

2006-1638: CREATING AN INDUSTRIAL WORK GROUP ATMOSPHERE IN TECHNOLOGY GRADUATE PROGRAMS: AN UNEXPECTED IMPACT ON MINORITY SUCCESS IN GRADUATE SCHOOL

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Creating an Industrial Work Group Atmosphere in Technology Graduate Programs: An Unexpected Impact on Minority Success in Graduate School

Abstract

The interdisciplinary graduate program in Microelectronics-Photonics (microEP) was created at the University of Arkansas in the fall of 1998 to merge traditional graduate research and educational excellence with specific training in operational effectiveness methods, intra and entrepreneurial skills, and teaming and group dynamics practice. The stated goal of this approach was to create a graduate program that emulates the industrial work group environment, with the group objective being that every graduate student achieves the highest academic training of which he or she is capable.

In the seven years since the microEP grad program was started, this educational experiment in creating a graduate program centered in a natural work group culture has proven beneficial to its students – and has even been largely adopted by the UA Physics graduate program¹. What was not expected is that this natural work group approach also created a graduate community that has acted to bridge minority students from the heavily supportive MSI atmosphere to the generally impersonal atmosphere found in white majority research intensive grad programs.

Including the fall 2005 entering microEP Cohort 8 students, one hundred and three students are currently enrolled or graduated. This includes seventeen minority students, a percentage half again as high as the national average of graduating minority PhD students² and much higher than the current enrollment in the traditional UA science and engineering graduate programs. Two African-American men have completed their PhD microEP degrees, with one joining Virginia Commonwealth University as a tenure track faculty member, and the second currently enrolled in the University of Alabama Birmingham Medical School.

In this paper the authors will first discuss methods that have been used to locate students in communities underrepresented in science and engineering that would be well served by the microEP research and educational training. The authors will then discuss their observations on how the natural work group approach to graduate education has unintentionally addressed some of the factors affecting minority student retention³.

Philosophy of microEP Graduate Program

The microEP graduate program at the University of Arkansas was started in 1998 with the intent of creating an educational environment for its students that was as much like an industrial professional technologist work group as possible. The technical focus of this work group would be in the areas of advanced micro/nanoscale materials and devices in the broad area of electronics and photonics. The method was to be the agency that would allow merging of already existing academic efforts in this field with operational methods and training in common usage in industry.

The summation of this approach is called the Cohort Method, with every student entering the program in a given academic year (Summer, Fall, Spring cycle) becoming part of that year's Cohort. The number of entering students in these Cohorts has grown from eleven in Cohort 1 to an average of eighteen students over the last three Cohorts. In general, about two-thirds of the students in each Cohort enter in the fall semester. There is no negative curriculum impact to the students entering in January, so our history has been that about one third of the microEP students enter in the spring semester.

This educational experiment was supported initially by a NSF small group research grant, followed by a 1999 NSF Integrative Graduate Education and Research Training (IGERT) grant and a 2000 Department of Education Fund for Improvement of Post Secondary Education (FIPSE) grant. The microEP program has since won a three year NSF Research Experience for Undergraduate (REU) site and then five year extension, a five year NSF Graduate Student in K-12 Education (GK-12) grant and then five year extension, a NSF Partnership for Innovation (PFI) grant and then follow up PFI grant, and a five year NSF Material Research Center for Science and Engineering Center (MRSEC) grant with a just awarded second five year continuation.

The microEP program has also met some success in implementing an industrial management approach into the academic environment. While the student activities in management training and practice are described in another paper submitted to the Engineering Management Division at the 2006 ASEE Annual Conference⁴, highpoints of both student management training and industrial management techniques used by the microEP program include:

- Matrix management of student curricula by major professor and cohort group manager
- Formal planning of research with Microsoft Project, including monthly reporting
- Peer mentoring on research planning in student-led weekly group meetings
- Research progress summary reports by semester
- Resume and curriculum plan updates by semester
- Summer short courses on narrow topics using industrial style scheduling
- Research presentations on current hot issues using industrial format reporting
- Solicitation-style candidacy exam process, with open written source access
- Creativity and team building through industrial-style one to two day seminars
- Formal summer classes in Ethics, and Proposal Writing and Management
- Formal fall/spring classes in Operations Management
- Formal class in Research Commercialization (intra/entrepreneurship of technology)
- MicroEP Program management through Administrator/Board type structure
- Recognition of microEP graduates shared between program and professor's department
- Active program management of research professor matching to students

These management techniques were designed to make the microEP program a partner in the success of our traditional departmental grad programs, not a competitor to the departments for resources. The intent was to create a new educational path that would attract additional students to the University of Arkansas rather than to redistribute the students already enrolled in our traditional departmental graduate programs.

Impact of the Cohort Methodology on program culture

As the microEP program was being defined in early 1998, it was recognized that the only way in which the student goal that every student achieve his/her full academic potential is if it was adopted as a work group goal. That is, the microEP program requires that its students consider themselves successful only if everyone in their cohort, and for that matter all cohorts, performs at their maximum level of which they are capable.

This program-required engagement with their professional graduate student colleagues drove many of the other program attributes, as it required extraordinary efforts to create the opportunities for students to know each other beyond the classroom environment. Without this level of knowledge of each other beyond the confines of the classroom, everyone stays a name without a face rather than a person with both needs and strengths.

It was anticipated that the barriers to microEP students actively and routinely helping each other would not be based in the willingness of students to help those in need. Instead, the barriers would be erected by the student needing help worrying that their professional stature would be diminished by admitting that they were having difficulties mastering class material or research skills.

By putting program activities in place such that the students know each other as people, and by microEP management active promotion of the concept of those in need of help today will be the expert in another subject tomorrow, the microEP program culture has grown into a true work group mentality with this common goal of total academic success. This in turn has been reflected in student interactions in multiple areas, as their focus has been redirected outward toward balancing organizational optimization with the optimization of their own local experience. This simple change in organizational philosophy has resulted in changes in personal behaviors at both the personal interaction level and in interactions between research groups.

A final aspect of the Cohort Methodology is in the admission of students to the microEP program. It was decided early in the program that students would be admitted to the program would be admitted to the graduate program, even with weak undergraduate academic records, if it was determined through personal interviews and recommendations that the student had identified and corrected the cause of their prior weak performance.

The attribute of admission policy that was inviolate was the absolute requirement that the research and educational strengths of the microEP program were well-matched to the career preparation needs of the student applicant. In other words, the program would only accept students who had a clear idea of their professional and personal goals – and how the microEP strengths would well-prepare them to meet their goals.

The metrics of success of the microEP program would include traditional academic measures such as graduation rate and time to degree, but only in the sense of that being an in-line process control for an academic program. The true metric of success would be the success of the students in finding positions in career fields of their choice after graduation, and in their early career professional and personal rate of growth and achievement.

Impact of Cohort Methodology on incoming students:

Students entering graduate school directly after their bachelors degree are faced with several transition areas that they must successfully navigate as they start their graduate degrees. These include:

- Increased coursework expectations
- Decreased accessibility to faculty at research institutions
- Differences in community cultures and activities
- Increased expectations of independent development of tasks
- Loss of support networks (academic and community)

These issues affect all incoming graduate students, with different students being impacted in different ways. For instance, international students certainly face many cultural changes – often including language induced difficulties. Students from small institutions are especially prone to a feeling of low importance when they cannot easily get meetings with senior faculty, not realizing that they have instead a wealth of new mentoring resources through post docs and senior PhD students. Students taking graduate classes for the first time often don't understand the higher level of knowledge acquisition required nor the amount of independent acquisition needed outside of that covered in the classroom lectures.

One of the issues that impact many students is the need to self regulate their own activities, and the large amount of work that they must both define and execute to complete even a MS level research project. The days of having well understood problems to solve, with answers available in the back of the book, are clearly left behind at the graduate level. Changing years of learned educational patterns that were successful tactics at the undergraduate level is a more difficult effort than most students realize.

Clearly the largest issue is the loss of support networks that have been built by a student over the years of their undergraduate work at their prior institution. This lack of personal support, coupled with the loss of expertise in the infrastructure of their educational institution, leaves students entering typical technology graduate programs in significant early graduate career risk.

The impact of the Cohort Methodology in this area is significant. Students entering the microEP program are directed by the program management team that they are required to put their energies into embracing their new professional community. They are required to attend several intensive training functions in their first week before the start of classes that are designed to quickly make them known to the expanded microEP community, and to introduce them to key mentors among their more senior student colleagues.

It is this expectation of their management team that they actively engage with their new community that gives them the authority to rapidly acquire all levels of knowledge about their academic and town communities. It provides the method by which a student with a specific problem has immediate access to multiple levels of knowledge pools, and the authority to tap into them without developing personal relationships with people in those knowledge pools.

Impact of Cohort Methodology on minority students

Minority students considering graduate schools in technology based areas have a wealth of opportunities in high quality research groups around the nation. There are many national funding agencies that issue solicitations for proposals in funded research areas, with the competition for these grants typically highly competitive. The problem faced by minority students is that a significant number of the bachelors degrees are issued from minority serving institutions (such as Historically Black Colleges and Universities and Hispanic Serving Institutions), but the vast majority of funded graduate opportunities are at white majority research institutions (WMI).

A student who has completed his or her bachelors degree at a minority serving institution (MSI) has an additional transition when considering moving to a graduate program at a WMI. That transition is in a sense a unique accumulation of the elements already described, with the cultural differences and the loss of access to faculty especially dramatic. Added to these is a new element – that the MSI faculty often have almost a parental relationship with their students, as compared to WMI faculty having interactions with new students that more closely approach an employer/employee relationship.

What was not anticipated by the microEP management team during the program definition was that the Cohort Methodology would provide a transition mechanism for minority students, a mechanism that is especially critical to students leaving a MSI environment. These entering students are embraced by a community that is based on a very different kind of shared culture, but it is a very vibrant culture that has a flavor of their prior experience. The intensive early interactions with the microEP management team and with their new community's other members provides a very real sense of extensive connectivity in their new home.

The Cohort Methodology also results in very active continuing support in all areas of performance. Mentoring in both the academic areas and research performance has already been discussed, but planned socialization activities outside of the campus give these students exposure to new experiences with a much wider range of people than many of them have experienced before. Once again, the publicly stated expectation by the microEP management team of the value of these shared experiences and the value of embracing the scope of a widely diversified knowledge base (perspectives based on race, gender, cultural background, academic background, etc) gives the students the authority to experiment with rather than avoid these experiences.

Together these activities have resulted in minority students being comfortable in joining the microEP graduate program, and having success in the program, that is significantly above the levels in the traditional science and engineering departmental graduate programs at the University of Arkansas.

Program demographics

As has been discussed, the ultimate measure of success in the microEP program is in the career success of our graduates in the professional positions they secure that match their goals. One

aspect of the program has been that some students' goals change under the influence of the microEP program's emphasis on outreach, community involvement, and obligation to give back to society to repay the investment society has made in their education. Even so, most student leave with the goal of being employed in a profession that fully utilizes the complex technical knowledge and the management skills they have developed as a microEP student.

Table 1 below is a listing of the microEP student demographics by Cohort:

Table 1: MicroEP Graduate Program Demographics									
Cohort	Degree Sought	Male Minority	Female Minority	Male Other	Female Other	Male Int'l	Female Int'l	Number PhD Path	
1	MS	1	0	7	3	4	2	1	
	PhD	0	0	1	0	0	0	n/a	MS microEP grads + Entering with other MS
2	MS	3	0	3	1	1	0	4	
	PhD	3	0	5	0	2	0	n/a	MS microEP grads + Entering with other MS
3	MS	0	0	5	1	4	1	1	
	PhD	0	0	6	0	5	0	n/a	MS microEP grads + Entering with other MS
4	MS	3	0	3	0	3	0	1	
	PhD	0	0	3	2	1	0	n/a	MS microEP grads + Entering with other MS
5	MS	0	1	1	2	1	1	0	
	PhD	0	0	4	0	3	0	n/a	MS microEP grads + Entering with other MS
6	MS	3	2	10	0	7	0	6	
	PhD	1	1	7	1	3	1	n/a	MS microEP grads + Entering with other MS
7	MS	0	1	9	2	7	2	4	
	PhD	0	1	9	1	7	1	n/a	MS microEP grads + Entering with other MS
8	MS	0	1	9	5	5	3	8	
	PhD	0	1	6	4	1	3	n/a	MS microEP grads + Enter with other MS

The minority participation has varied by cohort, but has been a largely continuous presence in the program. Of the one hundred and three active students and alumni, twenty-four are female, thirteen are African-American, and four are Hispanic.

Two African-American men have completed their PhD degrees (one in 2004 and one in 2005). One is now a tenure-track faculty member at Virginia Commonwealth University, and the other is in the MD program at the University of Alabama. One other African-American PhD male student is scheduled to graduate in May 2006, and is already working as a tenure-track faculty member at the University of Arkansas, Pine Bluff.

Another African-American male student has finished his MS microEP degree and is taking his PhD candidacy exam in the spring semester, and two African-American female students are

scheduled to complete their MS microEP degrees by August 2006 and take their PhD candidacy exams in spring 2007.

The incoming 2006-2007 Cohort 9 group of accepted applicants includes two African-American males and one female that were the direct result of the NSF REU site in micro and nanoscale science and engineering that is sponsored by the microEP Graduate Program.

While it is easy to celebrate successes, it is important to also understand the reasons for students not completing the microEP program. Of the minority participants that have joined the program that did not complete (with these students not being indicated in the numbers above), two joined other graduate programs and one is working outside of this field with all course work completed but lacking thesis completion. The program management has stayed in contact with the last student, encouraging him to continue progress toward his final degree requirement.

Summary

The microEP management group continues to work to develop new partnerships with MSI campuses, both independently and in partnership with the University of Arkansas' Office of Graduate Recruitment, in order to increase the visibility of the program to populations of minority students. Our goal is to create methods by which students that would be well-served in their career preparation by participation in the microEP graduate program can (1) easily find that our program exists, and (2) have confidence that they will be supported in their education, research, and personal development as a member of our graduate program's community.

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