Mining/Mineral Engineering Education on the Job: A New Concept

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Abstract

The aging mining workforce in industry, government agencies, as well as, academia and the uncertainty of being able to replace them due to declining number of mining engineering students and programs in the U.S and overseas certainly calls for a more attractive mining engineering education program. This paper presents a new concept for mining/mineral engineering education, which may be more attractive to the prospective students, industry, as well as, academia due to the understandable advantages to all three parties. According to the new concept, the students, after spending the first two years in a college/university to complete the foundation/basic courses, will be centered in the industry, where minerals engineering coursework will be offered in structured or self-paced learning formats through the internet. The students will start working up to 50% of the time with the industry after completing the initial two years of degree courses in a college/university and simultaneously take the additional required courses for the degree through distance learning systems established in the modern universities. The concept has several advantages for students, industries and academia, including: 1) Earning of a decent salary by the students starting from the junior years; 2) Industry's early access to employees to develop suitable engineering skills; 3) More effective learning for students through observing actual operations while learning the theory behind them from course-work; 4) Industry input for continuous improvement of academic curriculum; 5) Increase in the flow of real-life industry problems to be solved by university faculties through research; 6) Increased participation of undergraduate students in university research; and 7) An improved relationship between the academia and industries through the students enrolled in the program for mutual benefit and the betterment of the society at large.

INTRODUCTION

The number of academic programs offering degree in minerals/mining engineering has been consistently decreasing world-wide due to lack of critical student mass and high cost of education. In the U.S. alone, the number of Mining/Mineral Engineering programs has reduced to fewer than 15 graduating less than 90 students in the year 2004 from 22 programs in 1980 graduating 570 students and 20 programs in 1990 graduating 148 engineers (Kral, 2006). Clearly, the mining engineering related programs have been increasingly less attractive to the student population over the years. Some of the reasons behind the declining enrolment, as stated by Kral (2006), are the negative image of the mining/mining industry and poor financial condition of past. Often, the university administration looks at mining/minerals program as non-critical, and during budget crisis, decide to merge these programs with other large programs or in some cases eliminate it completely. That has left with only 13 mining/minerals engineering programs currently in existence in the U.S. universities.

Although consolidation in the industry and availability of software for engineering problem-solving has permitted the industry to work with fewer engineers over the past several years, the ever expanding mining industry is currently experiencing significant shortage of trained mining/minerals engineers. A recent study (Kral, 2006) reports that as much as 50% of current mining professionals in the U.S., both in industries and academia, are expected to retire within next five to ten years. Clearly, the low enrolment of students in the current mining engineering and related programs is expected to create a significant dearth of suitable professionals to fill this need.

In this paper, the authors present a new concept for mining/minerals engineering education utilizing the high technology distant learning programs in co-operation with the industry. The authors believe that the proposed system would make the mining engineering education more attractive and thus, significantly improve student enrolment in mining engineering programs. The following sections include a brief description of the current mining engineering education practice, as well as, the proposed education practice and the associated advantages and disadvantages/concerns.

DESCRIPTION OF CURRENT PRACTICE

An overview of the typical current practice of mining/mineral engineering education is shown in Figure 1. Students enter a senior academic institution (university) after high school or after obtaining an associate degree in science from a community college. During the first two years, a

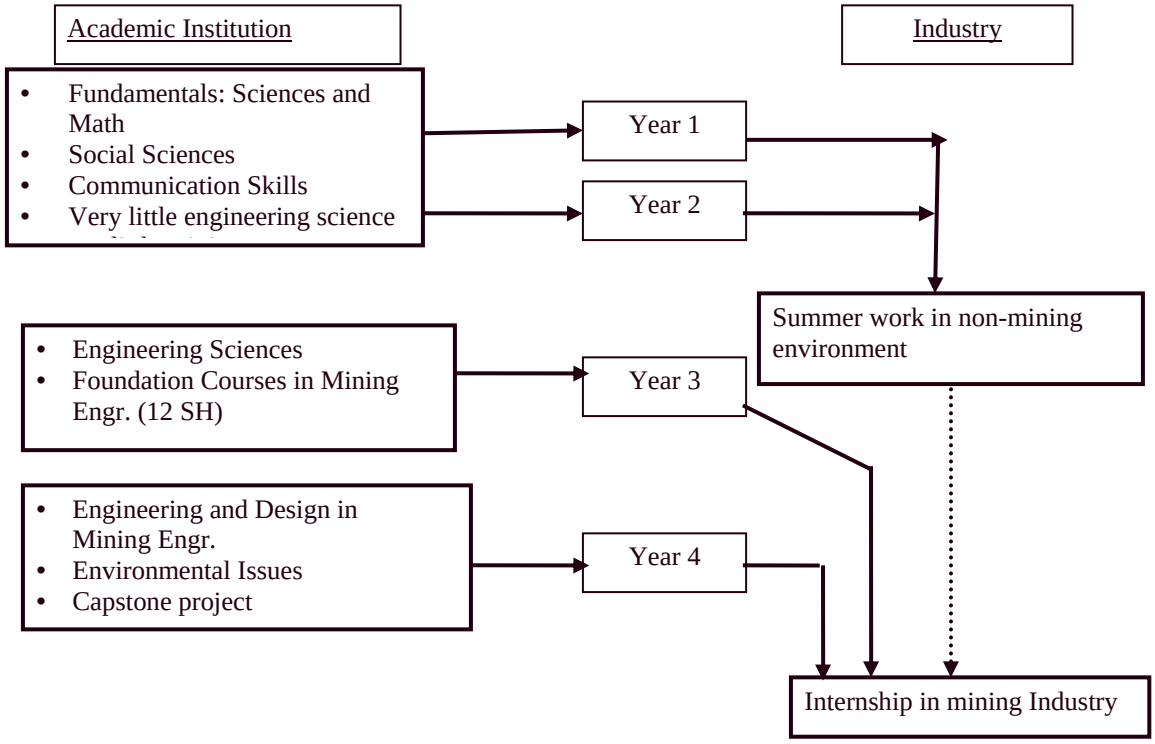

Figure 1: Typical current practice for educating mining/mineral engineers (Chugh et al., 2006; Chugh and Harpalani, 2003)

student focuses on fundamentals of science and mathematics, with little or no mining related coursework or field internships. Engineering Science and mining related coursework are emphasized during the junior and senior years (the final two years). The students also work as summer interns in mining/mineral industry during the summer time in these years. The outcomes of this practice for graduates, industry, and academia are as follows:

Graduates

- An average student requires about 4.8 years to graduate- typical of engineering graduates.
- Only up to 30% of the coursework is directly related to mining/mineral industry.
- A typical student spends no more than 6-months as an intern in mining industry. Of this, no more than 25% (less than 1.5 month) is spent in the face area. Most students work as helpers in surveying, construction, belt cleaners, quality control, and special projects earning $ 10-15/hour.
- Most graduates learn about mining operations after graduation on-the-job.
- There is limited ability to take electives and to specialize in different mining industries (coal, aggregate, etc.) since curricula are very structured to meet the accreditation (ABET) requirements and limited faculty at academic units.
- Students generally have to work part-time (50%) at low minimum wage to earn money to pay for school during the school years.

Industry and Academic Departments

- Industry spends considerable time recruiting summer interns and full-time graduates. In addition, they maintain on-the-job training programs for graduates to nurture them to fit within their organization.
- Industry gives out a lot of money as scholarship funds to various institutions.
- Academic departments spend a large amount of time in student recruitment, retention, and working with industry for scholarships. Typically, at least 10% of faculty time and 30% of the department chair's time is spent on these activities. That is equivalent to at least one full- faculty time allocation in a typical 8-faculty department in the United States.
- Since industry is understaffed, academic departments have to work hard to seek industry input on curriculum and performance of summer interns and graduates.
- Academic faculties don't often get to work on real-life industry problem. The lack of industry experience comes on their way to better prepare students for the industry.

Most of the aforementioned disadvantages for different constituencies could be overcome through an academic program that centers the students in industry during the last two years rather than at an academic institution. An example of such programs in the past is the well known cooperative programs (COOP) in mining education that involved students working for one semester in industry and then returning to school for coursework for the next semester. The quality of graduates and industry satisfaction from such cooperative programs was high. The academic units were able to run such programs efficiently and economically because student enrollments were high. In these programs, the students had to return to school for coursework because distance learning was not available. Therefore, the students ended up spending typically more than 6 years in a COOP before completing the degree requirements.

As discussed earlier, the current environment for mining education is very different. On the one hand, student enrollments and number of graduates per year, in most mining departments in the US are small, 30-50 and 4-6, respectively. The academic units are not well funded and have inadequate number of well trained faculty to run the programs. On the other hand, mining and related industries with a booming economy will be demanding well trained graduates over the next decade to account for aging and retiring workforce and future expansion needs. Therefore, there is a need to develop academic programs that allows industry to utilize workforce-in-training immediately, are more attractive to prospective students and are economic to run by the university with limited well–trained faculty. The authors have developed such a program concept utilizing both the age-old concept of COOP and digital age concepts of distance learning. The authors refer it cooperative program of the 21st century or, in short, COOP[21].

PROPOSED EDUCATION CONCEPT FOR MINING ENGINEERS (COOP[21])

The overall concept of the proposed plan is shown in Figure 2. Some of the salient program characteristics are summarized below. Additional details may be gathered by the academic units offering such programs as the program evolves.

- A student completes an Associate Degree in Science from a community college, or two years of Engineering from a 4-year college/university. The Associate Degree holders interested in a BS Degree starts contacting 4-year academic departments.
- The 4-year academic department interfaces with different industries (mining industry, utility, equipment manufacturer, government agency, etc.) to coordinate student placement to work half-time (50%) while pursuing a BS Degree. The 4- year academic units may interface with a near-by community college for contacts with students in that area, provide one-to-one education, provide laboratory training, etc. to prepare them for the industry.

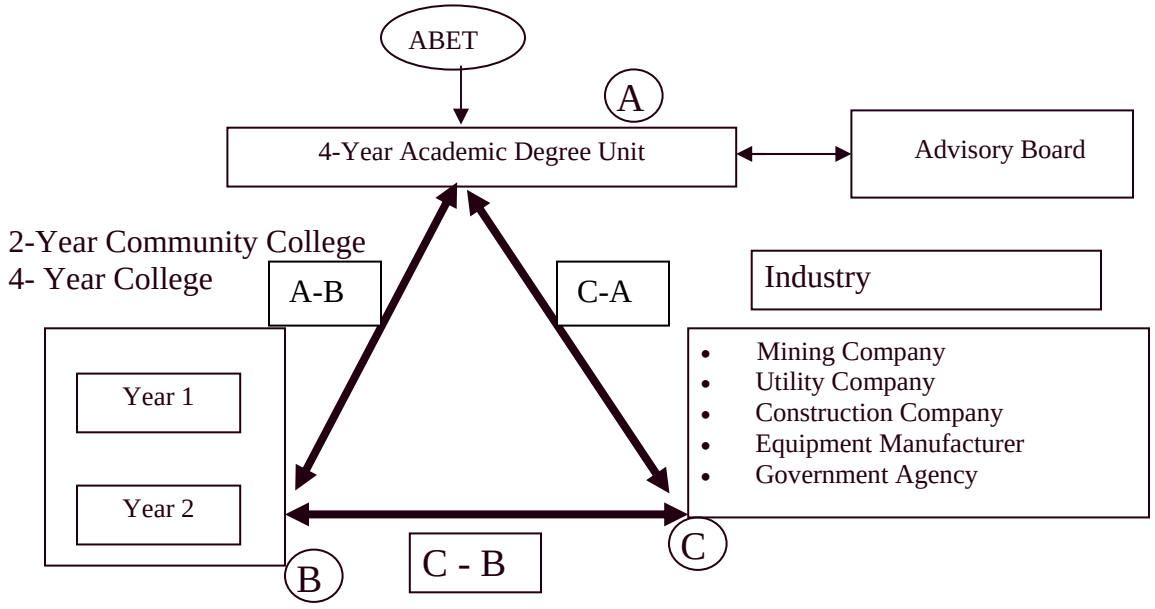

Figure 2. An Overview of the proposed COOP[21] Education Concept (Chugh et al., 2006; Chugh and Harpalani, 2003)

- Industries hire these students as Engineer-Trainee (ET) at 50% of the full-salary to provide opportunity to different individuals and find the best match for their organization.
- Faculty develops mining related courses that are taught on-campus and/or off-site (depending upon enrollment) using digital age concepts (distance learning, web site, problem-based learning, etc). Laboratory training is provided through on-campus, virtual, or in-mine laboratories or a combination thereof as appropriate. A capstone project is developed in concert with academic faculty and industry supervisors of the students. All Accreditation Board for Engineering and Technology (ABET) requirements of the EC2000 are met.
- Electives and Special Investigation courses for the ETs are developed jointly by the academic faculty and industry supervisors to address real-life problem faced in the industries.
- Students may choose to learn course materials through any or all of the concepts discussed above depending upon their work schedule and flexible study time allocated by the industries. Topics learned through coursework are supplemented through student experience in a field setting. Industries may give some flexibility to students to observe different mining-related operations beyond their work assignments.
- Students are evaluated by instructors and industry supervisors.
- Students interface with academic faculty through web-board, e-mail, or telephone calls during office hours maintained by instructors or in person.
- The ETs are upgraded to Full-time Engineers after the completion of their BS Degree under the guidance of both academic faculties and industry supervisors.

ADVANTAGES OF THE COOP[21] CONCEPT

The authors believe that the proposed concept has advantages for all involve parties, i.e., students, industry and academic institutions. Specific advantages for the students are as follows:

- Students earn a decent salary while going to school. This should make the mining/mineral engineering program more attractive for prospective students.
- Flexibility of curriculum allows students to specialize to a degree in different types of mining through placement in different industries – aggregate, coal, non-coal operations. The students also have some choice of electives and special investigation courses of interest.
- Students don't discontinue their education during summer semester or any other semester and hence complete their degree requirement sooner.
- Students learn state-of-art computer software in use at the industrial site and academia.
- Students learn from academic instructors and industry professionals simultaneously for a more effective education and quicker professional growth.
- Full-time career choices can be made by the students with knowledge of the actual work environment and job expectations.
- On-the-job training starts early. Therefore, potential for rapid professional growth is high.
- Students learn from instructional course materials with immediate application and/or supplemental education and training in real-life settings.
- Increased participation of undergraduate students in academic research.
- Students serve as a key link between academic department and industry.

From the industry's perspective, the following advantages are expected:

- Students will make a career choice after fully knowing the work culture and remuneration to expect in the industry; therefore, long-term potential for employee retention is very high.
- Half-time salary during the engineering education in junior and senior years should provide a strong recruitment tool for industries to attract good quality students to pursue degrees in mining/mineral engineering disciplines.
- Should some ETs choose not to pursue engineering degrees, they may still have potential to be employed in maintenance, assistants to superintendents, surveyors, or in charge of special projects.
- Industry will have immediate access to educated professionals on the move with long-term employment potential within a company.
- Industry gets the most out of the academic institutions. Real-life problems and projects of the industry can be solved through Electives and Special Investigation courses designed for the ETs.
- Industry gets an opportunity to provide continuous input on curriculum and course content to the academic-faculty.

The academic departments will have the following advantages:

- Increased student enrolment in the mining/mineral engineering programs.
- With limited faculty, units can effectively prepare professionals for different mining industries – coal, aggregate, non-coal, etc.
- Continuous feedback from ETs and industry professionals on course and curriculum.
- No efforts are expended on seeking scholarship support, recruitment, and placement in summer and full-time jobs. These efforts can be diverted to research and continuing education activities.
- Faculty learns more about the industrial practices, which would help them immensely in training the future engineers. Faculty also benefits from strong relationships with industry which may lead to consulting projects and matching funds for university projects.
- Faculty works on cutting-edge technologies and gets an opportunity to conduct more applied research to solve real-life problems faced by industry.

CONCERNS ABOUT THE COOP[21] CONCEPT

The authors have discussed the proposed concept with the current mining engineering students and also industry personnel from various industries. Some of the important concerns obtained from these constituencies are listed as follows:

- From students' point of view, the obvious concern was the limited face to face of interaction with instructors and limited academic supervision.
- Adoption of the proposed concept may lead to demise of the traditional programs and that could be dangerous.
- The main concern expressed by the industry group was that it might be difficult to get rid of an ET if the match between the specific ET and industry was not the best.

- Another important concern from the industry was that the ETs would be counted as employees since they will be on the company's payroll. This will not be looked at favorably by the management when a 'head count' is done for determining productivity and other things.

CONCLUSIONS

A new concept of mining engineering education has been proposed to directly address the issues of declining enrolment of mining engineering students and gradual elimination of mining engineering programs nationwide. According to the proposed system, after receiving the basic science, math and engineering courses during the first two years, the students will be recruited by industries as half-time employees. These half-time employees will work 50% of the time for the industries to earn decent salaries and comfortably meet their tuition and other expenses; whereas during the remaining 50% time, they will complete the mining engineering degree requirements by enrolling for distance-learning courses offered by academia through interent. Various advantages expected for students, industries and academia have been discussed in this paper. Most of the concerns raised by the students and industries can be easily addressed by making slight modifications to the proposed concept and/or slight adjustment with the book keeping style in the industry. Instead of making ET's education completely distance learning based, some face-to-face contacts during the evenings or weekends between the ETs and the academic faculties could be arranged on an as needed basis. While attempting to change any on-going system, some compromises and adjustments have to be made. It would be wise to make those compromises/adjustments now instead of when it is too late.

ACKNOWLEDGEMENTS

The authors sincerely acknowledge the efforts of the industrial advisory board and students to review the concept and provide meaningful comments for its further evolution. The support of Mr. Abinash Moharana in preparing this paper is also sincerely appreciated.

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