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## **Professional Preparation of Underrepresented Minority PhD's and Post-Docs for a Career in Engineering Academia**

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Dr. Cutright is a Professor of Civil Engineering at The University of Akron. She has a B.S., M.S., and Ph.D. in Chemical Engineering with emphasis on environmental remediation techniques with over 20 years of experience conducting site assessments, soil characterizations and treatability studies for a variety of environmental contaminants. In addition she also conducts education research via an EPA education grant, two NSF Scholarships for STEM education and a NSF collaborative research grant to host 1.5 day workshops to broaden the participation of underrepresented minorities that in engineering. Most recently she and her colleagues were awarded a NSF collaborative research grant to host summer professional training and academic year activities to broaden the participation of underrepresented minorities in engineering academia.

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## **ABSTRACT**

In engineering, women, racial and ethnic minorities, and persons with disabilities are classified as underrepresented minorities. Although strides have been made at the undergraduate level, diversity in faculty and academic administration positions still lags. This paper will present our approach and preliminary results of a National Science Foundation (NSF) sponsored collaborative project to broaden the participation of underrepresented engineering minorities in engineering academia by providing participants with an improved skill set for entry into a faculty position. This project, comprised of a two-week intensive summer professional preparation training in conjunction with year-long activities, built upon the findings of a previous NSF 1.5-day workshop. The specific goals of the project include: 1. increase the awareness of what is "needed" to be an assistant professor; 2. quantify the specific areas PhD students and post-docs identified they need the most assistance with; 3. increase participant knowledge on effective STEM undergraduate learning; 4. advance the awareness and skills pertaining to curriculum development, delivery and assessment; 5. enhance the establishment of a research career; and 6. increase participant networking opportunities. Achievement of these goals will yield a more diverse and better prepared set of engineering educators, leading to better-equipped engineers entering the workforce.

The first summer intensive professional preparation had 12 participants from the host institution, universities in the same geographical regions as the host, and from the collaborating institutions. Seventy-five percent of the ACADEME (Advancing Career in Academics with Diversity and Mentorship in Engineering) Fellows strongly agreed that the summer training content was useful for his/her professional development and 100% agreed that they would recommend the program to their peers. In addition to providing the assessment results from the first summer professional training, this paper includes recommendations from ACADEME Fellows for enhancing future summer sessions, results of a survey of a non-cohort group, lessons learned from recruiting, and the most effective activities during the academic year.

## **Introduction**

According to the 2009 U.S. Census, non-Hispanic whites held 72% of science, technology, engineering and mathematics (STEM) related jobs [1]. In 2011 ethnic minorities still held only 28% of STEM jobs [2]. Thus, it was not surprising that department chairs from the 200 top research universities agreed that increasing underrepresented minorities in STEM fields was an

important national need [3]. A variety of K-16 initiatives have led to an increase at the undergraduate level, however, these initiatives not translated into an increase at the graduate student and faculty levels [4], [5]. The American Society for Engineering Education report of all engineering degrees found that underrepresented ethnic minorities held 14.6% of B.S. degrees, 13% of M.S. degrees and 10.3% of the Ph.D. degrees, and 5.9% of the faculty positions, while women earned 20.8% of the B.S. degrees, 25.4% M.S. degrees, 23.3% of Ph.D. degrees and 16.3% faculty positions [6].

Even when they do persist and enter into academia, women leave at a higher rate than their male counterparts [7], [8], [9]. Nelson and Rogers [10] reported that even in disciplines where women earned more PhDs, the percentage of white male faculty at research universities was still higher. Gender bias in academia was first documented in a 1999 MIT study [11], and the findings of this study led the NSF to fund initiatives such as ADVANCE in 2001 to increase the number of women in faculty positions by addressing the issues of a 'leaky pipeline' (leaving the position before promotion) and 'chilly climate' [12]. Yet women still have higher turnover rates that were directly correlated to dissatisfaction with the level of research support, advancement opportunities, and free expression of ideas [13], [14]. Although some female faculty have benefited from programs such as ADVANCE, the 'advances' have not been sufficient to fundamentally change underrepresentation in STEM fields [15].

The ability to succeed in academia is often confounded by lack of preparation for one of the job responsibilities. The completion of the doctorate and/or post-doctoral study should have provided the skills needed for conducting research. At most major universities skillsets stretching beyond the ability to conduct research are needed. The majority of tenure-track faculty jobs include duties related to teaching, research, mentoring and service. A 2001 survey by Golde and Dore noted that 82% of the graduate student respondents identified enjoyment of teaching as being what attracted them to academia as a career [16]. However, 52% of the respondents indicated that they did not learn about teaching during their graduate studies. These results along with other factors have led to pleas for national educational councils [17], [18] to improve undergraduate STEM teaching. The implication is that by improving training in teaching, the number, diversity, and quality of STEM graduates would increase.

## **Goals and approach**

The specific goals of the project include: 1. increase the awareness of what is "needed" to be an assistant professor; 2. quantify the specific areas PhD students and post-docs need the most assistance with; 3. increase the participant knowledge on effective STEM undergraduate learning; 4. advance the awareness and skills pertaining to curriculum development, delivery and assessment; 5. enhance the establishment of a research career; and 6. increase participant networking opportunities.

The primary activity was a two-week professional development training during the summer. ACADEME (Advancing Career in Academics with Diversity and Mentorship in Engineering) Fellows were recruited from the three institutions collaborating on the project as well as from universities in the same geographical region as the host institution. The training involved teaching-focused sessions on: developing a teaching statement; developing a syllabus; delivering

20-25 minutes of instruction; developing learning assessment tool(s); learning different classroom management techniques; learning outcomes and academic integrity; and developing strategies for embracing diversity in the classroom. Research-focused activities included: developing and receiving feedback on research statement for job applications; preparing (and resubmitting) proposals or journal papers; defining what is a viable start up package; learning negotiation strategies; recognizing differences between proposals submitted to different agencies and educational and ‘traditional technical’ based research proposals; finding funding opportunities; managing time; and building collaborative research teams. A complete list of topics used for each week is given in Table 1.

Table 1. Topics used during the summer professional development training

| Research Week Topics                              | Teaching Week Topics                                    |
|---|---|
| Tenure track (TT) explained                       | Networking strategies                                   |
| Attributes of a competitive TT application        | What is a teaching philosophy                           |
| Expectations of assistant professors              | Using ABET criteria to develop course/learning outcomes |
| Feedback/revision of research statements          | Student centered instructional strategies               |
| Other professional development opportunities      | Teaching adult learners*                                |
| Approach to reviewing a research proposal         | Teaching diverse populations*                           |
| Mock research panel                               | Working session – lesson development                    |
| Interviewing tips and negotiating                 | Assessments   |
| Equipment and start up packages                   | Working session- develop assessment for lesson          |
| Developing collaboration                          | Deliver Mini-lesson                                     |
| How to prepare proposals                          | Teaching evaluations                                    |
| Differences between federal, state, local funding | Use of effective classroom technology                   |
| Developing a budget                               | Syllabus development                                    |
| How to address reviewer comments                  | Practical tips for first course prep                    |
|   | Effective use of office hours                           |
|   | Strategies for improving teaching                       |
|   | Translating teaching philosophy to the classroom*       |
|   | Academic integrity                                      |

\*: Topic lead by education faculty member

The summer training used a combination of formats including: PowerPoint presentations; discussions, both in person and on the learning management site; sessions for the Fellows to complete tasks, and networking dinners. The amount of time allocated for each topic and working sessions depended on the content and associated task. For instance, after learning about how to use ABET for developing learning outcomes, the Fellows had a 20-minute working session to construct learning outcomes for the content that he/she had prepared for their lecture. The working session for the mock panel review in the research-based week required more time. For the mock review panel, the fellows were given several hours to read two research proposals,

from a mix of funded and unfunded proposals (with PI and institution information redacted) that had been submitted to various funding agencies. Care was taken to match the ACADEME Fellows background with the proposal content. The PIs acted in the role of the program managers to facilitate the 1.5-hour panel. At the conclusion of the mock panel, the ACADEME Fellows were informed if the proposals were funded so that they could compare their rankings with the actual outcome.

As mentioned above, a learning management site was developed as a resource prior to the start of the summer training. The site was used to provide copies of all lecture materials as well as additional resources (i.e., journal articles, ABET criteria, etc.) for the Fellows. The site was also used as an announcement and discussion board, scheduling meetings with the mentors, and networking between the Fellows. ACADEME Fellows have access to the learning management site for the duration of the four-year grant.

The second activity for the program is ongoing during the year where the ACADEME Fellows were paired with mentors that were not from his/her home institution. Webex was used to enable the Fellows to meet with their mentor 'face-to-face' a minimum of twice a semester. The mentors kept a log as to the nature of the questions (research or teaching), the resolution, if follow up was needed, and tentative date for the next meeting. The Fellows were asked to keep reflective journals to track what he/she thought about the mentor's suggestion(s), the progress being made, etc. Finally, interested Fellows were given the option to write a travel proposal to advance their career path by visiting with funding agencies or participation at technical meetings. The first round of travel proposals was submitted on December 31, 2017.

### **Assessment methods**

A mixed methods approach was used by an external evaluator and the PI team to assess if the project was meeting its goals. The time points for assessing the ACADME Fellows were: before the summer professional development (pre), immediately after the summer professional development (post) and after the year-long activities (follow-up). A few of the assessment mechanisms, such as discussions and evaluation of participants' mini-lessons, were concluded during the summer professional development. A control cohort, similar in career timing but not participating in the program, was assessed by a survey administered in the fall semester (pre-assessment), while the post will be completed at the end of the spring semester. The post-assessment of the control cohort will evaluate if their knowledge of the key issues increased with time after raising their awareness by the first survey statements. The full assessment of activities and the control cohort's post assessment will be completed by June 2018.

### **Results and Discussion**

#### Lessons learned from recruiting

The project was officially awarded July 1 2017, and the first summer professional development training was offered July 24 through August 3, 2017. Although PI team starting advertising at the beginning of June when they heard from the program director that the project was being recommended for funding, the turn-around was still too quick. Several potential participants

who were interested indicated that the short notice kept them from applying as they already had prior travel plans or scheduled experiments. Similarly, some potential students could not participate as his/her advisor was traveling and did not forward the advertisement until after the summer training had ended.

Advertisements were sent to all engineering colleges in the same geographical region as the host institution. The most effective approach was an email from a PI to a specific faculty member in a department, often a known colleague or a member of an underrepresented group. It was also beneficial to have a link established for electronic submission of applications at the time of advertising. The two key lessons were to start recruiting early and to target emails to faculty that are members of underrepresented groups. Recruiting for the second group of Fellows began in November 2017 with an application due date of March. As of early February 2018, over 130 preliminary interest surveys have been received as well as four completed applications.

#### Participant and control cohort demographics

ACADEME Fellows were recruited from the collaborating institutions as well as from universities near the host institution. Due to the short time between the awarding of the project and selection of participants, only 12 eligible fellows were selected. All of the participants were PhD students. The control cohort was comprised of Ph.D. and post doctoral students at the host institution that had not been involved with the project activities. The demographics of the ACADEME Fellows (12 participants) and control group (40 survey respondents) are shown in Table 2. Although the survey results of the control cohort did not identify the gender of the ethnic minority students, the African American and Hispanic ACADEME Fellows were all male. This result was similar to Hill et al. [19] who found that women were present at lower numbers than their male counterparts across all ethnicities and all professional levels.

Table 2. Demographics and academic disciplines of ACADEME Fellows (12) and control (40) cohorts

|            |                               | Participant cohort (%) | Control cohort (%) |
|------------|-------------------------------|------------------------|--------------------|
| Gender     | Female                        | 69.2                   | 75                 |
|            | Male                          | 30.8                   | 25                 |
| Ethnicity  | African American              | 15.4                   | 5                  |
|            | Hispanic                      | 7.7                    | 5                  |
|            | Asian or Pacific Islander     | 15.4                   | 37.5               |
|            | Caucasian                     | 15.4                   | 35                 |
|            | Indian or Middle Eastern      | 38.5                   | 15                 |
|            |                               |                        |                    |
| Discipline | Biomedical Engineering        | 23.1                   | 10                 |
|            | Chemical Engineering          | 23.1                   | 25                 |
|            | Civil Engineering             | 23.1                   | 5                  |
|            | Computer Engineering          | 7.7                    | 0                  |
|            | Electrical Engineering        | 15.4                   | 10                 |
|            | Mechanical Engineering        | 7.7                    | 20                 |
|            | Polymer Science & Engineering | 0                      | 30                 |
|            |                               |                        |                    |

### Assessment of summer professional training and control cohort

The quality of the summer training was assessed first so that feedback could be used in potential modification to the activities. The Fellows' perceptions on the two-week summer training are shown in Table 3. No 'strongly disagree' responses were noted, so it was not included in the table. The Fellows agreed or strongly agreed that the content of the summer training was appropriate and helpful for their careers. For instance, 79.6% found the content to be "*useful for my professional development.*" The only response that had a disagreement was in the pacing of the summer training. Although the majority strongly agreed (45.2%) or agreed (45.2%) with the pace, 7.7% thought the training session might have been too long. To address this potential issue, a preliminary interest survey for the 2018 professional development workshop asked applicants if they prefer a two-week training with weekends free or a delivery of nine days in a row. The results were split, and therefore the 2018 training will be delivered in the same timeframe but with additional sessions for reflection.

Table 3. ACADEME Fellows perceptions of the quality of the professional development workshop

| Statement   | % Disagree | % Agree | % Strongly Disagree |
|---|------------|---------|---------------------|
| Content was useful for my professional development      | 0          | 23.1    | 79.6                |
| Skills presented were practical for future career plans | 0          | 30.8    | 69.2                |
| Material was presented in understandable way            | 0          | 30.8    | 69.2                |
| Presenters were engaging                                | 0          | 23.1    | 79.6                |
| Pacing of sessions was appropriate                      | 7.7        | 46.2    | 46.2                |
| Opportunities to network with peers were provided       | 0          | 30.8    | 69.2                |

The ACADEME Fellows and control cohort were given a survey to assess their knowledge associated with the different aspects of being an assistant professor in order to assess project goals 1 and 2. The survey was comprised of six open ended questions and 54 questions that asked if they had little or no knowledge (1), some knowledge (2) or if they were very knowledgeable (3) on a topic. The ACADEME Fellows were assessed both pre- and post-summer training to evaluate how their perception changed. One hundred percent of the ACADEME Fellows reported that their knowledge increased from before participating in the program due to the summer training in all categories surveyed. The sub-scale related to knowledge of teaching was statistically significant for all of the participants, while the topics associated with research depicted a significant change for only 77% of the participants. The average response associated with what is needed for a career in academia depicted the largest change from the pre- to post-training. Before the summer professional development, fellows had an average rating of 1.24 (Table 4). At end of the second week the average rating of their knowledge had changed 2.42.

Although the control cohort did not participate in the summer professional development, 69.2% had participated in some sort of professional preparation activity associated with research (72%, e.g., conferences) or career development (28%, e.g., EDGE leadership conference or a career fair). Similarly, 75.9% of the control cohort indicated that their advisor provided substantial input on his/her preparation in research. In terms of preparation for teaching, 43.8% of the control cohort received no input, while 34.0% and 20.7% received a little or substantial, respectively, input from his/her advisor. This result is similar to a 2001 survey that found 52% of the respondents indicated that they did not learn about teaching during their graduate studies [20]. Similarly, only 36.2% of the control cohort received some input on preparing job applications and over 56% of the control did not receive any help at all. A lack of guidance, particularly during the early years of a faculty position is one of the reasons women left research academic positions [21].

Table 4 contains a partial listing of the survey questions asked of the Fellows and control cohort. Due to space limitations, the top five questions that had the most change for the participants in terms of teaching, career related issues and research were shown. The first three columns are the Fellows' perceived knowledge level before the training, after training and the difference between these two averages. The next column contains the pre-assessment responses for the control cohort. The potential knowledge change of the control group cannot be completed until after the post survey has been conducted. The ACADEME Fellows' knowledge of how to evaluate their teaching had increased to 2.5 (half way between knowledgeable and very knowledgeable) after the summer training, while 50% of the control cohort had little to no knowledge in this area (1.5). Similarly, the Fellows' familiarity of the Grant Proposal Guide (GPG) increased significantly. Although 70.6% of the control group indicated he/she had little to no knowledge of the GPG (1.3), the pre-assessment was still slightly higher than that of the ACADEME Fellows (pre: 1.0). A full comparison between the two cannot be completed until after the control cohort's post survey have been conducted. These initial results, as well as the other survey responses indicated that the summer training was beneficial to the Fellows. In fact, 100% of the fellows would recommend the professional development to their peers. One enjoyed the experience so much that he "*wants to help when the summer training is hosted by his university*". Table 5 contains example comments as to why the participants would recommend it to their peers. A common theme was how much they learned about academics as a career.

#### Academic year activities

Only one semester of the academic year virtual meetings has been completed. Therefore, it is not possible to fully assess these interactions. Preliminary evaluations have indicated that it has been successful. One of the Fellows has had this/her mentor provide guidance on a national fellowship application. The Fellows have also used the network to solicit feedback from one of the other participants who was awarded fellowship previously. Other Fellows have sought feedback from their program mentors on refining their teaching philosophy and research statements for job applications. These interactions provide the Fellows another mentoring source, in addition to their research advisor and outside of their institution, to consider new ideas or pathways for their careers.

Table 4. Sample responses of ACADEME Fellows (12 participants) and control (40) cohort's perception of knowledge associated with aspects of engineering academia. Note 1 = little or no knowledge, 2 = knowledgeable, 3 = very knowledgeable

|  | ACDEME Fellows Perceptions |      |        | Control cohort |
|--|----------------------------|------|--------|----------------|
|  | Pre                        | Post | Change | Pre            |
| Knowledge level of teaching (Goals 3 & 4)                              |                            |      |        |                |
| Developing teaching philosophy statement                               | 1.2                        | 2.5  | 1.3    | 1.8            |
| Developing learning outcomes for teaching lessons                      | 1.2                        | 2.5  | 1.3    | 1.8            |
| Developing formative assessments                                       | 1.1                        | 2.6  | 1.5    | 1.7            |
| Developing summative assessments                                       | 1.2                        | 2.5  | 1.3    | 1.4            |
| How to evaluate my teaching  | 1.2                        | 2.6  | 1.4    | 1.6            |
| Knowledge level of career related issues (Goals 1 & 2)                 |                            |      |        |                |
| Strategies for time management as junior faculty                       | 1.2                        | 2.6  | 1.5    | 1.6            |
| Primary components of a start-up package                               | 1.2                        | 2.6  | 1.4    | 1.5            |
| Developing a tenure portfolio  | 1.0                        | 2.4  | 1.4    | 1.4            |
| Effective negotiating strategies during job search                     | 1.2                        | 2.6  | 1.4    | 1.4            |
| Responsibilities for new assistant professor                           | 1.2                        | 2.6  | 1.4    | 1.6            |
| Expectations to succeed as new assistant professor                     | 1.2                        | 2.6  | 1.4    | 1.6            |
| Knowledge of research (Goal 5)   |                            |      |        |                |
| Familiarity with the GPG for federal grants                            | 1.0                        | 2.7  | 1.7    | 1.3            |
| Addressing concerns of reviewers/program director for a grant proposal | 1.0                        | 2.6  | 1.6    | 1.6            |
| Developing research statement for tenure track application             | 1.2                        | 2.6  | 1.4    | 1.4            |
| Grant proposal review criteria   | 1.1                        | 2.6  | 1.5    | 1.7            |
| Addressing the requirements of a RFP                                   | 1.1                        | 2.4  | 1.3    | 1.5            |

Table 5. Rationale for recommending professional development training to others

| Reason for recommendation                    | % response | Example comments   |
|--|------------|--|
| Knowledge/skill for academic Career          | 46.2       | <ul style="list-style-type: none"> <li>• <i>“Offers sufficient knowledge and great help for people who want to become a tenured faculty in the future”</i></li> <li>• <i>“Very informative about how to become a successful faculty member”</i></li> <li>• <i>“Extremely relevant for anyone considering a career in academia”</i></li> <li>• <i>“For those decide to be a professor in the future, it is the best thing to do”</i></li> </ul> |
| Useful/learned a lot                         | 23.1       | <ul style="list-style-type: none"> <li>• <i>I learned a lot here I would want my peers to learn from the experts too</i></li> <li>• <i>Useful information that is not readily available”</i></li> </ul>  |
| Job search, interviewing, negotiation skills | 30.8       | <ul style="list-style-type: none"> <li>• <i>“This workshop will me in future for job search”</i></li> <li>• <i>[learned] “how to negotiate, important questions for job interview”</i></li> <li>• <i>“Yes, most people especially women, don’t have negotiation skills”</i></li> </ul>   |
| Research                                     | 15.4       | <ul style="list-style-type: none"> <li>• <i>“how you will write, review proposal, some startup package, how things actually work in academia”</i></li> <li>• <i>“How to write a proposal, how it will be evaluated”</i></li> </ul>   |
| Teaching                                     | 7.7        | <ul style="list-style-type: none"> <li>• <i>“I learned a lot about teaching, how you engage students, what are some strategy that you can use”</i></li> </ul>  |
| Networking (Goal 6)                          | 7.7        | <ul style="list-style-type: none"> <li>• <i>I got to meet and connect/network with a great group of people from various disciplines.</i></li> </ul>  |
| PI/Faculty                                   | 7.7        | <ul style="list-style-type: none"> <li>• <i>“The fact the faculty are still willing to help after workshop was not expected as I have never seen that before in other workshops that I participated. This is by far one of the strengths of the workshop (getting more mentors and advocates for my success inside and outside of academia).”</i></li> </ul>   |

## Potential changes to the program

The first Fellow cohort was comprised of all Ph.D. students. Additional recruiting efforts will be made to solicit participation of post-doctoral researchers. Inclusion of post-doctoral level Fellows would be beneficial in two ways. First, it would provide a comparison between the training that is needed by doctoral level students versus post-doctoral level researchers that are planning on entering academia. Second, it would provide an evaluation of perceived knowledge and expectations that could be associated with different career stages.

The order of some of the summer training material will be modified slightly to streamline the content. For example, the requirements and procedures used in completing a tenure track application will be completed first. In addition, some topics will be changed to voice over slides that participants watch prior to the sessions. This move to online content will be done to provide more time for fully developed discussions between the Fellows and PIs. These discussion times will be scheduled in into two-week summer professional training.

More free time will also be allocated in each day of the summer training. The free time could be used for the Fellows to complete training assignments (e.g., refining syllabus, read proposals for mock panel, etc.), reflect on content, work on their own research, and network with their peers. Time permitting, the PIs may incorporate a mock interview for the participants, which was an addition requested by the first set of Fellows.

## **Conclusions and Recommendations**

The first summer professional development training was successful as 100% participants would recommend the activity to their peers. Furthermore, comparisons with control cohort indicated that the Fellows had increased knowledge in key areas after the development training. Although the two-week summer training was successful, there are areas to make improvements. For instance, some of the content will be streamlined to provide more free time for the participants to work on development their assignments, networking, reflection or to conduct their own work. It is also very important to start advertising early. To that end, a preliminary interest survey was sent on November 9 for next summer professional development. Early and aggressive advertising may help with soliciting more post-docs. Comprehensive assessment will continue to be performed to provide quantitative and qualitative information about the goals of the program.

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