The Influence of an Externship on BME Predoctoral Students’ Career Development

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Abstract

Providing all students with information about diverse career pathways and the skills to pursue them is a national imperative. We developed an externship component of an NIH-funded training grant program (T32 EB007507) and examined the career development of predoctoral biomedical engineering trainees who participated. Data sources included program records, interviews, and a survey. All trainees who participated in the program since it began in 2009 were sampled.

An externship, when well-planned, afforded the trainees the experience of executing a study with significant independence. In doing so, participants learned to direct their work, further their research, and achieve project deliverables. Trainees were very confident in conducting research, especially in conceptualizing, organizing, and reporting a study. Most participants said their primary career goals changed over time, becoming less interested in faculty careers. Most participants planned to pursue research careers, but outside of academia. Trainees said the externship influenced their career decision-making, confirming current interests for some and opening alternate pathways for others. Trainees also participated regularly in scientific communication activities following the externship.

Participants identified ways to enhance the externship, emphasizing the substantial time needed for planning. A well-designed project promoted reflection on their career trajectories and satisfaction with the experience. Involvement of the faculty supervisor in establishing the externship was key. These results suggest that externships can positively influence trainees’ career development, but that impact could be enhanced through clear, structured planning. In response, we developed a learning contract that is being piloted. We present the learning contract as an emergent tool to support experiential learning among predoctoral biomedical students.

Introduction

Providing biomedical predoctoral students with information about a variety of career pathways and the ability to pursue them is a longstanding national concern [1] - [5]. Previous predoctoral education models—and associated research—emphasized preparation for faculty careers [6], [7]. However, changes in funding structures, scientific and academic labor markets, and students’ own career interests underscore the need for broader career preparation [8] - [11]. In a “hypercompetitive” biomedical landscape [12], predoctoral students must have the opportunity to pursue diverse career pathways to capitalize on years of intensive training and investment—personal, institutional, and public [13]. Well-prepared biomedical research scientists who take positions in multidisciplinary sectors can help meet the nation’s workforce, innovation, and healthcare needs [14] - [17].

One way to promote such career development is through opportunities outside of students’ home universities. Authentic, embedded research experiences have been associated with many desirable outcomes for undergraduate STEM students, including improved technical and communication skills, deeper understanding of core concepts, expanded professional networks, strengthened scientific identities, and enhanced academic aspirations [18] - [22], in addition to
serving important mentoring functions for women and students of color [23]. Structured programs for postgraduate and postdoctoral trainees in public health and biomedical fields are also fairly common, but available programming and literature focus heavily on physicians rather than predoctoral students [24], [25].

Despite success in other domains, experiential learning is comparatively rare in predoctoral biomedical training. An earlier study of NIH-funded training programs found that only 20% of those studied required off-campus externships [26]. As policymakers and educators seek mechanisms to support trainees’ development, the use of externships may be on the rise, but conclusions about outcomes are not in hand. For example, institutions funded by the NIH Broadening Experiences in Scientific Training (BEST) awards have included externships in their programmatic model of career development, but have not yet had time to assess impact [27].

In this paper, we present an exploratory study of an experiential learning component of our NIH-funded training program: an externship. Using mixed methods, we investigate the role externships play in the career development of predoctoral biomedical engineering students.

The comprehensive training program in imaging sciences and informatics

We developed the externship component as part of our NIH-funded training program in biomedical imaging and informatics for predoctoral students (T32 EB007507), which began in 2009 and recruits four students per year (n = 36). Its mission is to prepare comprehensive imaging scientists who can identify and solve clinically relevant problems. The major program goals are to provide trainees with comprehensive training in imaging sciences; support networking with faculty and clinical mentors; and expose trainees to a variety of research-related career pathways. Figure 1 displays the development model for trainees and the core program components.

![Figure 1: Model of the Comprehensive Training Program in Imaging Sciences and Informatics](image-url)
The externship component provides trainees with research experiences outside of their primary lab in multidisciplinary environments. The externship usually takes place in the summer between trainees’ first and second years and typically lasts between 6-8 weeks. The activity is expected to take place in an organization outside of students’ home lab. Sites have included research labs in universities, academic medical centers, national labs, and industry across the United States.

Students select externship sites using a few approaches: the student identifies the site based on existing professional connections; the student initiates a new professional connection based on their research interests; or, the most common and effective approach, the student’s supervisor initiates communication with a colleague. Even when the externship takes place in another academic lab, the intention is for trainees to gain experience in a different environment so that the trainees career pathways decisions are based on a broader base of mentoring and practice than that of a single department. Students are advised to select externship sites based on their research interests, using advice from their faculty supervisors, and in alignment with their overall career development plan. Because these combined characteristics are highly unique to each student, it is not feasible nor useful for program directors to provide a “guidebook” from which students can select externships. Rather, students are given the open-ended guidelines described above, including the flexibility and responsibility to design a meaningful learning experience in consultation with the program directors and their supervisor. Though the intention is clearly to help trainees benefit from the experience, the host site ideally gains from the trainees’ contributions in knowledge and innovation, as well.

Methodology

Theoretical perspective

We used Social Cognitive Career Theory (SCCT) [28] to frame the study. This perspective is rooted in an individual’s confidence in their ability to carry out specific tasks—their self-efficacy beliefs. Self-efficacy beliefs are influenced by four sources of information. Mastery experiences, or previous accomplishments, are typically the most powerful source in shaping one’s understanding of their abilities. Vicarious experience is gained through observing others performing relevant tasks and making comparisons of their own abilities. Social persuasion refers to messages one receives about their ability to perform a task, such as positive feedback from a trusted mentor. Finally, physiological arousal refers to feelings of anxiety one experiences when completing a task. The effects of these four informational sources on self-efficacy beliefs depend upon how the individual interprets them—individually, relatively, and cumulatively. Together, these sources constitute an individual’s learning experiences [29], [30].

Additional experiences influence the informational sources and indirectly influence one’s self-efficacy beliefs. Examples are opportunities to gain knowledge, build skills, and practice work in the field—for instance, planning and completing a research project under the guidance of a mentor. The quality of the opportunities, perceived success, and feelings of encouragement can positively influence self-efficacy beliefs and career interests [28], [31], [32].

SCCT holds that self-efficacy beliefs can shape individuals’ career choices and trajectories [28], a hypothesis well-supported by research [33] - [41]. We expected that trainees’ experiences in
the externship would provide access to these informational sources and promote their career development. Because of the exploratory nature of this study, we do not intend to make causal claims, but conduct an initial investigation as a foundation for future work.

Data collection

This mixed-methods study uses data collected in three phases (see Figure 2). We developed the study using recommendations for the effective investigation of biomedical training programs, including the importance of trainees’ own perspectives [17], [24], [42] - [44]. Traditional measures of success (i.e., publishing in top journals) gauge how well trainees have developed and how effectively programs have shaped them, indicators of how federal investments in biomedical research contribute to ongoing knowledge generation and the public good [6], [14], [45], [46]. We chose a comprehensive approach, integrating traditional career outcome measures with trainees’ descriptions of their experiences.

We used program records to categorize trainees’ externships, and for those who left the program or finished their doctorate, initial position type. We then conducted interviews in Summer 2016 ($n = 14$) and a survey in Fall 2016 ($n = 8/20$, 40% response rate), sampling from among all trainees who completed an externship since the program began in 2009. Of note, 24 program records were used for an additional cohort, but for the 2016 survey only 20 participants were available. All students who participated in the survey also completed interviews. We analyzed interview transcripts using structural coding [47] and survey data using descriptive analyses.

![Data Collection Sequence and Sources](image)

Career development measurements

The interview protocols were built on those used in previous studies of predoctoral student career development, including the formation of self-efficacy beliefs [48] - [50]. We asked trainees how they selected externship sites, what kind of projects they completed, the goals they identified, and whether those goals were achieved. We asked how participating in the externship influenced their self-efficacy beliefs, career interests, and goals. We finally asked about the extent to which
trainees received feedback, and how the results of the externship were woven into future professional development or research after returning to their home institution. Survey measures were developed from career development literature focusing on clinical researchers, predoctoral students, and postdoctoral trainees. Self-efficacy items were drawn from the Clinical Research APPraisal Inventory (CRAI) [51], and career interests and scientific communication items from career development studies of biomedical predoctoral students [34], [35]. These measures have been found to reliably measure social cognitive constructs in the formation of early academic careers. Additionally, the CRAI has been used in several studies of biomedical predoctoral and postdoctoral training programs, and noted as a consistent means of making sense of federal investments in such efforts [45], [52] - [55].

Results and Discussion

We present our results in alignment with our theoretical perspective, SCCT. We first describe the types of externships completed using program records, and then share trainees’ impressions of the externships using interview data. We then provide an overview of participants’ self-efficacy beliefs, participation in scientific communication, and changing career interests, all drawing from the survey data. Finally, we present trainees’ initial position types after finishing the program or their degrees, drawn from our program records. These measures and results help us track trainees’ progression from learning experiences (i.e., activities that provide access to the sources of efficacy information), to confidence in their ability in research-related domains, additional research performance, changing career interests, and finally to initial career pathways.

Externship sectors

Drawing on available program and employment records (n = 24), we compiled a matrix of externship sites and, for those who completed the program or their doctorates, initial positions. Of the 36 students in the training program, four have not reached externship stage. Three of the remaining 32 did not complete externships, and program information was not available for five of the remaining 29. Thus, we calculate and present information for 24 of the training program’s 36 students. Most trainees went to other university labs (n = 17), strengthening their experience in academic environments. Several others went to sites in industry (n = 5), while a few students went to government labs (n = 2). As described above, sites were selected through existing connections, student initiative, or supervisor support.

Externship experiences

In the interviews, trainees described undertaking unique research projects related to their programs and, typically, to the focus of the training program. Examples ranged from working in an industrial firm to learn about the process of patenting medical devices, and gaining greater understanding of the principles of translational and entrepreneurial science; developing algorithms related to image segmentation; exploring the use of different imaging contrasts and modalities; developing microscopy and instrumentation skills; and learning other specialized skills and techniques that would benefit their home lab, if not their own research.
Several trainees described their externships as open-ended and exploratory, and lacking a clear outline before arriving on site. These trainees did not discuss having “ownership” of the externship or their project, and it was not clear from their language choices exactly who should be developing such a plan. Students who did not have a clear plan were less likely to feel they received feedback on their externship performance, either on their day-to-day work or on the experience overall. These trainees had fewer opportunities to benefit from successful mastery experiences or positive messaging from site mentors, while the opposite was true for trainees with well-structured externships. For example, trainees in later cohorts explained that they had spoken with more experienced peers and, as a result, wanted to have specific plans in hand before starting the externship experience. Trainees who devised project plans early on with their supervisors and site mentors were more likely to feel satisfied with the externship and that their projects had concrete outcomes.

Positive trainee outcomes, based on the interviews, fell into a few research-related themes. Specific to their research projects, trainees gained technical knowledge and skills related to the content of their own work. Many specified that the objective of the externship was to learn a particular technique; learning the technique thus achieved the entire goal. For other trainees, completing their complete projects or significant aspects of them, increasing their knowledge and skills, or developing strong relationships with their site mentors were all viewed as successful outcomes. These experiences led to increases in trainee confidence and willingness to forge ahead in future projects—in other words, their self-efficacy beliefs.

Interview results suggest that the externship had two broad effects on trainee career development, as well: confirming current interests for some and opening paths to unexplored sectors for others. Several trainees connected with their supervisors’ colleagues, developed a technique or tool that would directly contribute to their home lab and further their current research, and did little to no investigation of new career spaces. These participants tended to describe the externships as successful investments of time and resources. Other trainees dove into their externships without plans. While they reported that they achieved little in terms of concrete research results, they came out with an appreciation for their ability to deal with ambiguous situations “on the fly.” A few trainees in later cohorts identified career exploration as a specific objective for their externship in addition to their research project, and included this goal in open conversations with their supervisor and mentors.

Self-efficacy beliefs

Trainees were very confident in their ability to conduct research following the externships, according to the Fall 2016 survey results (n = 8/20). Respondents were asked how confident they were in performing a number of tasks on a scale from 0-10, 0 being Not at all confident and 10 being Completely confident. Their self-efficacy beliefs were strongest in conceptualizing, organizing, and reporting a study, and were also quite strong in collaborating with others (see Table 1). These aspects relate to the elements of externships described above, in that they involve designing studies and making sense of objectives. For example, several interview participants discussed the value of identifying specific study component or skill to achieve during the externship; organizing their work; developing writing skills, and collaborating with others. These externship outcomes generally align with the research domains included in Table
1. However, trainees were less confident overall in designing their study and managing their work—additional elements of project planning that stand in contrast to their very confident beliefs in their organizational skills. Though the sample size is too small at this time to conduct comparisons between earlier and more recent cohorts, externship sector, and the nature of externship activities and specific efficacy belief domains, we hope that over time we may investigate such effects. We may also conduct additional interviews to tease out these interesting results.

Table 1: Trainee Research Self-Efficacy Beliefs

<table>
<thead>
<tr>
<th>Domain</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptualizing a study</td>
<td>8.26</td>
<td>1.68</td>
</tr>
<tr>
<td>Collaborating with others</td>
<td>7.07</td>
<td>2.15</td>
</tr>
<tr>
<td>Responsible conduct of research</td>
<td>4.73</td>
<td>2.24</td>
</tr>
<tr>
<td>Study design and analysis</td>
<td>7.31</td>
<td>1.73</td>
</tr>
<tr>
<td>Managing a research study</td>
<td>6.04</td>
<td>2.50</td>
</tr>
<tr>
<td>Organizing a study</td>
<td>8.22</td>
<td>1.00</td>
</tr>
<tr>
<td>Funding a study</td>
<td>6.24</td>
<td>2.90</td>
</tr>
<tr>
<td>Reporting a study</td>
<td>8.19</td>
<td>1.98</td>
</tr>
</tbody>
</table>

Participation in scientific communication

Though traditional academic forms of scientific communication—that is, peer-reviewed articles and conference presentations—are perhaps not valued as highly in industry, the ability to communicate clearly is a priceless skill. Moreover, the process of moving a product from initiation to completion is excellent preparation for any career domain. We asked survey respondents to provide the number of times they had completed the activities in Table 2 after their externships. Trainees were participating regularly in their field, preparing first author manuscripts, abstracts, and presentations, but participating more often in oral than written communication. They collaborated frequently with others, coauthoring materials and explaining their work in different settings. These results relate to the themes found in the interviews, especially the ability to report study results and collaborate with others.

Table 2: Trainee Participation in Scientific Communication Activities

<table>
<thead>
<tr>
<th>Scientific Communication Activity</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Written Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepared first-author manuscript independently</td>
<td>1.63</td>
<td>1.33</td>
</tr>
<tr>
<td>Prepared abstract for scientific meeting independently</td>
<td>4.50</td>
<td>2.65</td>
</tr>
<tr>
<td>Written portion of manuscript with coauthors</td>
<td>2.00</td>
<td>1.20</td>
</tr>
<tr>
<td>Oral Communication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Given presentation at national scientific meeting</td>
<td>3.50</td>
<td>2.67</td>
</tr>
<tr>
<td>Given presentation in local department</td>
<td>2.63</td>
<td>2.18</td>
</tr>
<tr>
<td>Asked a speaker a question at institution, scientific meeting</td>
<td>9.88</td>
<td>15.97</td>
</tr>
<tr>
<td>Explained research to group of experts</td>
<td>4.25</td>
<td>3.27</td>
</tr>
<tr>
<td>Explained research informally at a scientific meeting</td>
<td>7.88</td>
<td>9.34</td>
</tr>
</tbody>
</table>
Trainees reported that their career goals changed over time. We asked respondents to share, retrospectively, what their primary career goals had been when they began their doctoral programs and what they were at the time of the 2016 survey. While most (62.5%) were interested in faculty careers when they began their degree programs, only one-quarter (25.0%) were still interested in that pathway as a primary career goal. The proportion of trainees who were interested in research career in government, industry, or business remained consistent (37.5%), but more students became interested in joining an established business (25.0%). Yet, when asked if they had any interest in applying for faculty careers, half (50.0%) said they would be interested and another quarter (25.0%) were not sure. There was less ambiguity about trainees’ desire to remain in research careers. We asked respondents how strongly they agreed they would stay in research careers using a scale from 1 to 5, 1 being Strongly disagree and 5 being Strongly agree. Trainees somewhat agreed they would stay in research careers after graduation (mean 3.36, SD 1.20), but agreed more strongly they would do so outside of academia (mean 4.36, SD 1.20). These changing career goals are not surprising given the themes present in the interview findings. While the externship experiences opened doorways to nonacademic pathways for many trainees, it does not appear that the experience decreased their interest in research careers.

Returning to our program records, 15 former trainees have left the program or finished their degrees. We have externship program records for 12 of those trainees and employment records for 11 (see Table 3). Because of the small nature of the program, we are not able to provide an alignment between the externship sector and their exact position titles without potentially identifying individuals. One-quarter (3/12, 25.0%) worked in academic institutions in postdoctoral scholar positions. Half of the remaining former trainees (6/12, 50.00%) began working in industry, serving in roles that draw on their training as engineers and data scientists. Their position titles indicate they focus on process development, systems, algorithms, and programming.

### Table 3: Externship Sector and Initial Career Sector

<table>
<thead>
<tr>
<th>Externship Sector</th>
<th>Former Trainee</th>
<th>Initial Career Sector</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic</td>
<td>Former Trainee</td>
<td>Academic</td>
<td>5 (20.83%)</td>
</tr>
<tr>
<td></td>
<td>Current Trainee</td>
<td>Industry</td>
<td>12 (50.00%)</td>
</tr>
<tr>
<td>Industry</td>
<td>Former Trainees</td>
<td>Academic</td>
<td>4 (16.67%)</td>
</tr>
<tr>
<td></td>
<td>Current Trainee</td>
<td>Industry</td>
<td>1 (4.17%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information not available</td>
<td>1 (4.17%)</td>
</tr>
<tr>
<td>Government Lab</td>
<td>Former Trainees</td>
<td>Industry</td>
<td>2 (8.33%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Government Lab</td>
<td>1 (4.17%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>Academic</td>
<td>1 (4.17%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Industry</td>
<td>4 (16.67%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information not available</td>
<td>1 (4.17%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Current Trainee</td>
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<td></td>
<td></td>
<td>Information not available</td>
<td>1 (4.17%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Current Trainee</td>
<td>1 (4.17%)</td>
</tr>
</tbody>
</table>

*Does not equal 100.0% due to rounding.
It is too early in this program to determine associations between externship sector and early career pathways. However, if trainees’ interests in biomedical research careers outside of academia are reflected in both their career choices and available options, then those data underscore the continued need to support their comprehensive development through this program.

**Conclusions and Future Directions**

This study explored the influence of externships on biomedical predoctoral trainees’ career development. We found that the externships were highly individualized and fit within the comprehensive model of career and research development created for the training program. Externships that were more structured resulted in clearer and more satisfying outcomes than those without structured planning, though some trainees ascribed value to learning on their feet in unfamiliar settings. The results of this study align with the national narrative that fewer biomedical predoctoral students are seeking faculty careers. Most participants in this study who took postdoctoral researcher positions in academia have since transitioned into industry and have the capability to make impactful contributions to the biomedical enterprise and the nation’s wellbeing in those roles. Continued study and follow-up with all program participants can tell us about the longer-term impact of their participation and the role of the externship in charting their careers.

Several trainees’ feelings of success were connected to clear research related goal-setting and linking the externship to their overall career development plan. Building upon these results, we have developed a learning contract, which is being piloted with two cohorts. Learning contracts are individualized agreements that support professional development, providing structure for documenting goals, plans for achieving them, and evaluating and reflecting upon success [56] - [59]. This learning contract, in conjunction with widely-used individual development plans (IDPs) [60], will allow trainees to self-assess their interests, skills, and values, and select externships that address areas of greatest need. Though not yet validated, we present the learning contract in Appendix A to support experiential learning among other engineering educators. We plan to present the results of our learning contract study in future work. Continued engagement by program leaders, faculty supervisors, funders, and policymakers is needed to fully assess the value of the learning contract for those trainees who participated in the externship experience.

**Acknowledgments**

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References


M. Cousins and M. K. Markey, "Graduate internship/externship experiences in NIBIB funded graduate training programs," presented at the 121st ASEE Annual Conference & Exposition, Indianapolis, IN, 2014.


Appendix A: Learning Contract

Comprehensive Training Program in Imaging Sciences and Informatics
Summer Externship Learning Contract

Name: ____________________

• What are the goals of your externship?

• How do the goals of your externship relate to your career goals, as identified in your Individual Development Plan? e.g., how will the externship help you learn more about career paths or develop skills for particular career paths?

• How will your externship experience advance your development as an Imaging Scientist?

• How will your externship experience help you develop skills for interdisciplinary research?

• Where will you conduct your externship?

• What dates will you conduct your externship?

• What steps have you taken to ensure that all regulatory requirements are met? e.g., IRB, IACUC
• What specific activities are planned for the externship? Provide an estimated timeline.

• What will be the deliverables from your externship?

• How will your externship be evaluated? Indicate specific measures and performance targets for success.

• What follow up to the externship will occur after you return to UT-Austin?

• Summarize the financial plan for your externship experience, including travel to the site and housing.

UT-Austin Supervisor(s) Signature(s):

Name: _______________________________ Name: _______________________________ Date __________

Externship Mentor(s) Signatures(s):

Name: _______________________________ Name: _______________________________ Date __________

Trainee Signature:

Name: _______________________________ Date __________