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Application of Community of Practice Theory to the Preparation of Engineering Graduate Students for Faculty Careers

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ABSTRACT

In this paper, we demonstrate how theory can inform the design of a program to prepare graduate students for faculty careers. Preparing Future Faculty programs within and beyond engineering are not new, but explicit application of Communities of Practice and related literature is novel. We describe a prestigious teaching fellowship program that spans three years of increasing instructional responsibility, and present assessment data to describe the role of faculty mentoring and peer networks in student identity development as a Steward of the Discipline. The results are interpreted in light of the literature, and we conclude with areas for future research.

Keywords: preparing future faculty, graduate students, communities of practice

INTRODUCTION

In most skilled professions, novices entering the profession are mentored by experienced practitioners. These practitioners provide guidance and constructive feedback on the novices' initial efforts. As novices become more experienced, they receive less and less guidance, until they are proficient in the skills required of the profession and are ready to mentor the next generation of novice members. Doctors, psychologists, lawyers, pre-college teachers, and practitioners of every type of craft are routinely inducted into their professions with the aid of such guidance. As Stice, Felder and coauthors note, the only skilled profession that does not routinely provide mentoring is college teaching [1].

Historically, the focus of engineering doctoral programs has been preparing graduate students to conduct research. Learning how to do research is an important component of a Ph.D. program, but it should be exactly that—a component [1]. If and when doctoral students gain teaching experience, it is in the form of a teaching assistantship, sometimes with limited training and mentorship. National initiatives have attempted to bring this lack of adequate graduate student preparation to the forefront, such as through the Preparing Future Faculty (PFF) initiative [2]. Many universities have taken part in this initiative; resulting in university run PFF programs all across the U.S. Continued research in graduate education has increased awareness of the importance of discipline-specific training for graduate students [3].

Engineering features a wide range of existing programs, which have an array of timelines, many stemming from national PFF initiatives. One such program at Penn State targets all graduate student teaching assistants ranging from those that grade papers to students that have sole instructional responsibility for a course [4]. This semester long program is designed to prepare participating students for the many roles they have as graduate teaching assistants. Another slightly more involved program at the University of Cincinnati [5] combines a three quarter course sequence with a mentored teaching experience. The course sequence covers topics ranging from effective teaching pedagogy to the academic job search during the better portion of one academic year. Arizona State University has created a two year program as part of the national PFF initiative, in which students participate in activities across multiple campuses [6]. During the first year of the program (exploratory phase) students attend a bi-weekly seminar covering various topics related to faculty development. During the second year (participatory phase) students move to another campus where they are engaged in a hands on experience designed to develop their understanding of the dynamics of various types of institutions. Still another training program developed in the Department of Mechanical Engineering and Engineering Mechanics at Michigan Technological University was designed to achieve dual objectives: to improve the quality of undergraduate instruction by TAs and to develop leadership skills in graduate students for their professional growth [7]. Each of these programs is designed to meet the unique needs (and resource constraints) of the university at which it was implemented. Programs like these highlight the multifaceted elements necessary to prepare graduate students for the demands of an academic career.

The preparation of graduate students for faculty careers was discussed in detail in *Envisioning the Future of Doctoral Education*, a publication of the Carnegie Initiative on the Doctorate at the Carnegie Foundation for the Advancement of Teaching. In it, Golde [8] presents the concept of graduate students as future "stewards of the discipline," or scholars who will "creatively generate new knowledge … and responsibly transform those understandings through writing, teaching, and application." She explains that stewardship is not an innate quality, but one that can and should

be developed, and therefore the fundamental mission of doctoral education should be to develop these stewards of the discipline. In the same volume, Stacy [9], points out that graduate PhDs are not prepared to teach, nor are they prepared to mentor graduate researchers. Surveys confirm that only about half of graduate students report experiences preparing them for various teaching and advising activities [10]. Yet every year universities across the country graduate PhD students, who become brand new assistant professors, and expect them to succeed at conducting research, teaching, and mentoring graduate students; a combination of roles for which they were never prepared. It is this gap that programs, such as the Dean's Teaching Fellows program described in this article, attempt to fill. Being a steward of the discipline entails much more than just conducting research; it's about transforming that knowledge to those who will be able to carry the discipline into the future, both through scholarship and teaching future generations of engineers. While both types of training are necessary for graduate students to achieve success as faculty members, there remains a need to provide holistic training for graduate students combining teaching experience with research, scholarship, and service. More importantly however, a program of this type needs to assist graduate students in balancing the roles they will have to fill as future faculty members, providing authentic practice for graduate students to experience these roles before applying to faculty positions. Given the pervasiveness of future faculty and other graduate teaching programs, it is surprising that relatively few have demonstrated forward thinking about these students as future colleagues with multiple roles.

Graduate education, like other aspects of engineering education, can be more effective when guided by an appropriate learning theory [11]. One theoretical framework that is particularly relevant to many aspects of graduate education is Communities of Practice, which focuses on authentic practice with communities of peers and experts as the source of learning. This theory aligns well with the typical experiences of engineering graduate students conducting research in lab groups including faculty, graduate students, postdocs, technicians and even undergraduates [12]. Theory can assist in transferring this effective means of training, which has evolved naturally, to preparing graduate students for teaching and viewing their roles as interrelated. This article describes a multiyear evaluation of a program designed to directly address this issue: the College of Engineering Dean's Teaching Fellow (DTF) program at a large east coast state university. Examination of the DTF program, now in its third year, will be used to showcase how a theoretical framework can inform and ultimately improve graduate student preparation for faculty careers. First we discuss the role of Community of Practice (CoP) theory in creating the DTF program. This is followed by a detailed description of our qualitative methodology, a cross sectional study containing interviews of faculty, fellows and other TAs. We then situate the results within the theoretical framework and conclude with implications for graduate education.

THEORETICAL FRAMEWORK

Several specific theories have been proposed regarding learning as a social process [13-15]. The acknowledgement that learning is a social process has served as the foundation for further developments in social learning theory. Sociocultural learning theory, which includes the cultural aspects of social learning, provides a theoretical foundation that is widely used in training programs. Communities of Practice (CoP), the framework guiding this study, is a specific sociocultural learning theory [16, 17]. Communities of Practice, which grew out of the closely linked theory Legitimate Peripheral Participation (LPP) [18], asserts that education experiences are strongly influenced by individual interaction with faculty and peers, as well as factors specific to the environment in which these interactions occur.

Lave argues that learning is situated in the context and culture in which an activity occurs. Social interaction is a critical component of situated learning—learners become involved in a community of practice that embodies characteristic beliefs and behaviors. Communities of practice are groups of people who share a concern, a set of problems or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis [17]. Over time, they develop a unique perspective on their topic as well as a body of common knowledge, practices, and approaches. They may even develop a common sense of identity as they develop active roles as part of the institution and in affinity with academic colleagues [17]. Wenger et al. propose a three-fold structural model for communities of practice: (1) domain, (2) community, and (3) practice. A well-defined domain legitimizes the community by affirming its purpose and value to members and other stakeholders. Disciplines and departments may serve as communities, but communities of practice may form across disciplines, as in the case of engineering education and its various groups within ASEE.

The community creates the social fabric of learning, and a strong community fosters interactions and relationships based on mutual respect and trust. In a graduate degree program, community can be described as the relationships between current faculty, between faculty and the graduate students, and among the graduate student peer networks. The interaction of an individual with other individuals and groups has a distinct effect on his or her development and feelings towards the organization [16]. Thus the emphasis placed on research in graduate training has the effect of reinforcing a culture that devalues teaching. Both mentor/student and peer relationships strengthen (or weaken) the student's feeling of belonging within the current academic community (domain) and future professional community. Finally, the practice is a set of frameworks, ideas, tools, information, styles, language, stories, and documents that community members share. Practice can be thought of in terms of the pedagogy and culture that encompass educating future engineers, or engineering education itself. Through authentic practice with real research problems and real teaching responsibilities,

doctoral students are prepared to be stewards of the discipline, and additional attention to the theory would better ensure graduating students are fully prepared to accept this role.

Other researchers have used the CoP model as a framework for addressing other communities in engineering education. Streveler, *et al* [19] discuss how organizational partnerships were formed in the context of engineering education research workshops, and the formation of a CoP among workshop participants. They conclude with some recommendations for those who may want to use the CoP model to further their own communities. These recommendations include the importance of refreshing the "core" members of the community from those in the affiliated ranks. They also emphasize the importance of welcoming newcomers to "keep the energy flowing within the community." These ideas of replenishing the community by involving novices more deeply is reflected in Stewards of the Discipline as well.

The nature of graduate engineering education has evolved with the focus of training engineering graduate students to conduct research. This model has evolved not purely out of pedagogical considerations, but out of the necessity to continue the research cycle in the presence of a continuously renewing pool of graduate students. Graduate students who serve as teaching assistants (TAs) are no different. The current situation in academia has graduate TAs working alongside their faculty counterparts in the classroom, creating the same potential for authentic training as found in the research lab. Teaching, however, is viewed as a more private endeavor. Experienced faculty members are more likely to consult with each other about the results of a research study than to discuss (let alone ask advice on) their classrooms. To compound the problem further, TAs are often used as a resource to alleviate faculty teaching loads, without training for those who are considering a future as teaching faculty.

The following research study addresses this deficiency in graduate training by evaluating a program that is grounded in Community of Practice theory. This program was created to give graduate students opportunities to gain experience both in classroom teaching and balancing research and service activities—elements that are all part of the academic faculty workload. With CoP as a foundation, the model depicted in Figure 1 was developed to guide the current study.

The Dean's Teaching Fellow (DTF) program, which will be discussed in detail in the following section, combines coursework, social activities, and mentored classroom training to provide graduate students with authentic experiences akin to what is required of first year faculty members. This three-year program is structured after theory with stages that mirror an apprenticeship program by gradually increasing novices' responsibilities as they gain experience and move toward a more expert role. We have also combined aspects of CoP theory to include peer mentoring and other social elements, with more expert fellows providing guidance for the novice members. Upon completion of this program, fellows have assumed the role of the stewards of the discipline, particularly as it relates to teaching, and are able to transition immediately into new faculty positions.

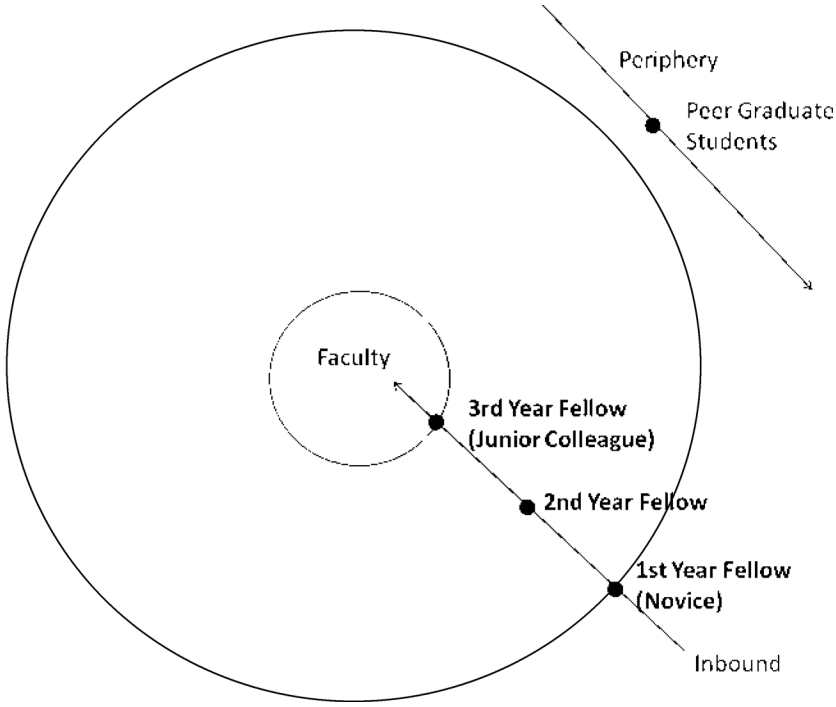

Figure 1. Model created to guide development and assessment of the Graduate Teaching Fellow Program. Adapted from [16].

METHODS

Setting

The DTF program, described in greater detail in our prior publications [20, 21], served as the setting for this study. Students who receive a DTF fellowship participate in a three year program designed to prepare graduate students for faculty careers through gradually increasing the fellow's teaching responsibilities. Fellows are provided with three years of an augmented stipend and tuition, along with a tablet PC and funding to attend engineering education conferences in the second and third year. Three years of participation in the program affords fellows pedagogical training, practical coursework, and feedback from peers and faculty members to facilitate their transition from novice teaching assistants into confident and practiced classroom educators.

Fellows in their first year of the program are assigned to serve as workshop (i.e., discussion/lab) leaders for first-year general engineering courses, which are centrally coordinated by faculty who teach the lectures. During subsequent years, fellows continue their training in their degree

granting departments, teaching sophomore through senior level courses. Engineering departments represented in this study include: biological systems, civil, computer science, engineering science and mechanics, industrial and systems, mining and minerals, and mechanical engineering. At the time of data collection, the program was in its 3rd year, and only one DTF had completed his or her PhD. Therefore, we relied on interviews of fellows and their faculty mentors to evaluate the role of theory in preparing engineering graduate students for faculty careers.

Participants

1. First Year Fellows and other Teaching Assistants

The participants in this study represent a cross sectional sample. Participants involved in the first year of the study were DTFs as well as other graduate teaching assistants (TAs) assigned to teach the first-year general engineering courses. All first-year course TAs (including DTFs) were invited to participate. During fall semester 2007, 13 workshop leaders were interviewed in four small focus groups by a graduate assistant with teaching experience in another department. This sample of TA's included five women and eight men. Four of the participants were DTFs and the remaining nine graduate students were hired from various engineering departments. Eleven of the thirteen interviewed taught in the first semester course; two others taught the second semester design course (which was taught off-sequence in fall). Eight had previous teaching experience in other departments or universities. Students' motivation for teaching ranged from simply earning money to testing their interest in a teaching career to gaining experience for a faculty career.

2. Second Year Fellows

At the beginning of all semester 2008, five third-year fellows (three female and two male) were interviewed by a graduate assistant with teaching experience in another department (This data is labeled "second year" because the third year had just barely begun, and most participants described second year experiences.). All five fellows applied for the DTF program to gain teaching experience because they were considering a career in academia. While the timeline for pursuing a faculty position varied, all five students remained intent, and in one case even more intent, on obtaining a faculty position. Of the five students interviewed for this program, three remained with the program for a third year; one has completed his or her PhD and is currently a faculty member, and the other has accepted a research fellowship at another institution. Retention and job placement will continue to be monitored for quantitative assessment of the program.

3. Faculty Mentors

In fall 2008, four faculty research and/or teaching mentors (one female and three male) from four different engineering departments were interviewed. In all four cases the faculty member served as

the fellow's research advisor, with three of the four taking on the role of teaching mentor as well. In a few cases the research advisor chose not to act as the teaching mentor, or fellows solicited advice from more than one faculty member. These additional faculty members were either unavailable or declined to participate.

4. First Year Course Coordinators

As part of a follow-up to the 2007 and 2008 assessment data, two course coordinators (one female and one male) for the first year general engineering program were interviewed during the fall of 2009. Each faculty member was responsible for coordinating the material, TAs and schedule for one course during either the fall or spring semester. Both faculty members had served as the course coordinators for at least the past three years.

Data Collection

The principal data sources were interviews of the fellows, their faculty mentors/ research advisors, and first year course coordinators. Permission to solicit the participants for interviews was obtained through human subjects (IRB) review. Written consent was obtained to audio record the interview for clarification and accuracy of direct quotations. A series of focus groups were conducted while fellows and other GTAs were working with the first year program, with audio recordings totaling approximately 4 hours. The following year, each of the second year fellows were interviewed, during which mentors and research advisors were identified for subsequent interviews. A total of eleven interviews were conducted, with each interview averaging about 30 minutes. For both phases of data collection a semi-structured set of interview questions (which varied for faculty, fellows and GTAs) was used, with probing questions added to garner additional details and clarification. Table 1 lists the interview questions from each data collection stage chosen for this analysis. Field notes were taken during each of the interviews and focus groups, which helped identify specific passages for complete transcription. The textual data, analyzed as described in the following section, comprised a combination of field notes and partial transcriptions.

Data Analysis

Earlier versions of this analysis are included in two conference papers [20, 21] focused on program assessment and consequently lacking a theoretical base. Thematic analysis [22] of the first year fellow and teaching assistant data revealed four main themes: workload and responsibility, training, mentoring and feedback, and peer interaction [20]. These results, along with program recommendations, were used to make specific improvements and shape the interview questions for the second year data collection. Analysis of the second year fellow and faculty

First Year Fellows and Other Teaching Assistants:	1. What kind of workload have you had? How does this compare to other departments?
	2. What training did you get? Was it effective / helpful for what you've done?
	3. What suggestions do you have for training?
	4. Tell me about working with the other TAs in the department. How much interaction do you have? How has working with other TAs impacted your development?
	5. What kind of feedback would you like to get for your teaching?
Second Year Fellows:	1. Did you receive adequate mentoring for your second year teaching assignment? Is there any advice or examples of practices we can tell other mentors about?
	2. What were the major differences between the first and second semester during the second year of your DTF program?
	3. How do you balance your teaching and research interests?
Faculty Mentors:	1. What impact has the DTF program had on __[fellows]_ 's success?
	2. What benefits do you see in this program? How might the DTF program be improved?
First Year Course Coordinators	1. What was the motivation for using TAs?
	2. What types of training do the TAs receive?

Table 1. Interview questions chosen for detailed analysis from each year of data collection.

mentor data revealed overlapping themes: mentoring experience between faculty mentors and fellows, peer mentoring and networking, the fellow's preparation for a faculty career, and the fellows' progression through the second year of the program. Our purpose in this paper is to better understand fellows' progression through the various stages of the program assisted by theory and other relevant literature. Additional data from first-year course coordinators was also collected.

Constant comparative method [23] was used to systematically analyze the data and arrive at conclusions. Using CoP as a theoretical framework, and results highlighted in other sources [24, 16, 17] we developed an initial coding scheme. A visual representation was created to begin grouping the textual data into general categories, and to determine the relationship between categories. Data were re-coded and new categories were created as necessary to capture emerging themes and relate them back to the research questions and theoretical framework. From this analysis, three themes evolved, as shown in Table 2, which aligned well with the stages in the program illustrated in Figure 1. Alignment of the findings with program stages is not entirely unexpected, since the program structure and fellow responsibilities are designed to change each year. This coding scheme also serves as the organizing outline for our results section.

Novice Experience as a First Year Fellow	• Increase in workload over other TA responsibilities. • Teaching assignment reduced research progress • Peer Mentoring/Networking o Working with peers to discuss similar teaching experiences o Community building and development • Workshop specific training and meetings
Second Year Fellows: Creating Stewards of the Discipline	• Increase in workload o Balancing teaching and research o Develop own courses and Preparation Time • Interpersonal development o Confidence • Time management ability • "Expert" Mentoring o Evaluation from advisor
Third Year Fellows as Junior Colleagues	• Extra responsibility o Undergraduate student research assistants o Departmental committees • Fellows changing identity o Changing view of faculty and other students in department

Table 2. Coding Scheme for DTF Data. Interview comments by students and faculty were grouped into the bulleted categories.

RESULTS AND DISCUSSION

Novice Experience as a First Year Fellow

In an academic community, developing the talent of teaching cannot be accomplished by memorizing principles and laws through specific coursework. Lave [15] suggested that learning is a process that involves becoming a different person with respect to interacting with other individuals in the environment, and is more than just simply receiving a body of factual knowledge. In their first year with the DTF program, fellows were introduced into the academic community as newcomers or novices. While both newcomers and novices are "new" to the community, newcomers are distinguished from novices by prior teaching experience. For example, a fellow who had taught

a laboratory course in his or her home department prior to accepting the fellowship would be a newcomer to the academic community, while a first year PhD student with no teaching experience would be a novice.

All fellows serve as TAs for the first-year (freshman) engineering program during their first year of the fellowship. This first year program hires graduate students from all over the College of Engineering to serve as "an extension of the faculty members" and instruct a two-hour hands-on workshop once a week for each section. The course coordinators responsible for overseeing each semester described the reason for using graduate students as twofold: 1) a logistical necessity, and 2) providing an opportunity to gain teaching experience for graduate students who are considering academic careers. As one course coordinator noted, "Logistically, approximately 1500 freshman students are enrolled each semester, and faculty members simply cannot teach all of the sections required to handle that amount of students." Faculty members responsible for the first year program saw this as an opportunity to provide a "teaching model" for graduate students who were interested in faculty careers.

The primary goal of the first year of the DTF program is to expose newcomers and novices alike to the structure, language, and social norms of the engineering academic community. Fellows are given guided classroom teaching experiences in a first-year (i.e., freshman) introduction to engineering course, with a great deal of feedback both from peers and faculty members. The first experience each new member has is the pre-semester course meeting prior to the start of the fall semester, designed to introduce all TAs to the general overview of the course, their role as a workshop leader, the faculty members, and each other. The size of the first-year program requires a sizable graduate teaching contingent, and the first-year program employs both DTFs and TAs from across the College of Engineering. Following this orientation meeting, the fellows continue to meet weekly with faculty members and other TAs assigned to their same course to review the materials, ask questions, and to discuss any other items of interest. (The only difference in treatment between fellows and other TAs is a reduced teaching load.) Fellows had little to say about course-specific meetings and training before the semester, but were enthusiastic about the weekly meetings (run by the same people). Novice and experienced DTFs and TAs cited a "big learning curve" associated with diverse course content and first-year students with a wide range of preparation and abilities. Despite the learning curve associated with the diverse material, fellows were appreciative of the experience of working with the first year program. One fellow commented,

> "I like how you get to spend the first year without all of the responsibility entirely on you, you have somewhere to go if something goes wrong. Then next year I will go back to my own department and teach [something else] but I will have already had the experience of standing in front of a class".

The weekly meetings played an important role in ongoing training, conveying information in manageable chunks, and as an outlet for asking questions. These workshop meetings appeared to be the central activity for training and mentoring among the fellows [20].

The nature of teaching assignments in this department, namely large groups of TAs assigned to just three courses, affords a high level of peer interaction and support. Fellows described differing levels of interaction with their peers; some attended each others' workshops to see how others present the material or deal with students. More experienced TAs who had worked with the course before didn't hesitate to offer advice on teaching in general or the course and department specifically. A new TA noted that "All of us have different backgrounds; it's nice to be able to take advantage of my colleagues' experiences…" Weekly meetings, prepared slides, experience teaching a smaller course section, and social interaction with peers are examples of more experienced members using scaffolding [25] to assist the novice and newcomer in taking on more responsibility.

In addition to support from more experienced TAs, each semester one faculty member was assigned to observe and evaluate each fellow using a locally generated form, discussed in detail in a prior publication [20]. Fellows considered the open-ended faculty evaluations to be very useful feedback. Students explained that the faculty member visited their class for 20-30 minutes and used the form to provide feedback on what they are doing well and what to improve.

A second source of peer and faculty feedback is provided through a teaching "practicum" course that fellows are required to take while they are working as instructors in the first year program. This course combines pedagogical readings with weekly discussions of ongoing teaching experiences. A major assignment of the course requires students to keep a reflective teaching journal in which they record their preparation, execution and analyses of their own course sessions as instructors. The course culminates in a report that details the instructional and evaluation methods of an assignment that the fellows create.

For many students, gaining entry into the community of practice is often the most challenging step. Students who wish to be accepted as members must quickly learn the structure, language, and social norms of the community [18]. Through the variety of experiences afforded students during the first year of the DTF program, novices and newcomers have the opportunities to learn these skills in a mentored environment. During the first year, expert members were providing feedback and support to novice members, allowing the novices to move closer to the core of an academic community. This is evidenced by one fellow experiencing "an initial glimpse of what it's like to be a faculty member." Initially the novice may listen to more experienced members and receive support from faculty members, but will slowly begin to take on more responsibility as he or she grows confident in his or her new position within the community.

Second Year Fellows: Creating Stewards of the Discipline

Once the fellows have completed a year in the DTF program gaining experience working with the first-year general engineering course and taking engineering education courses required for the certificate program, they are ready for teaching assignments in their home departments. The fellowship program guidelines state that fellows should teach 50% of a course with their faculty mentor during the first semester, and then teach the entire course the second semester, and that the third year of the program should repeat the same breakdown for a different course. While course availability in different engineering departments made strict rules impractical (many courses are taught fall or spring only), the general idea was that over the course of the next two years fellows were given increasing amounts of responsibility, and received more one-on-one mentoring from an expert in their respective fields.

Although fellows have received a full year or mentored teaching experience in an engineering academic community, different fields may have some social norms and structures that differ from those presented in the first year. The second and third year of the DTF program serve to expose fellows to the structure, language, and social norms of their respective fields, by giving them increasing levels of responsibility in the community. As fellows move closer to the center of their academic community, the DTF program gives them the discipline-specific experience and increasing responsibility required for training the stewards of their respective engineering disciplines [8] as well as the ability to balance the research demands placed on individuals pursuing careers in academia. The following themes evolved as being critical experiences for creating stewards of the discipline in the context of their respective community of practice.

1. Faculty-Fellow Mentoring

Each faculty-fellow pair designed their own mentoring practices that were a result of the relationship that developed over the course of the year, using a wide range of formal and informal feedback mechanisms and mentoring practices. All of the fellows cited their mentors' open door policy, and noted that the research advisor relationship made the mentor accessible most of the time. Some mentors provided additional feedback by observing the fellows while they were teaching; one fellow noted that during the "first semester my advisor sat in once a week and gave me comments." Another mentor-fellow pair took the feedback process one step further, creating a feedback journal for use during class observations throughout the semester. The fellow explained that the mentor and fellows shared "a teaching notebook where [faculty mentor] wrote down comments, we discussed what she wrote, and what I could improve on for next time....it was a running evaluation." The faculty mentor mentioned the same practice as an effective method of communication between the fellow and mentor: "I would take notes while she was teaching and we would review that at our meetings. She would keep that as a record." Mentors generally met with the fellow after the observation, or

after their regular research meeting. The teaching relationship that each mentor-fellow team had established as a result of their research relationship highlights the ease in which teaching could be introduced into any faculty-TA mentoring relationship.

Contrary to their limited experience when in the first year of the program, as fellows grew comfortable in the language and expectations of the academic community they began to network with a wider range of community members. As fellows grew more confident in their abilities, they sought out additional experts in the community, thus creating a larger social and professional network for themselves. Several fellows sought out other faculty members in the department they felt had relevant experience, including those who had previously taught the course. One fellow established "a team of mentors." Overall fellows felt that it was good to work with a few different professors for complementary perspectives, and that there was always "plenty of help available."

2. Creating Authentic Experiences

Another important aspect of becoming an expert graduate assistant is learning how to balance all of the aspects of being a faculty member, which include not only teaching, but research, service and outreach as well. During their second year of the program, fellows were nearly unanimous in their agreement about the benefits of having this type of experience in a "safe" environment. Regardless of the course taught, fellows cited a dramatically increased workload over working with the first year course. The majority of this workload increase centered on the additional preparation time needed to develop course materials (which had previously been provided to them in the first year program). One fellow "had to make all the exams and the homework and quizzes, do all of the grading" in addition to preparing for and teaching class several times a week.

Overall, fellows felt that attempting to strike a balance between teaching and research was an important part of preparing for a faculty career. One fellow agreed that "finding that balance is going to pay off so much later." They went on to express appreciation for "the opportunity now in graduate school to figure out time management with teaching rather than when I am in my first year as a new faculty [member]". The other fellows echoed this sentiment; learning to balance research and teaching this was a necessary step in their progression towards an academic career.

Aside from the benefits mentioned above, both the fellows and faculty mentors alike noticed positive gains in the fellows' interpersonal development. A faculty mentor observed that "this program has greatly increased his communication ability, the ease with which he speaks to large groups of students, and facilitated his ability to discuss complex subjects with people who may not have the same level of understanding as he." The increased preparation and teaching responsibility has given the fellows confidence in their ability to succeed in academia, which was especially notable in female fellows. One female fellow noted that "this program gave me the confidence to consider teaching as a career." A faculty mentor of another female fellow agreed, saying,

> "I think the impact on [her] has been HUGE. She was very shy, very reserved, did not have a lot of confidence in her own knowledge. The growth and the change that I have seen in her, and everyone has seen in her, she's gone from this shy quiet person to a real leader. She is much more professionally composed. The teaching was what did it, having to be up there and be responsible."

The same female faculty mentor also emphasized gains in confidence through experience: "When you are a new faculty member you are expected to do research and expected to teach, but you have never had any formal teaching experience. Having the teaching experience gives students confidence, which is especially important for women." Participation in this program has also increased the visibility of academic careers. One of the female mentors had "three women PhD students, and [current fellow] was the only one who wanted to go into academia. After seeing her teaching, they all now want to go into academia."

Creating authentic experiences for the fellows by allowing them to participate fully in many of the roles that faculty members take on is one more way that these students move still closer to the core of the academic community. By the end of the second year, the fellows have taken on many characteristics of a steward of the discipline, and more importantly, are seen as such by their faculty mentors and other members of their respective fields. During the third and final year of the program, most fellows have levels of responsibility nearly equal to tenure-track faculty members, and are viewed as junior colleagues by most full members of their academic community.

3. Social Networking with Peers

One of the aspects of the program structure that the fellows felt was lacking was more community-building activities among the fellows. Along with feedback through formal and informal mentoring activities, many of the fellows would have liked to have more sustained contact with peers in other departments. Several fellows commented that since leaving the first-year program, they did not see the other fellows as often as before and that they would have liked for the program to "continue to keep people involved." Other fellows mentioned how beneficial it would have been to have "met over lunch once every two weeks and said... 'I'm trying this in class and it works,' very informal." Still another student discussed peer support while working in the first-year program; she "liked being with other students in other departments and having the same experience and being able to talk with them." She continued to elaborate on the need for more contact with peers, "I thought we were going to have more interaction with the other fellows when I took the fellowship." Another fellow commented that although she "didn't feel isolated," more interaction with the other fellows would "help with the sense of community."

Future work with the program will address this issue by having more options for the fellows to meet socially with each other. While the fellows were encouraged by the progress they were making in their home departments, most if not all of the fellows mentioned a desire to interact with their peers more from the other departments. This aspect of social community development is a critical step to fellows developing a professional network in the future. At the current time, steps are underway to address this deficiency by creating a website for the fellows along with professional development activities and formal social events at the start and completion of the program.

Third Year Fellows as Junior Colleagues

Along with the increase in confidence and sense of preparedness for an academic career, faculty members and fellows alike noticed changes in the level of responsibility that fellows were undertaking. Fellowship responsibilities helped prepare the graduate students for faculty positions by giving them increased responsibility comparable to that of a new faculty member. As a part of this process, fellows acted—and were treated by faculty—as junior colleagues. Treating fellows like colleagues is important because they are the future stewards of the discipline [24, 3]. Their participation in departmental committees, such as ABET preparation and curriculum development allowed them to be involved at a level where they could contribute to the future of the department. As discussed above, one of the first ways that fellows began to establish their identity as faculty members was to develop more of their own course materials. One fellow had team-taught a class with his mentor during the first semester, and was given a new course for the second semester. He noted differences in the relationship between the two semesters: "In the second semester I can manage the class how I would like to. When you are working with a senior professor, the class is going to be managed how they want it. It was nice to make my own structure." Overall the fellows agreed that while it was nice to have the initial guidance in the beginning stages of course delivery, they enjoyed the flexibility and ownership of having their own course in the later stages of the program.

As fellows progressed in the program, faculty members not only allowed them more freedom in the course design and implementation, but fellows were also given more general responsibilities within each department. One of the fellows served on the undergraduate curriculum committee and the ABET assessment committee. She felt that this gave her a level of familiarity "with our [department's] overall curriculum, our goals, what we are trying to achieve." Another faculty member asked her teaching fellow to assist her in preparing the material for the ABET review of the course. Yet another fellow commented that her participation in departmental committees caused the "faculty to view me less as a student and more as a colleague." Fellows also noticed differences in the way

the department faculty and administration viewed them compared to other graduate students. One noted, "the department let me have the rope to go out there and see what happened, I had already been involved in the department, and I was comfortable talking with the administration. Many other graduate students are not involved at that level."

As the fellows neared the conclusion of their first year working within their home departments (second year in the DTF program), their perceptions of their status in the department changed from that of a graduate student who happened to teach, to more of a junior faculty member:

> "I feel like I am very close to being a faculty member but without the full responsibility...the teaching is a huge thing, but the balancing, the starting to see myself as a faculty member, changed my own vision of how I view myself and balancing my workload. I don't feel overly stressed about adjusting to a faculty workload. Everyone is starting to see me as a faculty member, which is a big mental adjustment."

Many of the graduate fellows also noted that there were research benefits to establishing themselves as effective and responsible teachers:

> "Through my department trusting me as a teacher ... I was able to take on two undergraduate students each semester...which was a nice benefit for my research progress. They normally don't allow the graduate students to mentor these students as independently."

Another fellow was given charge of undergraduate researchers as well. The increased responsibility also gave the fellows a chance to talk to undergraduate students about graduate school. The fellow currently in a faculty position also commented that working with undergraduate researchers, "gave me a chance to talk to undergrads about graduate school. As a faculty member now, it gave me a chance to recruit graduate students." Fellows having the chance to mentor undergraduate researchers not only prepared them for a future faculty career, but demonstrated the level of trust each department had in the fellows as future stewards of the discipline. Faculty mentors assigned to the teaching fellows also witnessed the changing viewpoint of the department: "the department was happy to give full responsibility to someone they knew they could trust."

Even with this increased workload and time commitment, teaching fellows agreed, as one stated, "teaching has not affected my graduation timeline, but it has made it harder." Faculty mentors were in agreement as well, stating that each of their respective fellows was on track to graduate at the

planned time, and many already had job interviews and offers waiting for them after graduation. One fellow had already used this fellowship to secure a faculty position,

> "The training I received has made the transition to faculty member a much easier one. For a person starting in a tenure track position the idea of obtaining grants and submitting publications as well as doing a good job in the classroom is very daunting, especially in the first couple of years. However, because of this program I'm very comfortable in the classroom and I need much less time to prepare than I did when I first started teaching. This really does make a new job much less stressful. Also, as an aside, I think the program teaches professionalism in the university setting - I know the appropriate ways to interact with students, handle honor code questions, grade questions, etc."

As junior colleagues, fellows had teaching responsibilities akin to those of full time faculty members. Many were also given other responsibilities in addition to their teaching that allowed them to interact with other faculty through the department and participate more fully in their academic community. As junior colleagues, these graduate students are right on the edge of being fully integrated faculty members. For many, the transition will be complete upon graduation when they begin their careers as faculty members, in most cases at other institutions. Participation in this program will greatly reduce the time it takes for the fellows to transition into their new professional academic communities. In short, there is strong evidence that this program serves to prepare graduate students for faculty positions in a range of ways not limited to teaching. Guided by a community of practice framework , increasing levels of responsibility with decreasing structure served to integrate these graduate students as stewards of the discipline with an identity as an engineering educator prepared to balance teaching, research, and service in their chosen careers.

CONCLUSION

Using a structure derived from the literature (Community of Practice, Stewards of the Discipline) we presented evidence of the additional depth that theory can bring to a program designed to prepare engineering graduate students for faculty careers. Although the program focused on increasing teaching responsibility, relationships that developed with faculty members and fellow students along with the need to balance teaching and research helped prepare the fellows for multiple aspects of their chosen careers.

A program like this need not cost much in terms of financial resources. At this institution, the College of Engineering held back a few teaching assistantships and allocated them to departments on a competitive basis. Departments shared the costs of funding the fellows, allowing them to be funded at a higher level than most other graduate students. The prestige of a competitive dean's teaching fellowship with augmented funding has been enough to sustain strong applications to the program, provided it is advertized broadly and early enough in recruiting and admissions cycles. Individual faculty welcome the opportunity to work with the best graduate students in ways that are already part of their jobs and sometimes alleviate their responsibilities. Faculty evaluations of graduate students seem like additional work at first, but provide a variety of benefits including monitoring TAs and workshops and providing a basis for continuing (or discontinuing) contracts and rewarding exceptional teaching assistants. Mechanisms for engineering education or teaching courses vary from campus to campus, but may include TA training by The Graduate School, workshops offered by teaching and learning centers, school of education courses, and in some cases engineering-specific initiatives.

In the spring of 2008, the DTF program graduated its first cohort of fellows. Over the next several years, approximately 12-15 more fellows will complete the program, and most will move on to faculty positions. Future work may attempt to follow these graduate students at their new institutions and compare their experiences to graduate students in faculty positions who were not participants in the DTF program.

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