Integrating Hands-on Manufacturing Project Experience into Manufacturing Education

Sheng-Hsien (Gary) Teng
Western New England College

ABSTRACT

Engineers are required to obtain state-of-the-art manufacturing knowledge, people skill, information gathering ability, time and project management background, and communication skill to face the challenges on their jobs. This paper will discuss the implementation of hands-on manufacturing projects to compensate the missing training in these skills.

I. Introduction

The common requirements for manufacturing engineers are the ability to react to the problems quickly, their knowledge on the state-of-the-art technology, their ability to gather information for problem solving, their ability to manage a project, and their communication skills in coordinating activities and selling the improvement ideas. Lankard discussed three important things for students to obtain a job [1]. Basic skills provide students with job-keeping and interpersonal skills. Technical skills allow students handle technology used on the job. Apprenticeship builds the bridge between school learned knowledge and the real-world work. Grossman and Blitzer suggested strategies for career survival which include an action plan, motivation, the establishment of required skills, and the understanding of the current challenges in industry [2]. Lankard also discussed the changes required to renew a person's career which results in a new way of learning [3]. These changes are also applied to traditional undergraduate students for getting an engineering job when they graduate.

Traditional training of future manufacturing engineers is more concentrated on classroom lectures. It resulted in a more one-way communication environment---professors feed information to the students. It is difficult to provide students adequate training in people and culture related problem solving. To include the required training to the manufacturing program, extra elements have to be added to compensate the weakness of classroom lectures. One tool can be used in the curriculum is the hands-on manufacturing projects.

The types of manufacturing projects being used for hands-on training can be a term project, a month long project assigned during the class period, a short term manufacturing laboratory project associated with a manufacturing course, stand-along short term manufacturing laboratory projects, and an individual project such as a senior project. Internship and co-op programs can be another ways to provide students the hands-on manufacturing project experiences.

Teamwork, project scheduling, developing feasible alternatives, and the selling of the project result are some of the key factors in finishing a manufacturing project and should be the heart of project evaluation. This paper will show the overall procedure in embedding hands-on projects into manufacturing education. The importance of this approach and the pros and cons of the approach will be discussed.

II. The current problem and research objectives

Common complaints from the employers in manufacturing industry are the college graduates' deficiency in people skills, their needs in step by step instructions, their inability in problem solving, and their inexperience in information gathering. In general, companies need engineers who can work in a team, can be a self-starter, can adapt to company culture quickly, can develop practical solutions to the manufacturing problems, can collect the required data for problem solving, and can sell their ideas to different levels of people. So the contents of a manufacturing curriculum should include the experience in real-world manufacturing environment.

The problem encountered here is how to give students adequate hands-on training in real-world problem solving and project handling. So the objectives of this paper are to discuss the use of the projects for hands-on practice, to examine the procedure of project implementation, and to measure the effect of hands-on projects.

III. The types of projects

Projects have been a good tool for students to gain hands-on experiences that cannot be obtained from classroom lectures. Students can be inspired by their project work experiences and can relate the usefulness of classroom lectures to their experiences more often. Companies are also looking for new graduates with hands-on experiences. Imel discussed one of the strategies used by the college graduates is to get work experiences through projects, internships and co-op education [5]. Farnham stressed that one important factor for the success of a job search is to get work experience [6]. Smith showed that to get a good job, college students need to have problem solving skills and to be involved in the activities that can demonstrate their leadership and teamwork ability [7].

In undergraduate manufacturing courses, students are mostly involved in short term laboratory projects. These lab projects may be done by one person or a team. The project contents often include the design of operations that utilizing lab equipment or fixed lab sections for specific manufacturing operations. This type of projects can provide students the basic concepts of manufacturing operations and the hands-on experience on lab equipment. Their weakness is that the experience often does not simulate a real industrial environment.

In an industrial environment, the expected result of a project is often defined by the management. An engineer may be required to specify the exact project title and direction and to determine what type of information should be collected and how to collect it. This person also needs to work with people from different departments as a team. The need to do project scheduling, to develop progress reports and alternative solutions, and to present project outcomes is essential for a manufacturing engineer. In order to give students a simulated industrial environment, project assignments have to be updated to fit the current industrial practice.

A project has to be at least a month long to give students enough time to finish it with a satisfactory result. A better type of project is a term project. It gives students enough lead time

to determine the project direction, to find their team member(s), to collect data, and to develop meaningful alternatives for final selection. Students should be required to do the project through a team environment. Hence, either the professor has to group students into project teams or the students have to find their own teammates. The author's preference is to allow students to find their own teammates. Recruiting teammates is also an important experience in project handling.

The requirements of term projects should include the collection of current market or cost information or the current industrial practice. In this case, even though the project assignment may include the utilization of lab equipment, students still need to go out to search for current industrial or market conditions in order to fulfill the project requirements. Another type of projects is to ask students to solve real industrial problems. Students need to go to companies to understand the existing problems, to develop a strategy to solve the problems, and to really solve these problems. This type of projects can be implemented through special projects, independent studies, or term projects. Since the weight for the project performance in a regular class is much lower than that in a project oriented class, students may not put enough effort in their projects. So the progress of each project has to be closely monitored to assure a satisfactory result.

The other type of project is a project being done through internship. Internship can provide students a very good hands-on experience in a real environment. Tetzeli emphasized the importance of the internship experiences for college students which teach students the soft skills in a corporate environment [8]. If the internship experience includes a project type of assignment in a company, the student will gain more of the required skills during the internship period and will understand the needs and knowledge required for a college graduate to get a desired job.

IV. The requirements for hands-on projects

No matter what types of projects are being used to enhance students' learning, the contents and requirements of these projects have to satisfy a basic purpose---giving students real-world experiences. Hence, students have to consider the feasibility of their ideas against the common requirements in industrial projects such as the constraints of production volume, raw material costs, capital equipment cost sharing, the potential changes in manufacturing methods, and the required labor cost. The faculty should give students a list of conditions in a simulated manufacturing environment along with the expected achievement at the end of the project.

Another element, the competition in the current market, should be included in the assigned projects. A competitive environment can be simulated by letting students compete with the other teams for the best project grade. In pure project classes, all project teams can be assigned to solve a same industrial problem to obtain the element of competitiveness. If each team is pursuing a different project, then the project has to be done in the way that the consideration of competition is included in the whole project period.

The next major element in the project contents is the development of feasible alternatives. Students should be asked to develop several feasible solutions for their projects and the criteria for the selection of the best alternative. This training provides them the understanding that no solution is perfect and the best solution is selected according to the specified conditions and

limitations. One other critical element is the final presentation. Engineers who do not possess the ability to sell their project ideas and results are not successful engineers. An engineer needs to be able to give an impressive presentation when s/he completes a project. Accomplishments will not be noticed unless a good presentation is given.

V. Project implementation

To gain the benefits of hands-on experience in a simulated industrial environment, the faculty has to closely monitor the progress of each project. This monitoring process can include the requisite of a proposal, the in-progress reports and the final report. Periodic meetings can be held to discuss the progress, the incurred problems, and the technical knowledge required in the project. Projects should be evaluated following concept development, data and information gathering, technical contents and alternative development, teamworking ability, and project completion. Students should demonstrate their major contributions in the project during their final presentations. Students have to learn how to show their contribution in the project work.

The grade for a project should be based on the proposal, the in-progress reports, the final report and presentation, and the ranking among project teams. The last two items should be given more weight since the success of an industrial project is based on how the team sells the project result and how it defeats the competitors. Team competitions are necessary to enhance students' ability to survive in the competitive market. The grade for each individual student should be based on the team project outcome. All members in a team get the same grade or get different grades based on their consensus agreement on each individual's contribution to the project. One important lesson they have to learn is that no one succeeds in a failed team project. Students have to learn the process of teamwork through dealing with their teammates, working with other people, scheduling the team meetings, and sharing the project responsibilities.

VI. The effects of the hands-on project

After students complete several projects, they should have the ability to collect data, to integrate the manufacturing knowledge they learned into project work, and to obtain project handling skills. With these training, their interest and ability in absorbing technical knowledge in the classroom will be increased. Classroom lectures will become true two-way knowledge exchanging processes. Students will be eager to learn the skills for problem solving, the methods for manufacturing design, and the tools for manufacturing implementation. A center theme in the career can be established by the students during their college years. They know what they want to do after they graduate. They have the hands-on experiences to talk about in their job interviews and have the understanding of industrial environment to convince employers that they will adapt to the manufacturing environment successfully.

There are some problems associated with the use of projects for hands-on training. Students will need to make more efforts to complete a project. Some students may not put enough effort on the project to gain all the hands-on experiences. Industrial projects may be hurt by some bad apples in which will damage the reputation of the manufacturing program. Therefore, the faculty has to figure out a way to drive students forward while doing the project. The faculty will also

need to spend more time on project monitoring and industry contacts.

VII. Conclusion

Hands-on projects are important to the success of manufacturing education. Students have to gain the required teamworking, problem solving, and project handling ability during their college years. They have to be familiar with the real-world manufacturing environment before they graduate. Simulated or real industrial projects are good training tools to provide students all these skills. Without these training, students are not competitive in the job market when they finish their manufacturing degrees. Students who know how to complete an industrial project have many advantages in searching a job. They know how to sell their accomplishments and ideas. They understand the art of working with other people. They recognize the need of information gathering and data collection. They take work seriously and learn manufacturing knowledge quickly in the classroom.

If hands-on projects are not integrated into manufacturing curriculum, other methods have to be used to provide hands-on industrial experiences to the students. Otherwise, students will not be ready for the real manufacturing world after they completed their manufacturing degrees. To generate the expected result, each project assignment has to provide training in teamwork, project handling, and project marketing. A project assignment concentrated on design and technical contents will not supply students the adequate training. So faculty has to inform students the importance of the non-technical contents in the project during project assignment.

Step-by-step and very detailed guidance during the project period should be avoided to allow students the chance to make decisions at each project step. The purpose is to stimulate their ability in problem solving and decision-making. With the inclusion of these hands-on projects in manufacturing curriculum, students will get more up-to-date training, their working ability and their classroom performance will be enhanced, and their ability to get a satisfactory job after graduation will be increased. Meanwhile, the manufacturing industry can get the quality people they want from manufacturing programs.

VIII. References

1. Lankard, B., "Employers' Expectations of Vocational Education," *ERIC Digest*, No. 149, 1994.
2. Grossman, B., and Blitzer, R., "Choreographing Careers," *Training and Development*, 46, No. 1, 1992.
3. Lankard, B., "Career Development Through Self-Renewal," *ERIC Digest*, No. 138, 1993.
4. Heinemann, H., DeFalco, A., and Smelkinson, M., "Work-Experience Enriched Learning," *Journal of Cooperative Education*, Volume 28, No. 1, 1993.
5. Imel, S., "Job Search Skills for the Current Economy," *ERIC Digest*, No. 150, 1994.
6. Farnham, A., "Out of College, What's Next?" *Fortune*, 128, No. 1, July 12, 1993.
7. Smith, L., "Landing that First Real Job," *Fortune*, 129, No. 10, May 16, 1994.
8. Tetzeli, R., "Interns Have Edge on Jobs," *Fortune*, 127, No. 10, May 17, 1993.