. (1998). Beginning graduate school: Explaning first-year doctoral attrition. In M. S.
Anderson (Ed.), *The experience of being in graduate school: an exploration*. San
Francisco: Jossey-Bass Publishers. Retrieved from
http://rave.ohiolink.edu/ejournals/issn/02710560

Golde, C. M. (2005). The Role of the Department and Discipline in Doctoral Student Attrition:
Lessons from Four Departments. *The Journal of Higher Education*, *76*(6), 669–700.
https://doi.org/10.1353/jhe.2005.0039

Golde, C. M. (2010). Entering different worlds: Socialization into dispclinary communities. In S.
K. Gardner & P. Mendoza (Eds.), *On becoming a scholar: socialization and development
in doctoral education* (1st ed, pp. 80–95). Sterling, Va: Stylus.

Graybill, J. K., Dooling, S., Shandas, V., Withey, J., Greve, A., & Simon, G. L. (2006). A rough
guide to interdisciplinarity: Graduate student perspectives. *Bioscience*, *56*(9), 757–763.
https://doi.org/10.1641/0006-3568(2006)56[757:ARGTIG]2.0.CO;2

IES. (2011). *Predoctoral and Postdoctoral Fellowships for Academic Years 2004-05 through
2010-11*. Retrieved from https://ies.ed.gov/funding/doc/training_2014.docx

Kniola, D., Chang, M., & Olsen, D. (2012). Transformative graduate education programs: an
analysis of impact on STEM and non-STEM Ph.D. completion. *Higher Education*, *63*(4),
473–495. https://doi.org/10.1007/s10734-011-9453-8

Leahey, E., Beckman, C. M., & Stanko, T. L. (2017). Prominent but Less Productive: The

    Impact of Interdisciplinarity on Scientists' Research*. *Administrative Science Quarterly*,

    *62*(1), 105–139. https://doi.org/10.1177/0001839216665364

Martin, P. E., & Umberger, B. R. (2003). Trends in Interdisciplinary and Integrative Graduate

    Training: An NSF IGERT Example. *Quest*, *55*(1), 86–94.

    https://doi.org/10.1080/00336297.2003.10491792

Martinez, A., Chase, A., Carney, J., Boulay, B., Chawla, D., Layzer, C., … Haviland, D. (2006).

    Contractor Annual Report and Summary of the Cross-Site Monitoring of the NSF

    Integrative Graduate Education and Research Traineeship (IGERT) Program. *Abt*

    *Associates*. Retrieved from https://eric.ed.gov/?id=ED546147

McDaniels, M. (2010). Doctoral student socialization for teaching roles. In Susan Kristina

    Gardner & P. Mendoza (Eds.), *On becoming a scholar socialization and development in*

    *doctoral education* (pp. 29–34). Sterling, Va.: Stylus. Retrieved from

    http://site.ebrary.com/id/10545740

Millar, M. M. (2013). Interdisciplinary research and the early career: The effect of

    interdisciplinary dissertation research on career placement and publication productivity of

    doctoral graduates in the sciences. *Research Policy*, *42*(5), 1152–1164.

    https://doi.org/10.1016/j.respol.2013.02.004

National Academies (U.S.). (2005). *Facilitating interdisciplinary research*. Washington, D.C:

    The National Academies Press.

Newswander, L. K., & Borrego, M. (2009). Engagement in two interdisciplinary graduate

    programs. *Higher Education*, *58*(4), 551–562. https://doi.org/10.1007/s10734-009-9215-z

Pion, G. M. (2001). *The early career progress of NRSA predoctoral trainees and fellows*. US

    Department of Health and Human Services, National Institutes of Health. Retrieved from

    http://www.academia.edu/download/39159910/54cba3160cf29ca810f2d0a4.pdf

Read, E. K., O'Rourke, M., Hong, G. S., Hanson, P. C., Winslow, L. A., Crowley, S., …

    Weathers, K. C. (2016). Building the team for team science. *Ecosphere*, *7*(3), n/a-n/a.

    https://doi.org/10.1002/ecs2.1291

Repko, A. F. (2008). *Interdisciplinary Research: Process and Theory*. SAGE.

Saldaña, J. (2016). *The coding manual for qualitative researchers* (3E [Third edition]). Los

    Angeles ; London: SAGE.

Schmidt, A. H., Robbins, A. S. T., Combs, J. K., Freeburg, A., Jesperson, R. G., Rogers, H. S.,

    … Wheat, E. (2012). A New Model for Training Graduate Students to Conduct

    Interdisciplinary, Interorganizational, and International Research. *BioScience*, *62*(3),

    296–304. https://doi.org/10.1525/bio.2012.62.3.11

Strober, M. (2011). *Interdisciplinary conversations: Challenging habits of thought*. Stanford

    University Press.

Trautmann, N. M., & Krasny, M. E. (2006). Integrating Teaching and Research: A New Model

    for Graduate Education? *BioScience*, *56*(2), 159–165. https://doi.org/10.1641/0006-

    3568(2006)056[0159:ITARAN]2.0.CO;2

Van Noorden, R., & others. (2015). Interdisciplinary research by the numbers. *Nature*,

    *525*(7569), 306–307.

Walker, G. E., Golde, C. M., Jones, L., Bueschel, A. C., & Hutchings, P. (2008). *The formation

    of scholars: Rethinking doctoral education for the twenty-first century* (1st ed). San

    Francisco, CA: Jossey-Bass.

Weidman, J. C., Twale, D. J., & Stein, E. L. (2001). *Socialization of graduate and professional students in higher education: a perilous passage?* San Francisco: Prepared and published by Jossey-Bass in cooperation with ERIC Clearinghouse on Higher Education, Association for the Study of Higher Education, Graduate School of Education and Human Development, the George Washington University.

Wulff, D. H., Austin, A. E., Nyquist, J. D., & Sprague, J. (2004). The development of graduate students as teaching scholars: A four-year longitudinal study. In D. H. Wulff & A. E. Austin (Eds.), *Paths to the professoriate: strategies for enriching the preparation of future faculty* (1. ed, pp. 46–73). San Francisco: Jossey-Bass.