

AC 2007-335: ENABLING THE U.S. ENGINEERING WORK FORCE FOR TECHNOLOGICAL INNOVATION: THE ROLE OF INTERACTIVE LEARNING AMONG WORKING PROFESSIONALS

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Enabling the U.S. Engineering Workforce for Technological Innovation: The Value of Cohort Learning

Abstract

This is the second of four invited papers prepared for a special panel session of the National Collaborative Task Force on Engineering Graduate Education Reform to enable a strong U.S. engineering workforce for competitiveness and national security. There has been a significant increase in educational opportunities for the working professional, as employees and their companies have recognized the criticality of continuous learning to sustaining economic growth and prosperity in a highly competitive global economy. To meet the needs of a demanding and highly diverse constituency, educators have experimented with a wide range of program formats, modalities, and pedagogy in an effort to insure a high quality learning experience in the face of significant career obligations. This paper focuses on the benefits of employing a cohort-based learning model for practicing engineers and all professionals who wish to develop their technical and innovative skills. It will highlight the experiences of two graduate programs that are structured around a cohort model but have adopted different delivery strategies, to provide an illustration of how institutions can tailor the cohort model to meet the needs of its key stakeholders.

Introduction

Unlike undergraduate education which emphasizes knowledge transfer from teacher to student in preparation for entry into a profession, graduate education for experienced professionals must leverage students as valuable sources of knowledge and wisdom if these programs are to realize their full potential. The mere presence of experienced professionals in the classroom is no guarantee of a high quality interactive learning environment; instead, strategies and practices must be put in place to create an environment that fosters collaborative knowledge sharing. The use of cohort groups is one such strategy.

A “cohort” has been defined as a group of students who enroll at the same time and take courses at the same time for the duration of their educational tenure [1]. Beyond the structural implications of this definition, Drago-Severson [2] refers to a cohort as a “tight-knit, reliable, common-purpose group.” A cohort can also be thought of as a simple form of a “learning community,” a programmatic effort to create an academic and social community for students and instructors [3,4]. Learning communities and, by extension, cohorts aspire to provide an interactive and interdisciplinary environment to help students think differently and in more complex ways by providing exposure to diverse viewpoints and experiences [5]. In short, learning communities and cohorts are intended to promote collaborative learning, critical reflection, and knowledge creation for a higher quality educational experience.

Many benefits have been ascribed to the use of cohort groups (or learning communities) in academia. High levels of collaborative knowledge sharing critical to innovation have been shown to correlate strongly with the existence of social networks, which is a common attribute of cohort groups [6,7]. Students in learning communities were found to generate more ideas and to think in

new ways [3]. Given the key role that engineers play in technology and product innovation, the value of cohort-based learning to graduate engineering education (and to the mission of the National Collaborative) is significant. Cohorts have been shown to foster both individual and group development by creating an environment that supports mutual respect, risk taking, critical reflection, and shared understanding, while promoting diverse perspectives and understanding of alternative disciplines [1,7,8]. Cohort members tend to have very positive feelings about their experiences and place a high value on the opportunity to be part of a collaborative group [9]. Alexander [3] reports increased self-confidence and a stronger foundation for individual learning. Students and faculty benefit from the coordination of material across courses and from the exchange of information about student performance [5]. Felder [10] showed that cooperative learning is more effective than either individual or competitive learning in the achievement of desired learning outcomes. Finally, networking and benchmarking (against practices within other industries, companies, and organizations) is markedly facilitated by cohort groups.

While cohorts have been found to be overwhelmingly beneficial to adult learning, certain factors may limit the effectiveness of cohorts. These factors include “passive or dominant group members, changes in group membership, lack of commitment to the cohort, failure to meet group expectations, members viewing the instructor as the ultimate authority, and independent learning styles that cannot adapt to group environments” [1]. Faculty and program administrators must be cognizant of these characteristics if the value associated with the cohort model is to be maximized.

A two-year study of over 40 Master’s degree programs and 700 interviewees reported in [11] found several key attributes associated with high quality Master’s experiences that are common to cohort-based programs:

- A culture with “unity of purpose” – collective ownership and a unified sense of value and commitment; one that builds effective relationships.
- A supportive learning environment: ethic of cooperative support between participants, faculty, and administration; strengthened by social gatherings and informal discussions outside the classroom; a trusting environment for students to challenge and consider alternative perspectives, and engage in new learning activities.
- Immersion-type experiences for students (and faculty) to work closely and build camaraderie and provide a forum to develop cohort groups, nurtured by an environment of continual interaction (classroom, lunch discussions, intensive team-based projects, external organized activities such as business trips).
- Committed students with diverse backgrounds and experiences. Listening to and learning from peers’ varied professional and life experiences was found to be one of the most valued aspects of successful Master’s programs.

All of these attributes are either fundamental components of cohort-based educational experiences or are dramatically strengthened by the cohort model.

The remainder of this paper will describe two cohort-based graduate programs, both of which aspire to help experienced engineers and technical experts transition to leadership roles in product and technology innovation. While these programs have similar goals, they have adopted

different delivery strategies, which provide an illustration of how institutions can tailor the cohort model to meet the needs of its key stakeholders.

Program Descriptions

Purdue's Master of Science Degree in Technology (WMP)

In 1998, the College of Technology at Purdue University introduced a 22-month graduate program targeted at working professionals in technology roles. The mission of this Weekend Master's Degree Program is to develop innovators and leaders in technology. The program was designed to allow students with two or more years of professional experience to continue their education while working full-time. This is accomplished by combining distance education with a series of three on-campus sessions offered on weekends each semester. The on-campus weekends include both traditional lectures and student presentations focused on application of concepts to industry. Distance education technology includes WEBCT-Vista and video chat sessions using web-cams provided to the students.

The curriculum consists of 30 credit hours of coursework which follows a fixed plan of study. In addition, there are three one-credit hour modules which covers a directed (applied) project. Students are encouraged to select an area for improvement in their career area. The target size of a cohort is 25 students.

In 2005, a program was initiated in cooperation with Rolls-Royce Corporation that was modeled after the Weekend Program. It also follows a fixed plan of study modified to meet the needs of Rolls-Royce and is delivered at the UAW/Rolls-Royce Training Center by Purdue University Faculty on two evenings each week.

RIT's Master of Science Degree in Product Development (MPD)

RIT's program began in 1999 through a partnership with MIT and support from the National Science Foundation. RIT, the University of Detroit Mercy, and the Naval Postgraduate School joined MIT and its Center for Innovation in Product Development to disseminate a new graduate program focused on product development leadership. By integrating courses in management and engineering (through partnerships between the engineering and business schools at each university), the MPD program's intent is to develop technically oriented leaders with a systems perspective and knowledge base of the total life-cycle product development system. Targeted students include engineers, scientists, technical managers, and other experienced professionals moving to mid- and senior level positions associated with product and services innovation. Students are selected and fully sponsored by their organizations. RIT chose an executive format with classes held all-day on Fridays for two full years.

The 60 credit hour program consists of 13 business and engineering courses, including three electives, plus a two-quarter Capstone project. Specific electives are offered on Fridays consistent with the executive format, but students may select other electives offered at other times during the week or via distance delivery. In addition to coursework, students take two business trips, one in the US and another overseas.

Experiences with the Cohort Model

The Purdue and RIT programs share many attributes of effective cohort-based programs. Both programs are characterized by lock-step curricula that offer abundant opportunities for relationship development inside and outside of the classroom. Significant team-based project work is embedded in both programs, adding a valuable dimension to the cohort experience by putting students in small structured working groups. In addition to emulating the work environment within most companies, team-based activities have been shown to positively impact individual and group learning and academic achievement [12, 13]. Students in both programs are primarily engineers and technologists focused on developing the leadership skills needed to drive technological innovation. Experience has shown this constituency to be highly focused and dedicated, with a strong sense of ownership. Diversity in experience, company, and industry, is also a strong feature of the two programs.

Below are additional observations from Purdue and RIT that support benefits of the cohort model:

- Highly interactive classes. Students and teachers report significant discussion and debate for a larger portion of class time than found in other programs. Students are particularly impatient with instructors who utilize significant class time for canned presentations, and program administrators are alerted to student concerns on a real-time basis. Students appreciate faculty who have industry experience in addition to their academic background. Faculty benefit immensely by being directly exposed to the latest practices and strategies from industry, and they gain a much better understanding of the needs of sponsoring companies. This fosters currency in the traditional courses taught on campus.
- Professional networking and career support. Alumni report the development of very productive long term professional relationships. Several examples can be given of alumni finding jobs for other displaced alumni, a byproduct of the tight relationships formed through cohorts. Students place high value on the opportunity to study with technically oriented peers from a wide range of businesses, industries, and job responsibilities. Documented rationale include: benchmarking and experience sharing, commiseration with similar business frustrations, quality of interactions, and contribution to solving real-world problems.
- High return on investment for sponsoring firms. The significant length of time that students in a cohort program work together increases the likelihood of tackling challenging problems, generating creative ideas, and making significant contributions. Direct financial benefits from capstone projects have been reported as high as \$2.2M, largely because of the sophistication of the students and the relatively long duration of projects within the cohort. A number of directed capstone projects have been derived from prior projects through interactions between students, alumni, sponsoring managers, and faculty, something that is seldom seen in non-cohort programs. In non-cohort programs faculty represent the primary source of project ideas and project continuity, whereas students and alumni have been found to be a more significant contributor in these cohort programs.
- Strong commitment, ownership, and satisfaction. Student satisfaction with the MPD and Technology programs is very high, as indicated by exit surveys, course evaluations, and

testimonials. Students actively provide input as individuals and as groups to program administrators during courses, rather than waiting until evaluations are presented at the end of each quarter or semester. Alumni have made significant contributions of time to helping students and the program through direct promotion, lectures, advisory support, and project ideas. Anecdotal evidence suggests that this level of alumni engagement is extraordinarily high compared to other non-cohort based graduate programs.

- Supportive learning environment and social networking. Students overwhelmingly support the cohort model, as indicated by program assessments and exit interviews. In fact, not a single graduate has indicated regret or has suggested the use of an alternative model. At the start of each new cohort, conflicts inevitably emerge, but in virtually all cases the cohort group has resolved issues without external interference. Social support systems have become vital to these programs, offering not only academic and professional support but also personal support. Frequent and long term interactions are supported by group lunches, dinners, social events, team projects, and business trips (RIT), many paid for by program administration. The relatively small cost associated with these “perks” pays significant dividends through elevated customer satisfaction. Increased self confidence has been reported not only by students and alumni but by sponsoring managers, and data regarding promotions to positions of more responsibility supports the contention of enhanced self confidence.

The primary difference between the Purdue and RIT programs is the relative utilization of distance learning technology and the associated implications for face-to-face interactions between students. Purdue holds occasional weekend classes to augment distance learning while RIT’s program is entirely classroom based with all-day sessions every Friday. (An exception to this is the Purdue/Rolls-Royce Master's Program which meets two evenings each week). Purdue has taken great lengths to insure that students work together as much as possible given the fact that they are not physically together on a weekly basis. RIT’s students are together in the classroom, for group lunches, and for other casual hallway discussions, in addition to spontaneous gatherings at the end of the day at RIT or off-campus for dinners and “happy hours.”

Therefore, RIT has less of a challenge fostering continuous interactions between students, while Purdue takes explicit steps to do so. State-of-the-art technology has enhanced the productivity and “connectedness” associated with the distance-learning, and students in the Purdue program have reported high levels of satisfaction with the combination of distance delivery and face-to-face interaction. Non-value-added travel time is reduced and students have the flexibility to schedule the distance-delivery portion of their assignments to minimize the negative impact to family and work commitments.

Other differences include:

- Formal business trips integrated into the RIT program have proven to be invaluable vehicles for relationship building, internal and external networking, and for benchmarking cultural practices and business process. Oftentimes, spouses or partners join the students on these trips, further strengthening social networks. On occasion business trips are taken with students from other schools offering the MPD program, further expanding the “cohort.”

- The intra-university collaboration that has been built-in to the RIT program through its partnerships with other founding institutions provides a ready-made channel for sharing course material, corporate best practices, and capstone and thesis topics, not to mention interpersonal interactions that emerge between faculty and students. Since the demographics of the students and cohorts enrolled in each program are very similar, a natural synergy is in place to facilitate networking. In several cases, companies have sent students to both the RIT and MIT programs, enabling these students to directly share what they have learned and apply them to their organizational challenges.

Discussion

This paper has outlined a number of benefits associated with the cohort-based learning model in graduate education, with an emphasis on two specific programs targeting practicing engineers and technical specialists. While the cohort model is unquestionably of value to a wide range of academic programs, its utilization is of particular relevance and valuable to leadership programs. Leadership is a “full-contact sport” that is all about interpersonal relationships: managing conflict, issue selling, maximizing contributions of individuals and teams, etc.

Attributes of the cohort model are fully consistent with and complementary to the goals of leadership education, which strongly suggests the use of a cohort model for developers of leadership programs. Of particular relevance to the National Collaborative Task Force on Engineering Graduate Education Reform is the relationship between innovativeness and collaborative knowledge sharing, which has been shown to be augmented by the use of cohort groups.

The Task Force mission to reshape engineering education to improve the competitiveness of U.S. industry through technological innovation, will be positively impacted by the use of cohort-based educational models. At Purdue and RIT, the impact of cohort-based education has been universally positive, with significant benefits to all stakeholders: students, alumni, sponsors, faculty, and administration.

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