Session 3142

Graduate Student Practice of Technology Management: The Cohort Approach to Structuring Graduate Programs

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Background

Many conferences have been held to discuss the skills needed by engineering and technology program graduates to be successful in technology based careers. These conferences strive to understand the full spectrum of job requirements by typically including representatives of academe, government, and industry. A common result of these conferences [1, 2, 3, 4, 5] has been lists of desired characteristics in newly hired technologists, including first and foremost the academic competency demanded by the technology job position. But they follow this need for technical competency with a need for proficiency in operational and interpersonal skills, skills that allows technologists to apply their academic training in an efficient manner in today's high tech work environments.

In the field of technical decision-making, it was felt that technical proficiency will not be sufficient to assure that future scientists and engineers make proper decisions, or to even assure that they are successful in their personal careers. They must also be able to work effectively in areas outside of their technical expertise, as they are no longer allowed to exist in an isolated technical environment. The fact is that many products require a high level of technical sophistication to even evaluate if it is the proper product for an application. As a result, today there must be more interaction between the developers of a new technology product and the customer. The scientist or engineer is therefore forced into active participation in such areas as customer negotiations, marketing and business planning, and manufacturing support. While their need for technical competence is not being reduced to support their primary task, their need for other non-technical knowledge is being increased by the many secondary roles that they are being asked to play.

From the large industry perspective, the need for a broadened knowledge base in their scientists and engineers lies in the broad financial impact of the decisions they will make. In a survey of manufacturing engineering jobs, Mason[4] reports, "The results…also emphasize the importance of a broad education. Engineers need to be technically proficient at their job and at the same time understand the economic and engineering implications of their decisions." The Boeing Company CEO Philip Condit has stated, "…it is important that engineering education also have breadth. Students need to know about business economics: What does it cost to build a project? What's involved in integration?" [6]

On the other end of the business size spectrum, small entrepreneurial technology startups are requiring their smaller employee base to not only develop the technology but also manufacture and market it. Robert Morgan has reported the results of a meeting of fifty leaders of the National Academy of Engineering (NAE) that "Engineering employment in manufacturing has moved somewhat from large companies to medium and smaller ones, including many start-up businesses. These workforce changes have created a demand for engineers who can fuse technical, managerial, financial, and industrial skills."[5] The same attendees noted that future technologists "… need a breadth of knowledge to handle complex objectives and multidisciplinary functions, to understand non-engineering issues, and to perform systems engineering in a loosely bound environment".

The daily headlines of economic activities in countries around the world, especially in countries that support significant business activity in high technology products, are a reminder that we are now at the forefront of a global economy. As part of this environment, the global nature of high technology industry has evolved from being an association of production facilities in countries around the world to being a true interactive developmental collaboration of individuals around the world on a daily basis. The interactions between these individuals in a global effort are both creative in the direct developmental sense as well as strategic in providing critical local country perspectives in the product definition and marketing stages.

The need for individuals to work effectively with others around the globe drives a strong need for graduate students to not only intellectually understand and accept, but also emotionally embrace, the potential negative impact that cultural differences between countries can introduce to the needed collaborative effort. Bella Poroberts of Lucent Technologies has described this need for cross cultural sensitivity as "… engineering teams, and virtually all other functions throughout an organization, must be cross-culturally aware in order to leverage resources to develop, market, manufacture, and service increasingly complex products and services around the globe. Sensitivity to other cultures is a business need throughout the organization."[7] Participants at the NAE workshop expressed a similar viewpoint when they said, "This emerging global marketplace is creating new opportunities for international collaboration. (The changes driven by these opportunities) ensures that communication skills within an international, intercultural, context will require much more attention" [5].

Academic communities wishing to respond to even this limited set of additional needs of their academic program's customers are faced with the challenge of providing their students with an ever-increasing scope of technical knowledge while also being asked to train them in management related skills that have not been part of a traditional curriculum. All of this must be accomplished without any increase in academic hours required for degree completion, resulting in a boundary condition type problem that defies traditional academic approaches to a solution.

The University of Arkansas defined in 1998 an experimental education approach to this problem in a newly defined interdisciplinary technology graduate program in Microelectronics-Photonics (microEP). This solution fosters management skills development without intruding on the academic hours needed for academic courses in technology. The simple, yet profound, heart of this experimental approach is that the graduate students are taught and practice technology management skills by operating in an industry-like workgroup setting known as a Cohort. The details of the implementation of this Cohort methodology and its dissemination into other graduate programs will all be discussed in the following sections. In addition, early alumni and employer survey results will be discussed.

Cohort methodology description

The Cohort methodology was designed by Ken Vickers, this paper's primary author, based on his eighteen years of experience in Texas Instruments (TI) in engineering management supporting integrated circuit manufacturing and development. Because of Texas Instruments' policy of hiring almost exclusively from new graduates, Professor Vickers directly observed both the strengths and weaknesses of recent BS and MS graduates from many science and engineering programs around the country. These observations were communicated with the faculty at the University of Arkansas when Professor Vickers would come to the campus on recruiting trips for TI, and if fact matched many of the conclusions drawn by the industry workgroups already cited in this paper.

One observation of particular interest was that recent graduates had little experience in organizing, planning, and executing several complex tasks simultaneously. This was especially noticeable when the tasks also involved coordination between multiple individuals and/or multiple work groups. But it was noted that the students that did have the ability to effectively coordinate multiple activities between themselves and others had a tendency to advance more rapidly in the reward and recognition assessment process. This effect was especially noticeable in low seniority technical staff that could communicate well with all elements of the organization, not just the technical community.

At the University of Arkansas, a faculty group led by Dr. Greg Salamo (co-author of this paper) secured in 1997 a NSF EPSCoR[8] research grant to investigate ultra fast electronic materials and devices. Included in this research grant was a Director's position funded specifically to hire an experienced technology manager from industry. The person hired to this Directorship would be expected to create and implement an interdisciplinary graduate program spanning the science and engineering departments involved with research and education in electronically and photonically active materials, and the devices and subsystems that could be created from those materials.

The challenge in this task was that the graduate program was expected to not only create graduates with top technical skills, but also with the operational and interpersonal skills that had been identified as necessary for successful future technical professionals in the global technology economy.

Professor Vickers was recruited to fill this position, and reported to the University of Arkansas in April of 1998. Once again, his direct observation of the academic workplace led to the conclusion that the professional behaviors being taught in the academic classrooms of the science and engineering programs did not match the behaviors that the students observed in the professional staff of the University. That is to say, the reward and recognition system in the university environment encouraged professional behaviors by the faculty that were opposite to the behaviors that were being taught as beneficial to the students.

To illustrate this concept, Table 1 below compares the professional behaviors that generate rewards in both the academic and industrial environments in several general job tasks.

Practice	Industrial Workplace Behavior	Academic Workplace Behavior
Job goal alignment	Management defined to support group goals	Individual voluntary alignment to departmental efforts
Creative work	Balanced between management assigned tasks and self defined tasks	Self defined, with possible voluntary collaborations on large projects.
Work hours	Coordinated to optimize group performance	Self scheduled to meet personal goals and institutional assignments
Work location	All work at common location to support ad hoc work groups	Independently set hours between home and campus to meet needs and office hours.
Compensation system	Rewards group performance, then individual contribution	Rewards individual accomplishments, not departmental success
Problem solving	Collaboration is necessary for success and is strongly coordinated across groups	Collaborations are theme-based coordination of individual research projects

Table 1: Comparison of typical task behaviors between the industrial and academic environments

These differences in behavioral patterns between the two work environments does not indicate that one or the other of the patterns is wrong, or that one set of other behaviors is even better than the other set. What it does indicate is that the reward system for professionals in the academic environment is significantly different than that in industry, and the professional behaviors in both environments have evolved to follow the reward system priorities.

But for a student to leave the academic environment and be successful immediately in a non-academic workplace (which is the probable path of most of the graduates of our science and engineering graduate programs), it became necessary to create a method by which the students could learn, observe, and practice the behaviors that would generate rewards in that work environment. The method created and implemented at the startup of the microEP graduate program is now known locally as the Cohort method.

This organizational approach to the graduate program management starts with all students entering in a given academic year (summer, fall, spring sequence) being grouped together as a natural work group known as a cohort, regardless of whether the entering students are MS or

PhD level students. Each cohort is identified with the year of the program existence, so that the first year of the program created microEP Cohort 1, then microEP Cohort 2, etc. This begins to immediately form a group identity for new students on campus that is based on their level of experience on their new campus.

Students are allowed to join a cohort group program only if they accept a core value of the cohort: that the primary responsibility as a Cohort member is to assure that all Cohort members achieve the highest level of academic success of which they are capable, and that their Cohort is not successful unless the group itself is successful.

This core value immediately focuses the student in an outward direction instead of the inward focus of most academic programs. It also forces the entering student to begin thinking in terms of group dynamics and group optimization. A key insight that is quickly gained by the students is that the most difficult task for them will not be in tutoring a fellow Cohort member that is having academic problems, but is instead trusting his Cohort colleagues enough to ask for help when his own academic performance is declining.

Creating a true group atmosphere in the academic environment is difficult, primarily because each student's curriculum and research is aimed at a very personal and specific individual goal. Yet the creation of a trusting group atmosphere with in the Cohort is the single necessary element for this graduate program method to succeed. Trust in this case is accomplished through a ongoing series of group activities designed to first create a sense of shared experiences and top level knowledge of all the members of the Cohort, and then designed to deepen the knowledge of each other's backgrounds, cultures, educational strengths, etc.

Most students enter graduate programs during the fall semester, with some students reporting to campus during the summer and a few students joining a program in the spring semester. All summer and fall entry students in a new Cohort are required to report to campus one week before the start of the fall semester. During this week, traditional orientation activities occur to logistically introduce the students to the campus infrastructure.

The event that is not typical during this week is an industrial style two-day "summer camp" to immerse the students in a physically active retreat. The activities during the retreat combine elements of creativity training, team building, awareness expansion, etc. The camp is required of all program students, both the entering Cohort members and the returning Cohorts.

Activities are chosen that require both small and large group cooperation, and some activities are designed to foster a good-natured competitiveness between the Cohorts while growing the since of identity with the graduate program as a whole. The camp resembles at times a toy factory in an interior classroom environment, and then transforms itself into a ropes course-type outdoor activity with students being manhandled through a spider-web like rope maze.

The group identity is strong at the end of the summer camp, but would be subject to rapid decay if it were not refreshed at routine intervals through other structured academic and social activities. The structured academic activity is provided through a weekly operations seminar of each Cohort group to discuss issues that affect a person's operational effectiveness in a technology based workplace. The subject matter of each meeting is structured to address the level of organizational and interpersonal skills training that has already been received by the students. Table 2 shows the path of both MS and PhD entry students as they progress in years through the program.

	Terminal MS Student	PhD track MS Student	PhD Student
Year 1	Communications. Cultural awareness. Operational methods. Project management.	Communications. Cultural awareness. Operational methods. Project management.	Communications. Cultural awareness. Operational methods. Project management. Research Definition.
Year 2	Management skills. Interpersonal skills. Career selection. Interview skills.	Management skills. Interpersonal skills. Research techniques.	Management skills. Interpersonal skills. Research techniques.
Year 3	Career entry job.	Research definition.	Research reviews. Teaching skills. Group leadership. Dissertation defense. Funding approaches.
Year 4	Program feedback, Alumni and Supervisor.	Research reviews. Teaching skills. Group leadership. Dissertation defense. Funding approaches.	Interview skills. Career entry job.
Year 5	Program feedback, Alumni and Supervisor.	Interview skills. Career entry job. Program feedback, Alumni and Supervisor.	Program feedback, Alumni and Supervisor.

Table 2: Cohort weekly operations seminar subject matter

During these operations seminars the students also have a chance to learn in detail how other world cultures address educational issues, social interactions, family responsibilities, etc. Through frank discussions with Cohort colleagues that they know personally (and trust because of that knowledge), many preconceptions about these other cultures can be examined and understood. This results not in agreement on what are the merits of the different cultural approaches, but rather that working with professionals from other cultures can easily lead to communications difficulties – even when both sides of a conversation are trying hard to cooperate. This is in a real sense a vaccination in cultural tolerance, a tolerance that will be highly needed if the student is working in a worldwide technical environment.

The students directly experience another industrial organization approach, the use of a matrix organization format within the program. Each student reports directly to the Cohort Leader, typically a faculty member with extensive industrial experience, as well as to a major professor for traditional academic research training and advising. The major advisor fills the role of the direct supervisor in industry for daily operational success (the completion of the research project), while the Cohort Leader fills the role of a special projects team leader. In this way, the students experience the difficulty of fulfilling different types of expectations from different supervisors, even though both the major advisor and the Cohort Leader are both working in tandem to help assure the student's academic success.

Organizational effectiveness textbooks emphasize the need for socialization in the creation of effective organizations, organizations that achieve extraordinary results with ordinary resources[9]. This socialization must be provided at sufficient frequency that the students in the program fill comfortable in attending or not, without fear of retribution for not attending a program function. There must also be various types of social functions, such that students with different interests will find some occasion to join the group outside of the academic environment.

In the University of Arkansas programs these socialization events fall into two general categories. The first are informal standup dinners and games evenings at a faculty member's home. These are most successful if there are a wide variety of games available for the students to join in a fluid environment. Games that have been popular to microEP students include inexpensive home air hockey tables, pinball, cards, darts, and ping-pong.

The program also takes advantage of the natural beauty of the Ozark Mountains to host moderate day hikes in the mountains, float trips on the Buffalo River, etc. It is anticipated that every location has opportunities for a group to experience some outside activity, although each university will have significantly different activities.

A third category of training has been utilized to a small degree, that being industrial style training retreats on specific subjects such as creativity training and supervision skills. These are typically off-campus, and require a time commitment from the participants of typically two days. These training events are usually open to both students and faculty, and are considered "took kit" seminars (education and practice in particular skill sets in simulations of where the skills would be needed). These training retreats are usually scheduled early in the summer.

Other methods may be used to enhance group identity. A common office area for new students to use until they identify a major professor and research lab is effective. Identification of all Cohort members in classes to entry Cohort students enhances the sense of mentorship from the earlier Cohort students. The creation of a study and computer access area available only to the program students at night has also proven beneficial.

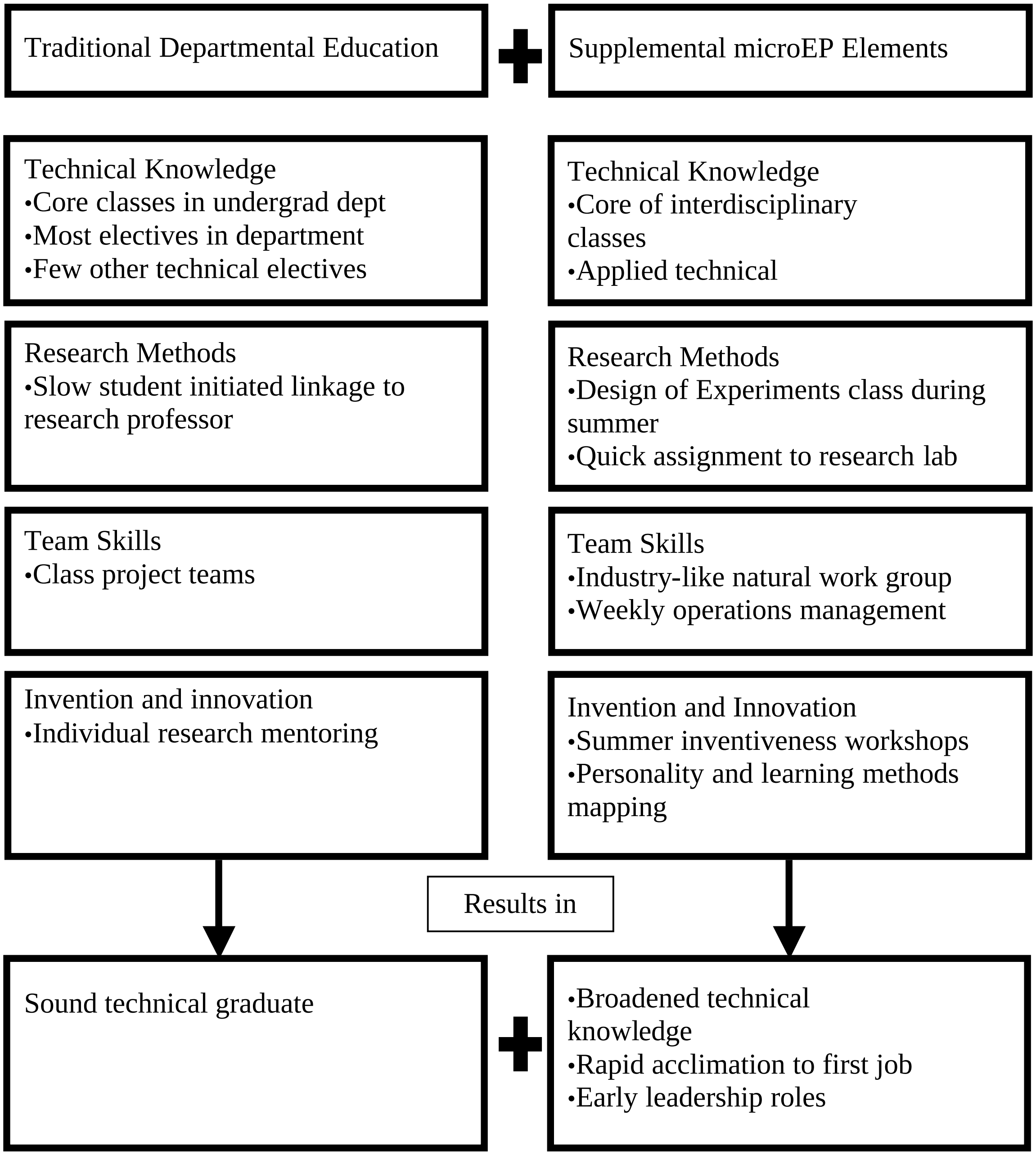

Figure 1: Interaction between Cohort and traditional educational elements

Figure 1 summarizes the interaction between the Cohort educational elements and the traditional graduate program educational elements as applied to the interdisciplinary microEP degree. It must be emphasized that the Cohort methodology does not remove or replace any traditional elements, elements that have resulted in many highly successful graduates of the program. It only brings additional education to the graduate environment in a way that supports the needs of its graduates in the modern technology workplace without degrading their technology education.

In summary, the Cohort methodology is nothing more than a focused effort to give the students in a graduate program the sense of community and trust that is necessary for them to form a natural work group. If this work group mentality is properly formed and nurtured, then each student's individual academic success will naturally improve. The techniques they learn and apply through the cohort activities gives them the interpersonal and organization skills valued in the technology workplace.

Impact of the Cohort methodology

One direct measure of the Cohort methodology is its acceptance under peer review by educators in the engineering and science communities. The Cohort methodology formed the educational core of the new MS Microelectronics-Photonics (microEP) degree[10] that was approved in July 1999 at the University of Arkansas. These MS microEP educational methods were then used as the core of a NSF IGERT proposal[11] to expand the interdisciplinary program to the PhD level. The microEP program was awarded an IGERT grant in the fall of 1999, and the program submitted its PhD academic program for approval early in that same fall semester. The PhD microEP was approved in July of 2000.

One test of transportability of this type of methodology is whether the concepts can be implemented in an existing graduate program. In 2000 the Physics Department[12] at the University of Arkansas submitted a proposal to the Department of Education FIPSE program[13] to implement the Cohort methodology into its Physics graduate programs. The funding for this dissemination experiment was approved in the fall of 2000, and the Physics Cohort 1 was formed from all entry Physics graduate students in the fall semester of 2001.

Another measure of success of this program is in the makeup of the student population. The microEP program has a total of 53 students that have entered the program, with 41 students currently on campus. Of the total enrolled students, seven are African-American (13%) and eleven are women (21%). Five of the seven African-American students are PhD track, and seven of the eleven women are PhD track. While it cannot be accurately determined why the percentages of underrepresented class students is higher in this program than in its associated traditional departments, anecdotal evidence does indicate that the group support inherent in a successful Cohort environment is attractive to students.

Student Perceptions of the Team Building Environment of the Cohort Methodology

The use of the Cohort methodology requires students to evaluate their preferences and abilities to develop, maintain, and communicate in an integrated team-working environment. In the last three years, data have been collected annually on students' perceptions of their team building and communication preferences and abilities. The purpose was to obtain information about the types of students that enroll in graduate science and engineering programs that do and do not use the cohort methodology, and investigate whether their team building preferences changed as they progressed through the program. The inventories were administered each year the week prior to the start of classes in the fall.

The Interpersonal Work Styles inventory is a modification of a survey instrument created by Murry[14] for assessing four components of team building and leadership skills. The instrument was created using Zenger's theory of change in the workplace environment. The four scales assess interpersonal work styles such as communication among groups, development of group work environments, motivating others to build and work in teams, and modeling the team building process.

The first scale (VALUING COMMUNICATION) is defined to measure individual communication preferences and styles. A high score in this category indicates that a person values frequent communication with others and perceives himself/herself to be a strong communicator, especially in groups. A low score indicates that the person prefers to communicate in smaller groups and the use of communication other than verbal face-to-face interaction.

The second scale (DEVELOPING COMMITMENT) is an assessment of the level of commitment one has to creating and maintaining an integrated group work environment. High scores in this category identify individuals who tend to foster collaboration, actively involve others, and empower others. Low scores identify individuals who tend to make decisions and complete activities on their own; these individuals are more likely to do the work themselves rather than involve others.

The third scale (INSPIRING ACCOMPLISHMENTS) is an assessment of the desire to inspire others to work as a team rather than on an individual basis. People on both ends of this scale may passionately believe they can make a difference; both groups may have ideal and unique images of a vision for the future. Yet, a high score in this category indicates that a person tries to create a shared vision and successfully get others to also see exciting future possibilities. A lower score in this category indicates that the person may aspire to a personal vision and goal with a strong emphasis on personal responsibility.

The fourth scale (MODELING TEAM BUILDING) is a measure of the degree to which one models a team building and team-working environment. A high scorer in this category may serve as a role model for others in identifying their perception of standard of excellence and modeling that behavior for others. A low scorer sees their behavior and conduct as private and personal. This person is concerned with his or her own behavior and values and less concerned with other people emulating them. There are 5 items for each of the valuing communication, inspiring accomplishments, and modeling team-building scales. There are 10 items on the developing commitment scale. The scores for each scale have been converted to a range of 1 to 5.

The Interpersonal Work Styles inventory was used to provide feedback on the four team building and leadership style preferences for the students enrolled in the multidisciplinary cohort graduate program as compared to students enrolled in more traditional graduate science and engineering programs. Data were obtained for thirty-two students in the microelectronic-photonics program that uses the cohort methodology and seventeen students from traditional science and engineering programs not using the cohort methodology. The first analysis is a comparison of initial team-working and leadership preferences for the two groups to determine if there are differences in team-working preferences of students selecting the multidisciplinary program that utilizes the cohort model and students enrolling in more traditional science and engineering programs. There were no significant differences in the valuing communication and developing commitment scales ($F(1,47) = 1.59$, $p = .21$ and $F(1,47) = .99$, $p=.32$, respectively). There were significant differences on the inspiring accomplishments and modeling team-building characteristics subscales ($F(1,47) = 4.66$, $p = .04$ and $F(1,47) = 4.03$, $p=.05$, respectively). The effect sizes for the two comparisons are moderate ($d = .64$ and $d = .61$, respectively, for Inspiring Accomplishments and Modeling Team Building). The students enrolling in the multidisciplinary cohort program had significantly higher scores (see Table 3) indicating a greater identification with the two leadership characteristics. These results provide insight into one of the reasons the microEP students may be attracted to a multidisciplinary program that incorporates a cohort methodology and their respective advisors that are the proponents of the multidisciplinary cohort model.

	Cohort Program			Traditional Program		
	N	M	SD	N	M	SD
Developing Commitment	32	4.14	0.46	17	3.99	0.51
Inspiring Accomplishments	32	4.29	0.56	17	3.91	0.65
Valuing Communication	32	3.94	0.66	17	3.69	0.65
Modeling Team Building	32	3.93	0.57	17	3.56	0.66

Table 3: Team-work and Leadership Style Preferences for Traditional and Multidisciplinary Cohort Model Graduate Programs in the Hard Sciences

A second analysis was to investigate potential changes in team-working preferences for microEP students as they progress through their academic program. Although data have been collected annually for three years, the number of students having three years of data is small ($n=3$). Therefore an analysis was conducted to investigate change from the first year of the program to the beginning of the second year of their program.

Eleven microEP students participated in the testing during their first two years in the program. The descriptive results are located in Table 4. There were no significant changes in team building and leadership preferences from year 1 to year 2, ($F(1,10) = 0.00$, $p = 1.00$, $F(1,10) = 3.10$, $p = .11$, $F(1,10) = 3.88$, $p = .08$, and $F(1,10) = 0.00$, $p = .95$, respectively, for the valuing communication, inspiring accomplishments, modeling team building, and developing commitment scales). Because of the small sample size that results from collecting data on students enrolled in an individual graduate program, the reporting of effect sizes are important as an indicator of potential effects to be investigated over time. The differences on the modeling team building scale from year 1 to year 2 were fairly large, with an effect size of 0.43. These preference values for the students decreased from 3.95 to 3.58 indicating that their preference for modeling team-working characteristics in the workplace environment had slightly declined. The effect size for the differences in inspiring accomplishments was also large ($d = 0.43$) for the

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microEP cohort. The mean value decreased from 4.33 (SD = 0.49) to 4.09 (SD = 0.35), also displaying a tendency to move from group accomplishments to more individual work.

		Year 1		Year 2	
	N	M	SD	M	SD
Developing Commitment	11	4.01	0.51	4.02	0.37
Inspiring Accomplishments	11	4.33	0.49	4.09	0.35
Valuing Communication	11	3.85	0.74	3.85	0.61
Modeling Team Building	11	3.95	0.56	3.58	0.75

Table 4: Teamwork and Leadership Style Preference Scores for the First Two Years of the Cohort Model Program.

Of particular interest is the long-term effect of participating in the multidisciplinary cohort program on team-working preferences. Unfortunately, only three students have been in the study for three annual testing sessions. The descriptive statistics are supplied for this group, but interpretations are only speculative in nature. For these three students, valuing communication and modeling team building remained virtually unchanged for the three years. Inspiring accomplishments is hard to interpret with a possible slight decline over the three year time period, while developing commitment had a small, but consistent increase.

		Year 1		Year 2		Year 3	
	N	M	SD	M	SD	M	SD
Developing Commitment	3	4.17	0.45	4.33	0.59	4.47	0.50
Inspiring Accomplishments	3	4.87	0.12	4.40	0.53	4.47	0.50
Valuing Communication	3	4.60	0.40	4.33	0.58	4.47	0.50
Modeling Team Building	3	4.00	1.00	4.07	1.01	3.93	0.92

Table 5: Potential Indicator of Teamwork and Leadership Style Preference Trends of Students in the Cohort Model Program for Three Years.

The size of the longitudinal samples limit interpretation, but the possible declining trend in the inspiring accomplishments and modeling team building characteristics areas from both the two year and three year analyses needs to be investigated further. Is it possible that even though students might see themselves as having leadership qualities prior to participation in graduate education, being required to work in a formal cohort model situation might change their opinion regarding themselves as a leader or diminish their preference toward acting in a leadership capacity? Two general possibilities are provided.

It is feasible that these students excelled in their undergraduate programs, which is typical of students who continue with graduate education, and therefore may have been more likely to be the leaders in their program areas. Although they may not have functioned as a leader of a specific group, they might have been identified by their peers as being a knowledgeable contact person for assistance. In this capacity, the students might serve informally as a leader for students in their programs. When these same students enroll in graduate school, they may find themselves as being representative of the “norm” rather than the student who excels. Thus, their perception could change from perceiving themselves as being a leader to being more of a general member of the team.

A second possibility is that working with others, including those of other genders and cultural backgrounds, in an integrated team environment may not always be an easy process. Learning to communicate and function efficiently within a group, in addition to trusting a group of strangers to be responsible for the group’s academic success as a whole can be a disconcerting task for students typically educated using an individual accountability and accomplishments model. As a result, after completing a year in the program, their perception of their effectiveness or their preference working in a team situation may decline due to difficulties in effectively developing and maintaining an effective team environment.

While the students may self-assess themselves as being less effective, the struggle to learn how to effectively coordinate efforts of a wide diversity of colleagues (diverse in gender, educational background, cultural background, ethnic background, etc.) is best learned in the academic environment rather than the early career environment. It is in the academic environment that new approaches to these personal interactions may be tried and, if found wanting, discarded with no permanent career negative implications. When instead this learning occurs in the early career work environment, poor interpersonal approaches will create negative impressions that can be career limiting.

Even with the small declines in the self-assessment scores, the ratings on the scales are still extremely high in the direction of preference toward the development of teams, modeling team building, inspiring accomplishments in an integrated team environment, and valuing communication among group members. Thus, even if a change in perception is occurring due to the change in the environment, the preferences of these students are still toward a team-working model versus an individual work model.

The team-working and leadership characteristics need to be investigated with larger samples of the quantitative data coupled with qualitative feedback from the students on their perceptions of their interaction and preferences with teams and their perceptions of their leadership roles. This is an ongoing process in the current data collection.

Post Graduation Survey Results

A second area of inquiry was to provide feedback on the perceptions of graduates of the program utilizing the cohort methodology and their immediate supervisors regarding what characteristics they believe are the most important in being effective in their jobs and their opinions of the microelectronics-photonics program in providing this type of training to their students. The graduates and their supervisors were surveyed six months after the graduate obtained their first professional career placement.

At completion of the second year of the microEP graduate program, twelve graduates exited the program and obtained jobs in their field. Of the twelve, contact information was obtained for ten graduates and nine supervisors. Of these, six graduates returned completed surveys and four of the supervisors completed surveys. Although the sample is not sufficiently large for generalizations, the results are reported to provide initial insight on issues that are important to graduates and their supervisors regarding graduate level training in microelectronics-photonics.

The graduates and their supervisors were asked to evaluate a set of characteristics on their importance in completing the job the graduate currently holds and the degree to which the graduate displays each of the characteristics listed. There are four initial questions regarding characteristics of academic training and one personal work style question that were used for describing general characteristics of academic training.

1. Broad range of expertise
2. Specialization in one program area
3. Knowledge level in area of expertise
4. Internship during graduate program
5. Ability to work independently

Additionally, four scales that address workplace related characteristics were utilized: communication in the workplace, problem solving abilities, team-working characteristics, and business skills. The communications scale consists of two items addressing effectiveness in communicating with co-workers and communicating with people of different cultures. The problem solving scale is a set of five items measuring the ability to problem solve independently, in groups, creatively, and expediently. There are two team-working items that measure perceived ability to work in a team environment and demonstration of team leadership characteristics. The business skills scale is a set of three questions addressing project management, technical writing, and oral presentation skills. The scales and the independent questions are scored on a scale of 1 to 5.

Comparisons between the alumni and the supervisors were conducted to determine if there were significant differences in the perceived level of importance of the types of work characteristics described by the four scales: communication, problem solving, team-working, and business skills. Again, caution is used with the results based upon the small sample sizes and the small number of questions. This information will be combined with future data obtained for more stable interpretations.

There were no significant differences between graduates and supervisors' perceived level of importance of communication, problem solving, team working, and business skills. Both groups identified each of these areas as being very important with problem solving and communications being listed as the most important for both groups ($\underline{M}$ = 3.87 and $\underline{M}$ = 3.83 for the graduates and

M = 3.90 and M = 4.00 for the supervisors, respectively). Table 6 provides the descriptives on the four subscales for the two groups, in addition to the means on the individual academic training items.

	Graduates			Supervisors		
	n	M	SD	n	M	SD
Communication	6	4.58	0.49	4	4.63	0.48
Problem Solving	6	4.33	0.50	4	4.70	0.38
Team-working	6	4.33	0.41	4	4.38	0.48
Business Skills	6	4.28	0.57	4	4.08	0.83
Broad Range of Expertise	6	3.67	1.21	4	3.75	0.96
Specialization in One Program Area	6	2.83	1.60	4	3.50	1.29
Knowledge Level in Area of Expertise	6	3.67	0.82	4	4.50	1.00
Internship in Graduate Program	6	3.67	1.51	4	4.00	1.15

Table 6: Importance of and Assessments on Academic Training Characteristics of the Microelectronics-Photonics Graduate Program

Interestingly the graduates, as a whole, rated the soft skills higher in level of importance in completing their job than the academic characteristics. Their perception of the most important job-related skill is the ability to communicate effectively, with the remaining skills of problem solving, working in a team environment, and completing business related tasks efficiently considered very important. Comparatively, the supervisors rated problem solving and ability to communicate efficiently as the two most important job-related skills. Different from the graduates, they consider knowledge level in one's area of expertise to be equally important. (The difference in the values for the *knowledge level in area of expertise* question should possibly be discussed with caution, because it may be assumed that any person obtaining one of the positions the graduates hold would have a minimal level of expertise. Follow up discussions with the graduates may provide the further information to interpret this data.)

The characteristic that both the supervisors and the graduates considered least important of those addressed was the *specialization in one program area*. To interpret the response to this question, it needs to be analyzed within the context of the remaining academic training types of questions. Supervisors appear to be indicating that they want an employee that has a detailed knowledge level in their area of expertise. Whether that employee has one area of specialization or a broad range of expertise may not be as great of an issue. It would probably be obvious that a supervisor would prefer for someone to be an expert in many areas rather than just one, but actually being an expert in a number of areas is not mandatory. What appears to be more important is that the employee IS an expert in the area for which they were hired.

The results of the supervisors' ratings on these three questions, as a whole, are probably not surprising. What may be interesting is the relationship of the graduates' responses to these three questions. Unlike the supervisors, the graduates foresee the broad range of expertise as important as the knowledge level in their area of specialization. This may not be surprising given the context of the microelectronics-photonics graduate program that is designed to be a multidisciplinary graduate degree that trains students in a wider range of content areas than more traditional graduate science and engineering programs. Students who enroll in these programs may be more likely to align with the multidisciplinary philosophy.

Thus, the next step was to investigate supervisors' and graduates' perceptions of the effectiveness of the graduates' training in these areas. Again, note that fewer supervisors ($\underline{n}$ = 4) responded than graduates ($\underline{n}$ = 6), so the comparisons are not of the same graduate students (a couple are missing). The group values are used, however, as an initial indicator for comparison purposes.

The values in Table 7 represent the groups' perceptions of the graduates' abilities as compared with their peers at the same companies. The values of the scores again range from 1 to 5 with a value of 1 indicating that the perception of the graduates' skills are extremely poor, a value of 3 indicates that the graduates' skills are average, and a value of 5 indicates that the graduates' skills are perceived to greatly exceed their peers.

The graduates rate themselves higher on the soft skills than on the academic types of training. They see themselves as most effective in the areas of communication and problem solving, with just slightly lower ratings in the areas of team-working and business skills. The values for the four scales indicate that the graduates consider their skills to be slightly above average in these areas. In the areas of academic training, they see themselves as average in terms of knowledge level in area of expertise, broad range of expertise, and slightly below average in the specialization in one program area. Their below average ratings on the internship question may indicate that they either did not participate in an internship experience or that their internship experience did not compare to some of their peers' experiences.

Comparatively, the supervisors rated the microelectronics-photonics educational training in the areas listed higher than the graduates of traditional programs on all areas except one. The supervisors also rated communication skills, problem solving skills, and ability to work in a team environment above average. They rated the graduates' business skills as only slightly above average. Comparatively, the supervisors rated the graduates' knowledge level, range of expertise, and specialization in one field as substantially higher than the graduates with all measures being above average.

The supervisors appear to perceive the microelectronics-photonics academic and soft skills training to be above average in terms of the graduates they are producing. Interestingly, the supervisors' perception of the internships indicate that they believe the graduates' internship experiences (or possibly lack of experience) to be approximately average to their other employees in similar jobs. As the internship experiences increase in volume for the microelectronics-photonics graduates, it is anticipated that this measure may change substantially.

	Graduates' Ratings			Supervisors' Ratings		
	n	M	SD	n	M	SD
Communication	6	3.83	1.08	4	4.00	0.82
Problem Solving	6	3.87	0.62	4	3.90	0.84
Team-working	6	3.67	0.41	4	3.88	0.75
Business Skills	6	3.67	0.56	4	3.33	1.19
Broad Range of Expertise	6	3.33	0.52	4	4.00	1.15
Specialization in One Program Area	6	2.67	0.82	4	3.50	0.58
Knowledge Level in Area of Expertise	6	3.33	0.52	4	4.25	0.50
Internship in Graduate Program	6	1.83	1.17	4	3.00	0.82

Table 7: Ratings of Microelectronics-Photonics Graduates as Compared to Their Peers in Industry.

Overall, the graduates' and supervisors' perceptions of the importance of the characteristics assessed seem to be quite similar. Both perceive problem solving and communication to be very important, in addition to team working, business skills, and knowledge level in area of expertise (particularly for supervisors). The microEP management team was gratified to see that both supervisors and graduates perceive the training provided in the microelectronics-photonics program (utilizing the cohort training methodology) as being more effective than the average program in facilitating students' abilities in being effective communicators, problem solvers, and workers in a team environment.

Although the graduates perceive their academic training in terms of knowledge level in an area of expertise and range of expertise as being approximately average, supervisors perceive their training to be substantially above average. This information provides positive feedback to the faculty in the program that their perceptions of the importance of the academically related skills are mirrored in the business world and their business contemporaries believe that the procedures they are currently using in facilitating their students abilities in these areas appear to be effective. An area that the faculty may want to further assess is the training in business related skills such as project management, oral presentations, and technical writing. Supervisors and graduates consider this area to be important and the supervisors' ratings of graduates in these areas indicate that they perceive their training to be about average.

While there is not perfect alignment between the assessments of the microEP alumni and their supervisors, it is clear that the Cohort methodology is focused on training its graduate students in the elements that are highly valued in the industrial workplace by both its graduates and their supervisors.

Conclusions

The experimental approach to graduate education based in the Cohort methodology is proving to be effective at creating a graduate educational environment that is valued by students, both on campus and in their early career workplace, and by their employers. The Cohort methodology has received national recognition through its success in acquiring external funding support of its educational development activities.

The two applications of the Cohort methodology in graduate programs at the University of Arkansas will continue, and will continue to be assessed and reported in appropriate forums. The microEP graduate program would encourage inquiries from other programs interested in implementing this approach to graduate education, as additional implementations would provide valuable comparative data to our educational experiment.

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