AC 2011-1158: HANDS-ON MANUFACTURING ENGINEERING EDUCATION, AN ANALYTICAL STUDY

Sabah Razouk Abro, Laurence Tecnological University, Department of Engineering Tecnology

Dr. Sabah Abro is an internationally educated math professor and program Director at Lawrence Technological University. He graduated with a Bachelor degree from the University of Baghdad, pursued a post graduate diploma in planning from the United Nations institute in the middle east, Went to Wales in the United kingdom to get his Masters degree and then to Belgium for his Ph.D. He has also international work experience; he served as Faculty at Al Mustansiria University in Baghdad, a regional consultant at the Arab Institute for Statistics, a position that enabled him to lecture in a number Arab countries. In Jordan he served as the Chairman of the Math and Computer Science department at Al-Isra University. In The United States he worked as an adjunct faculty at Wayne State University, University of Detroit Mercy and Oakland Community College. He held a position of the Math program leader at Focus: HOPE for several years. Sabah has been involved in engineering education paradigms since 1996, he coordinated work with university partners to develop new curriculum in engineering education with a support of NSF grant. Dr. Abro has work as a consultant in six sigma training and certification where he was exposed to manufacturing facilities and their practices. He has many publications related to education and statistics. He is a member of several professional organizations like the American Mathematical Society. Sabah has participated in 2010 in AESS conference with a paper jointly with Ken Cook

Jerry Cuper, Lawrence Technological University

Jerry Cuper is a professor and advisor in the Department of Engineering Technology in the College of Engineering. His education includes graduate and undergraduate degrees, and completion of a technology apprenticeship program. Mr. Cuper's career has spanned a wealth of experience in the machine shop, on the drawing board, in construction, and many years in engineering design, testing and development, management, and planning. Most of his career was with the Ford Motor Company. Mr. Cuper's last assignment was managing the Ford Technology Review Center to help implement suppliers' new technologies. He developed and led the implementation of a new supplier process to dramatically change the way supplier technologies were integrated into Ford products. This supported Ford's vision to change from being a fast follower to being a leader in technology. Mr. Cuper developed the first-production automotive application of Graphite Fiber Reinforced Plastic; this bracket was given the Materials Engineering "Award of Merit". Cuper has taught courses in engineering and business at Lawrence Tech evening programs as an adjunct instructor since 1978. He has demonstrated the ability to work extremely well with students to focus their efforts on academic achievement and long-term career goals. Mr. Cuper's passion is muscle cars. He has owned 20 Mustangs over the years, starting with the 1965 2+2 Fastback and now has a 2010 GT convertible.

Hands- On Manufacturing Engineering -- An Analytical Study

1. Abstract

A new paradigm in manufacturing engineering education was born as a result of long and diverse meetings and discussion between five academic educational institutes and five new industrial partners in Michigan. In 1993, the above mentioned entities joined in the Greenfield Coalition for new manufacturing engineering education. The Greenfield Coalition was one of several throughout the U.S. sponsored grants from NSF.

The objective was to help training and educating our students to be the “renaissance engineers”.

To reach those very challenging objectives, the Greenfield coalition started building the new paradigm in a non- classical academic approach. The paradigm consisted of two avenues; the academic curriculum and the hands-on program.

The curriculum was structured in a reverse order process where the skills of the graduate were determined through a series of meeting between educators (the university partners) and the customers (the Industrial partners). Once the skills were agreed upon, knowledge areas were identified which led to choose the courses needed to serve the goal.

The hands- on program was very rigorously designed to help students acquire the best possible experience in real- world manufacturing. All students in the program worked 40 hours a week in the Center for Advanced Technologies (CAT); a state of the art factory which manufactured parts for the industrial partners. Each student has to follow a comprehensive rotation plan that will expose him or her to various departments from shipping and receiving through engineering.

Teaching by objective was a theme that was used in development of courses. These objectives were reflected in the design of the syllabi of the courses and were served through well- defined outlines.

Just- in- time math and science ideas and self- paced learning were introduced in these programs to help interrelations between engineering courses and the math and science prerequisites.

The nontraditional approach to education was borrowed by some universities, were self- paced and one- room math schoolhouse type of classes was introduced.

The program incurred many challenges but opened up many opportunities for success for students. Despite the success, the program still faced considerable administrative challenges.

The experience proved that the collaboration could benefit Academic institutions and industrial partners and above all benefit the students.

Coordination of work among different academic institutes was one of the biggest challenges. Each institution would be part of the degree offered by other institutions which created many problems, yet it opened a door for possible improvement of inter- academic institution relations.

Many years after the financial resources from NSF and industry dried up, this paper will:

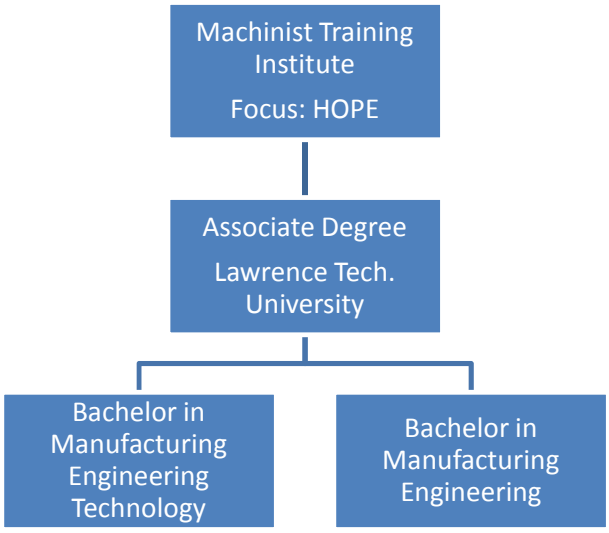
- Analyze the Greenfield Coalition educational paradigm.
- Discuss successes and failure of the Paradigm.
- Recommend a sustainable approach to this educational model

2. Background

The Greenfield Coalition at "Focus: HOPE" is a coalition of five universities, seven manufacturing companies, the Society of Manufacturing Engineers, and Focus: HOPE. (a civil right's organization dedicated to intelligent and practical action to overcome racism, poverty and injustice in Detroit and its suburbs). The Greenfield Coalition at Focus: HOPE was formed in 1968 in the wake of the racial unrest in Detroit.

Funded under the Engineering Education Coalitions Program at NSF, the Greenfield Coalition has established a new paradigm in manufacturing engineering education leading to degrees in both manufacturing engineering and manufacturing engineering technology. The students would qualify to be admitted in these program only if they came from the Machinist Training Institute (MTI) at Focus: HOPE. Students would be admitted at the Center of Advanced Technologies (CAT) as candidates and work full time at the CAT while they attend classes after work.

The diagram below summaries the path from MTI to a bachelor degree.



The Greenfield Coalition began examining the existing manufacturing engineering programs with its intent to build an educational experience rich in real-world manufacturing examples. Greenfield Coalition Members were from Academia and Industry. University partners included Lawrence Technological University (LTU), Lehigh University, Michigan State University, University of Detroit Mercy, Wayne State University; Affiliate Partners: Ohio State University, University of Michigan, Walsh College. Industry Partners consisted of Cincinnati Machine, DaimlerChrysler, Detroit Diesel, Electronic Data, Systems, Ford Motor Company, and General Motors.

Some important milestones are: First associate degree from LTU was awarded through the Greenfield Coalition in 1994, first bachelor degree in Engineering Technology was awarded in 1997, and first bachelor degree in manufacturing engineering was awarded in 1998.

3. The Educational Model:

In 1993 a proposal to NSF was written by Greenfield Coalition to support the experiential education process. Building on a modular delivery system in which learning was packaged into small

one-credit packages, Greenfield intended to use multi-media tools to allow candidates to access the knowledge they needed to support their assigned job. Again, the idea of both job flexibility and flexible educational delivery supporting each other was a noble idea. The idea of one-credit courses increased the complexity of tracking student progress, and challenged the records processes at all partner universities.

The Greenfield Coalition Mission was to:

- Establish a new paradigm in manufacturing engineering education that integrates actual manufacturing experiences into the academic program.
- Develop learning products to support this paradigm.
- Deliver the new program to candidates at the Focus: HOPE Center for Advanced Technologies.
- Transfer the Greenfield paradigm to our partner universities, industry, inner city training and education centers, and the larger manufacturing education community.

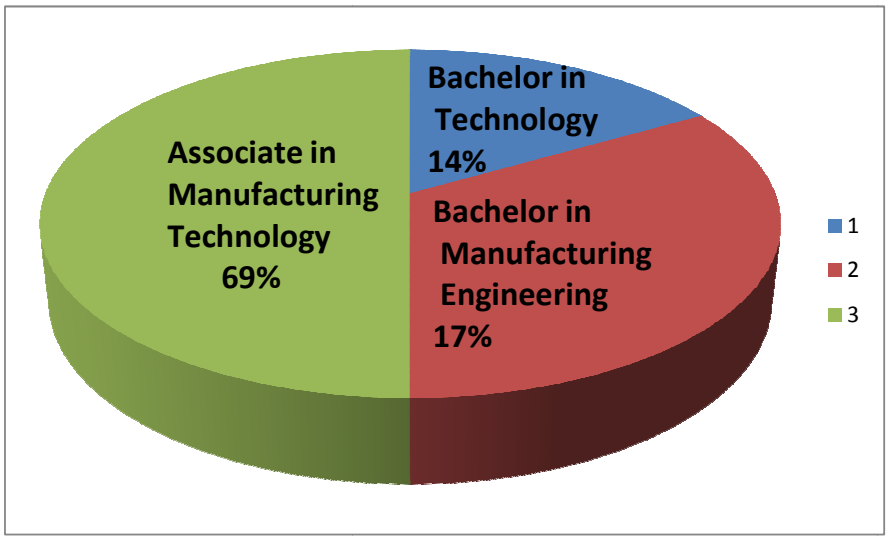
The Greenfield Coalition Curriculum was designed under the theme of " Just in Time" credits. This meant that all GC (Greenfield Coalition Curriculum) courses were increments of one credit hour rather than the traditional three or four credit courses. Furthermore, models were developed to satisfy the new concept. The concept of just in time meant that a student can take physics that requires a calculus background even if he or she did not finish the whole calculus four credits. The idea was since the student will need only differentiation techniques, then a prerequisite was met after passing the module (credit) of differentiation.

The coordination between the manufacturing of the CAT and the Focus: HOPE education team, under the patronage of the Greenfield Coalition experts, did provide a unique opportunity for students to rotate in different departments of the production process as they progress in their credits achievement. This environment did prepare graduates to be ready to work and be effective parts of the team in their employer's entities after graduation.

4. Graduates Statistics

The number of students benefiting from the program has exceeded 250, yet the number of students finishing a degree was 181since the new paradigm adoption till the end of 2010. The number of students granted their associate degree through the program was 125 representing 69% of all the graduates. The total bachelor degree students was 66 students representing 31% of the total number of graduates.

The following chart illustrates the graduates distribution.



The statistics highlight that only 56 students with associate degree have made it to the bachelor degree through the same program. This does not mean that the rest of the students did not manage to finish of failed through trhe process.

Actualy, the problem that the CAT had up till 2004 is to keep the students from quitting after the associate degree and accept some good job offers that would include educational expences. This might be one of the major variables contributing to the extreme differences in the percentages of graduates.

5. Analysis of the model:

The new paradigm introduced by the Greenfield Coalition has many strong points and benefits for the students, schools and industry. Some of the most important positive aspects were:

- The joint educational and production environment.
- Harmony between the curriculum and training rotations.
- Readiness to work effectively in industry upon graduation.
- Learning by objectives, a delivery method that has proven efficient.
- Participation in real-life production problem solving.
- Reduced travel time and expenses since the classes and the work were at the CAT.
- Curriculum challenges were distributed into small increments of one credit hour which means that the need for retaking a class will not consume another 16 weeks of the student time.
- Application of theory from classes directly to work .
- Integrate team work concept and practice at work into class work.

- Students are exposed to faculty from different universities while they are in the same campus.
- Availability of industrial mentors and tutors throughout the partnership with industry
- Migration of some delivery methods, the self-paced learning, from the nontraditional educational environment at the CAT to the traditional campus environment.

Despite the above mentioned strong points and benefits in favor of the new paradigm, there are few deficiencies that did affect negatively the sustainability of the program, such as:

- The high cost of the program. The cost variables were salaries of the students, cost of the Greenfield Coalition administrative and consultants, and the cost of developing learning materials as electronic modules.
- The one-credit increments of the courses is liked by the learners, but it has created a major administrative problems (registrar and enrollment offices) in the schools participating in the program and to other schools that CAT students may transfer to.
- The program definitely presented a new culture shift in manufacturing education, but it created some conflict with the culture on campus.
- Educationally, the module of one-credit increments did cause a weakness in the capability of students to integrate the knowledge area easily.

6. Conclusion and recommendations

- The Greenfield Coalition educational model established a collaborative philosophy between industry and academia that is a win-win situation for industries, universities, and students.
- The hands-on experience and theory in the classroom proved very effective, but costly. However, the program could be modified to make it sustainable.
- One suggestion to make the program sustainable would be to have the students be part of an internship that includes a single university and multiple industrial sites. Grants could be used as an incentive to support this model.

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