Field Trips: An innovative approach in teaching 'Manufacturing Processes' to traditional undergraduates

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Abstract

Teaching manufacturing processes to undergraduates with industrial and mechanical engineering majors poses a challenge, in that, students have little background from which to begin building their knowledge. Comparing and contrasting different processes becomes just another 'book' problem to solve and/or visualization of the processes is problematical for many students. A 'learning beyond the classroom' experience of industrial field trips has been implemented for four years as a regular class activity and integral part of student learning. The industries selected are local to the college and four field trips per semester are scheduled during regular class time to assure participation of the entire class. Key to this learning experience is that all trips are scheduled to coincide with topics being covered in class. Students are able to 'see' the technology presented in the text, establish a dialogue with the company's engineer and use their observations in class discussions. Small notepads are provided to each student to encourage note taking, improve retention of process details, and provide an opportunity for a student to role-play, as a practicing engineer. A formal trip report is required and comprised of questions regarding the process technology and products manufactured at the facility. A key question on each trip report states, "What resources, i.e., information and people, would you request if you were a new engineer at this company?" In class, this question sparks discussion and to provides a link between the student's pre-professional experience and their future in the real world. The feedback from the students has been overwhelmingly positive. Assessment of student learning and basic knowledge is evidenced by the significant improvement in quality of the class discussions and the technical content in the trip reports. The feedback from industry has also been positive and their cooperation has been an asset to this activity.

I. Introduction

For the past four years, industrial field trips have been effectively integrated into and are a required part of the IE314 Manufacturing Processes course at Western New England College (WNEC). As student learning was assessed through case studies and examinations, it was qualitatively observed that many students were weak in correlating the information from the lectures and reading to a new manufacturing problems or in-depth analysis of new applications. Facilitating active class discussions was often difficult due to the lack of exposure to and experience in an industrial environment by the students, most of who are juniors and have not had the opportunity for industrial internships or summer jobs. Therefore, the instructor

hypothesized that technical information presented in the oral lectures and assigned reading alone, may not be sufficient to provide an active learning environment for students with different learning styles.[1] Thus, the need for and implementation of industrial field trips, a 'learning beyond the classroom' activity, provides all students with a 'real-world' experience that is directly related and relevant to the traditional lectures presented in this course.

Traditionally, at our college, the student chapters of the professional societies or student clubs have sponsored industrial field trips. These trips are usually organized by students as an activity to gain insight into the profession and their engineering discipline, and are not specifically coordinated with the student's course work. Also, attendance for these trips is voluntary and the experience student's gain is a function of their personal interests and preferences. Since there is no required accountability for the information ascertained during these trips, it is difficult to use these experiences in class discussions. In an effort have the entire class at the same experience level; the trips must be well planned and coordinated with the topics being presented in the Manufacturing Processes class.

The industrial field trips also work to accommodate all students and support their different learning styles. The trips provide an educational experience that incorporates the visual and kinesthetic sensory modalities used for learning information. [1] To support the observations of the instructor and to gain insight into the needs of today's students, the VARK (Visual / Aural / Read-Write / Kinesthetic) survey[1,2] administered to students in IE314 in Spring 2001. The results of the survey shows most students prefer to utilize a kinesthetic and/or visual sensory modality in learning new information. That is, 4 of 8 students prefer visual information; 1 of 8 prefer aural information; 3 of 8 prefer read/write or information in words; and 6 of 8 prefer kinesthetic information, e.g. learning through experience, practice or simulation. Also, 4 of 8 students selected more than one sensory modality as their preference in learning. This initial data supports the need for integrated experiences or activities, such as the industrial field trips and the corresponding academic requirements that are presented within this paper. This recent information also supports the positive comments from students who took this course in previous years and expressed a benefit from this activity.

II. Implementation

a. Course Description and Requirements

In the IE314 Manufacturing Processes course, students experience the 'learning beyond the classroom' activity of industrial field trips as an integral and required component of this course. The course is taught 2 times a week for one hour and fifteen minutes or 3 time a week for 50 minutes and field trips are scheduled for a two-hour period by extending one of the sessions. The administration specifies a 'laboratory period', which corresponds to the working hours of most companies and the student's course schedules.

The accompanying textbook is *Materials and Processes in Manufacturing* by E.Paul DeGarmo, J.T. Black, Ronald A. Kohser, Eighth Edition, Prentice-Hall Inc., Upper Saddle River, NJ, 1997.The course description is as follows:

> "This course introduces the fundamental workings of a variety of manufacturing processes. Engineering students, with concentrations either in design or

manufacturing, will benefit from this basic information on materials and processing, and an introduction to the 'language of manufacturing'. The student will analyze each manufacturing process, its capabilities, typical applications, and its advantages and limitations. The topics highlighted in this course are; material selection, measurement and quality control, casting, forming, material removal, joining, and the integration of these techniques into a manufacturing system. The course is presented in a series of classroom lectures, selected videos, case studies, and field trips."

b. Organizing the industrial field trip

The goal in this activity is to 'bring the book to life' and allow the students to 'see' industry practicing and applying the technology, which is being presented in the lectures and in the textbook. The student can evaluate processes, materials and equipment used in industry without necessarily 'touching' the equipment. Noting the students can simulate a 'real-world' situation in industry, e.g., a 'union shop' where engineers (usually) cannot touch the equipment. Keen observation skills combined with fundamental knowledge of the manufacturing process allow students to evaluate the technology used at the various companies.

The instructor carefully selects the various sites of the trips, and the dates of the trips are coordinated with the class lecture and topic stated in the syllabus. The course topic is matched with the host company as shown in Table 1. For instance, during our study of conventional machining / material removal processes, Techni-Products, Inc. is visited to complement our study of precision turning, milling and drilling. During the semester, four of the field trips are conducted to companies selected from Table 1. Trips to companies specializing in casting and conventional machining / material removal processes are always included. Logistics for these trips include scheduling the visit during the 'laboratory period', reservation of the college van(s) for transportation to and from the selected site, and arrangements with host companies. Since the college owns the van(s), the cost incurred for this activity is minimal (under $100 per course).

Local manufacturing businesses donate their time to accommodate our students and their facilities to host our tours. The owner(s) and/or engineers often share their personal experience and insight into the manufacturing of their products and of their business with the students. The owner(s) and/or engineers, i.e. 'tour guide(s)', are briefed on the goals and educational nature of these trips in order to maximize the educational benefit to the students. In the discussion, the 'guides' are told that the audience is a group of students, who are traditional engineering students in their junior or senior in our manufacturing processes course and studying the specific manufacturing process, e.g. conventional machining. For planning purposes, the number of students attending is given and the length of the tour, which is usually one hour, is booked. The subject matter included in the tour is discussed and a rough 'script' is worked out prior to the field trip. The local manufacturing businesses that have hosted our class, to date, are listed in Table 1.

Prior to going on the field trip, students have had one or two lectures on the specific technology, a reading assignment and have completed at least one homework assignment. From a practical perspective, one or more closely related technologies may be covered in class assignments and viewed at the company, as shown in Table 1. This in-class preparation familiarizes the students with the basic vocabulary and fundamental engineering principles; therefore, during the field trip

they can deepen their knowledge, ask questions, and 'see' the implementation of the processes and equipment.

Table 1. Local manufacturing businesses hosting field trips and company information

Host Company ***Location***	**Course Topics from Syllabus**	**Manufacturing Processes on Site**	**Type of Business**
American Saw and Manufacturing, Co. *East Longmeadow, MA*	Conventional material removal processes; joining	Conventional machining (milling) heat treating; and welding	Saw blades; large lot sizes
O-A Manufacturing, Inc. *Agawam, MA*	Conventional material removal processes; measurement and quality control	Precision, conventional machining; turning, milling drilling and lapping	Aerospace components; job shop; varied lot size
Techni-Products, Inc. *East Longmeadow, MA*	Conventional material removal processes; CNC machining; measurement	Horizontal milling and drilling; CNC machining centers	Aerospace components; job shop ; complex high precision parts
A.G. Miller, Inc. *Springfield, MA*	Nontraditional machining; metal forming	Laser cutting; high speed punch press	Sheet metal fabrication; Job shop; varied lot size
Yankee Casting/ Yankee Magcast, Inc. *Enfield, CT*	Casting	Sand casting of brass, aluminum, and magnesium	Aerospace and specialty sand casting; small lot size
Hamilton Sundstrand *Windsor Locks, CT*	Non-destructive inspection	FPI, radiographic and ultrasonic inspection	Large aerospace company; NDT department and laboratory only
Columbia Manufacturing, Inc. *Westfield, MA*	Metal forming; joining; painting/coatings	Tube bending, welding and brazing plating and electrostatic painting	School furniture; desks and chairs; Large lot sizes

During the tour, students are expected to play the role of a practicing engineer, who is visiting the company to evaluate their technical capabilities. In this activity, students are encouraged to ask questions and take careful technical notes on the manufacturing processes. The instructor provides small note pads (at approximately $1 each), specifically for this purpose. A formal trip report is also required in this activity and the typical form is given in Figure 1. Note taking and recording accurate technical information, particularly the 'details', improves professional skills and the trip report reinforces the serious purpose of this trip. To add value and assure effort from the students, these trip reports are counted as quiz grades.

The same questions, which are shown in the form in Figure 1, are used for each industrial field trip. The responses are graded and reviewed with the class in a follow-up discussion. The responses to these questions facilitate class discussions about the specific technology and in the interrelationship between other manufacturing technologies employed in the processing a complex assembly.

TRIP TO Yankee Magcast, Inc.,
IN Enfield,CT

Trip Report – Weekly quiz - **QUIZ #** – 10 points ; prompt for class discussions

All questions must be answered in essay form on separate sheet of paper.

1. Describe **two** technologies or manufacturing processes that were of interest to you.

2. List **five** issues or factors important to the implementation of the processes described in question #1.

3. *If* you were a new hire at Yankee Magcast, Inc., what information, resources or background information might you request? (What resources, i.e., information and people, would you request if you were a new engineer at this company?)

4. How does this trip complement our class discussions and illustrate basic principles presented in the lecture and homework?

5. What is your *professional* opinion on this trip? What would you like to learn more about? Can you make any recommendations on the technology or manufacturing processes observed on this tour?

Figure 1. Typical report for industrial field trips

III. Impact of industrial field trips on student learning

As stated in the course syllabus, the learning objectives and assessment methodology are as follows:

> " The objective is to provide engineering students, majoring in design or manufacturing, with basic information on materials and processing. The student will be provided with the tools to describe, qualitatively, the workings of a variety of processes, the relative advantages and disadvantages associated with the individual processes, and the interrelationship of a single process to other process(es) in the fabrication of a complete assembly or product. The knowledge of the vocabulary or terminology, basic process parameters and unique characteristics

associated with each process is required. Each student will be assessed by her/his performance on quizzes (trip reports), exams, homework assignments and applications of the learned principles to case studies."

The degree of detail reported by students in the trip reports steadily improved throughout the semester. The students who faithfully utilized the notebook, submitted significantly more detailed reports than those that did not. Through active participation in class discussions, students could evaluate each other and realized, amongst themselves, that note taking was a critical and beneficial activity.

The class discussion improved where all students began to feel on equal ground with the experiences and applications, i.e., everyone in the class began to participate equally as the discussion was focused toward the field trip experiences. Students valued the insight and expertise of their tour guides and the relaxed environment, where questions were welcomed.

Although the trip reports only officially count as quiz grades, improved performance on exams and in case studies is noted and partially attributed to the educational experience gained from the field trips. As shown in Table 2 for the Spring 2001 semester, the class average for both exams and case studies increased as the semester progressed. On the case studies, students researched the problem in more depth and asked more insightful questions. Qualitatively, the influence of the discussions with company engineers hit a chord with students and reinforced the importance of 'attention to detail' in a manufacturing process.

Table 2. Qualitative evaluation of factors in student learning influenced by industrial field trips

Area of Evaluation	**Evaluation Criteria**	**Spring 2000**	**Spring 2001**
Exams (Class average)	Change from Exam #1 to Exam #2 & #3	Not available	Increase 10 points (100 points total)
Case study (Class average)	Change from Case study #1 to Case study # 2 & #3	Not available	Increase 2 points (10 point total)
What did you like about this course?	Response: "Field trips"	3 of 7 students	4 of 7 students
What worked best in assisting your learning in the course?	Response: "Field trips"	5 of 7 students	5 of 7 students

As the semester progresses, student began to realize the level of scientific and engineering understanding required to select the optimum manufacturing process and that fact that this technical information which they are studying is really applied in the 'real-world'. The responses on the student evaluation form reflected the value of the industrial field trips, as tabulated in Table 2. Additionally, this statement was evidenced by student responses to the following survey question (from Spring 2001).

Question: Comment on the field trips as a 'learning beyond the classroom' experience.

- "Field trips were very interesting. It's good to see how the processes are done and things that need to be considered, such as the heat treatments. Plus, as an IE it was interesting to see those principles at the same time."
- " …I could actually see what I was learning about. They helped me understand the information more by providing real world, hands on examples to the theory."
- "The field trips all helped to better understand some of the larger scale applications of the basic processes. I learned a lot of basics in high school shop, but actually seeing the full scale manufacturing aspect tied it all together."

Students believe the industrial field trips greatly enhanced their learning and matched their learning style. Most students showed a preference for the visual and kinesthetic sensory modality for learning information. From the response to these two questions on the student survey (from Spring 2001), the benefit of this activity is clearly evidenced.

Question: Briefly, describe how you learn best, that is, describe your learning style.

- "… by reading and seeing or doing to reinforce the material. "
- "I like seeing things work. Hands on experience helps me remember certain details that we go over.'
- "My learning style is hands on. I learn better by actually doing something rather than reading about it. Reading up on information about something does help, but don't get me wrong, but actually seeing and doing is much easier."
- "Hands on experience is definitely how I learn best and quickest. The field trips were very well planned because they reflected upon what the class had just recently read about. Things that are read in a book are often forgotten quicker than things you see / experience."

Question: Did the field trip ' experience' complement your learning style? How?

- "The field trip experience definitely complemented my style of learning by allowing visual aids to be combined with well structured lectures and reading."
- "Yes, I did, for me, everything I do on homework or test questions, I try to get a physical picture of 'what is going on'. And going on the trips helped me apply most of what we learned."
- "Yes, because seeing these processes is as close to doing them as possible. "

As noticeable in student's writing and in-class questions, this 'learning beyond the classroom' activity contributed greatly to improving their understanding and ability to analyze new technology. Relating the theory and lectures to 'real world' and practical applications was very important to this group of students. Insights from industrial were valuable and student's respected the insight from the company's engineer. The field trips and the interaction with the company personal in an educational situation gives students a bit of extra confidence in their abilities, should they chose to work in a manufacturing environment.

IV. Future work

The logistics have been set into motion and the class is developing a favorable reputation at Western New England College. Here it is shown that students are excited about this activity and

perceive that it truly helps their learning and mastery of the course material. Students also deem this activity as a 'fun' and a 'practical' experience. Developing a system or protocol to quantitatively assess student progress and/or learning styles as direct result of the industrial field trip will be investigated in the future. This may be used to change the usual lecture format of the class, the length of the class meeting, and to develop additional class activities based on the industrial experience with the goal of improved student learning.

V. Summary

Industrial field trips have been successfully integrated into traditional framework of the IE314 Manufacturing Processes class at Western New England College. The field trips are officially scheduled as a part of the class; therefore, the attendance on the trips is a course requirement. The instructor coordinates the trip with local manufacturing businesses to coincide with the topics being taught in the lecture portion of the course. Cooperation from local manufacturing businesses is invaluable in the effort to making this educational experience successful. Accountability of each student for information ascertained on the industrial field trip is reflected in a formal trip report. The positive influences of this 'learning beyond the classroom' experience are supported by more participation in class discussions and improved performance on exams and case studies. In a broad sense, these industrial field trips have enhanced student learning in this class and will hopefully provide a valuable link between the student's pre-professional experience and their future in the real world.

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VIII. References

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