Teaching Lean Manufacturing by Learner-centered Methods

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Abstract

A learner-centered environment benefits learning remarkably. For the last three years at Kansas State University, the instructors of IMSE 564 (*Product and Process Engineering*) have tried to create the learner-centered environment to teach an engineering topic *Lean Manufacturing*. Their endeavors have produced encouraging results. Students not only gained the practical knowledge and skills but also acquired the confidence to meet the challenges in their future careers. In this paper, the instructors of IMSE 564 will share some experiences in teaching the course, and discuss how the learner-centered environment was established for the class.

Keywords

Engineering education; Lean manufacturing; Learner-centered environment.

1. Introduction

At Kansas State University, *Product and Process Engineering* (IMSE 564) is an engineering course offered once a year to the senior undergraduates by the Department of Industrial & Manufacturing Systems Engineering (IMSE). It is a required course for the students whose major is Manufacturing Engineering, and the students with other majors may take it as an elective. In the course, the students learn how to design the economic production processes for different products in a competitive manufacturing environment. Since 2002, the instructors (the authors of the paper) have tried to create a learner-centered environment in teaching this class. This practice has received positive responses from the students, and the popularity of IMSE 564 has steadily grown. As can be seen from Fig. 1, the enrollment of IMSE 564 has kept going up over the years starting from 7 students in 2002 to 27 students (pre-enrollment data) in 2005.

The success of IMSE 564 lied in the establishment of an effective leaner-centered environment. By using the learner-centered approach, the students are placed in the center of the education, and they are responsible for the learning. The instructors act as the facilitators to help the students to acquire the basic skills to learn [1]. In the next section, the authors will introduce their experiences in how to use the learner-centered methods to teach the engineering topic.

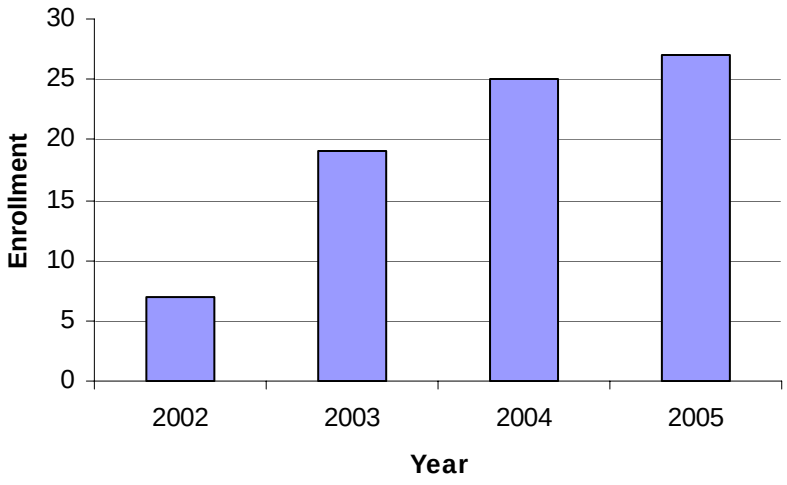

Fig. 1. Enrollment for IMSE 564.

2. Creation of the learner-centered environment in IMSE 564

Learner-centered education was developed a long time ago, and it continues to take on different shapes [2]. The distinguishing characteristics of a learner-centered method are [3-5]:

- Curriculum based on learners' needs;
- Learners' responsibility for contributing to their own learning;
- Teacher's role as facilitator to guide education experience;
- Group activities for practice and learning reinforcement;
- Stimulus for discovery and self-learning;
- Opportunities for discourse;
- Stimulus for inner discipline;
- Project-based learning;
- Basis for learning throughout life.

The instructors of IMSE 564 have had more than four years of industrial experience. From their personal experiences, the learner-centered approach in engineering education is an efficient way to facilitate learning and simulate motivations for engineering students. In order to establish such an environment, they have explored the following five areas:

(1) Select suitable topic;
(2) Encourage group activities of the students with the facilitations of the instructors;
(3) Use multi-media technologies in teaching;
(4) Involve industrial professionals in teaching;
(5) Make the course project-based.

2.1 Topic selection in engineering education

For most senior engineering undergraduates, they have gained considerable capabilities to solve specific technical problems. However, the IMSE 564 instructors think the students should have the knowledge that not only benefits their current job hunting, but also helps them to be successful in the professional development as a team leader, a supervisor, a manager or even a CEO a few years beyond. Based on their extensive exposures in manufacturing industry, the instructors decided to introduce *Lean Manufacturing* to the class.

Lean Manufacturing first appeared in the public domain in 1996. It is an engineering philosophy that teaches people how to make more and more with less and less [6] through a series of techniques (such as Kanban, 5S principles, etc.). *Lean Manufacturing* is becoming more and more popular in manufacturing industry worldwide. The knowledge about *Lean Manufacturing* has become a necessity for the industrial engineers nowadays. An alumnus, who is working as a production manager in a food ingredient company in Wisconsin, said, "To know lean (manufacturing) might not guarantee you a job, but it does help."

The successful teaching of *Lean Manufacturing* needs to be supported by good teaching materials. After careful selection, two books and some technical papers on *Lean Manufacturing* were chosen:

- *The Kaizen Revolution* (Regan, M.D. and Slattery M., Holden Press, 2000). This book is used in the first half of the course. It helps the students to build the basic framework of *Lean Manufacturing* through a fiction story.
- *Lean Thinking* (Womack, J.P. and Jones, D.T., Simon & Schuster Inc., 1996). This book is used in the second half of the course. It introduces *Lean Manufacturing* in depth with a lot of real cases and analyses.
- Some technical papers from industrial magazines. These supplementary teaching materials help the students to digest *Lean Manufacturing* even further.

The students enjoyed these teaching materials as indicated by their comment such as the following: "The books we read are helpful and explain the material in simple ways".

2.2 Group activities with facilitations from instructors

In the learner-centered environment for IMSE 564, group activities were encouraged. Before each session, the students were asked to read several chapters of the books. Each student was responsible for summarizing one chapter, and was asked to collect five "ah-ha's" from the reading assignment. In each session, the students were divided into groups of 3 – 5 people. They were given 10 – 15 minutes and each individual shared the chapter summary and the "ah-ha's" with other group members.

After the group discussion, the students were asked to put forward their questions. The whole class was encouraged to answer those questions. Often times, confusions and ambiguities could be addressed by the students themselves. If a consensus could not be reached among the students, the instructors would guide the students through various scenarios, and help them to identify the possible solutions in different situations.

About once a week, the students were given a short quiz. There were 5 – 10 questions in relevance to the contents of the teaching materials just covered. There were four steps to finish the quiz. First, the students were asked to finish quiz by themselves with closed book and closed notes. Then, they could refer to the textbooks and find the answers from there. Next, group discussions were held to see if group members had a consensus on the answers. Finally, the instructors went over the quiz and answered the questions from the students.

The group activities encouraged the students to learn *Lean Manufacturing* by themselves. It received warm welcome from the students and here are some of their comments:

- "Explaining the concepts and topics with each other in class really does help."
- "I like the group discussion."
- "Helpful to talk with others and discuss our opinions."
- "I like discussion w/in groups + w/in the class. I like the questions we have been working on because they make me think about different situation that may arise w/in the workplace."
- "I think the way you are running class now is fun and stimulating (I enjoy the discussions)."

2.3 Use of multi-media technologies in teaching

IMSE 564 was taught in a technology classroom. The classroom was equipped with a large projector screen, an overhead projector, VCR and DVD equipment, and a computer with Internet connection. To help the teaching process, the professional videotapes - SME Fundamentals on Lean Manufacturing Series - were played in line with the course development. These videos helped the students' learning, as can be seen from the following comments:

- "Movies with oral review questions (keeps my attention on the info. in the movie)."
- "Movies - I like to see stuff actually done in companies."
- "Watching videos where there are examples that are easier to visualize."

To further help the students' learning, K-State Online was also used. K-State Online is an integrated online education platform that is built on Java J2EE technologies. It delivers educational opportunities to individuals when and where they need it through its distance education programs [7]. Fig. 2 and Fig. 3 are the User Interfaces of K-State Online provided to the instructors and to the students.

K-State Online provides benefits to both students and instructors. At anytime, students could log into IMSE 564 via K-State Online and access the lectures, presentations, homework assignments, exams, and grades. They could also post their questions, or submit their homework with this tool. K-State Online also offered several useful functions for the IMSE 564 instructors to prepare and organize the teaching materials, to post the homework, exams and grades, and to answer students' questions online.

Fig. 2. User Interface for the instructors.

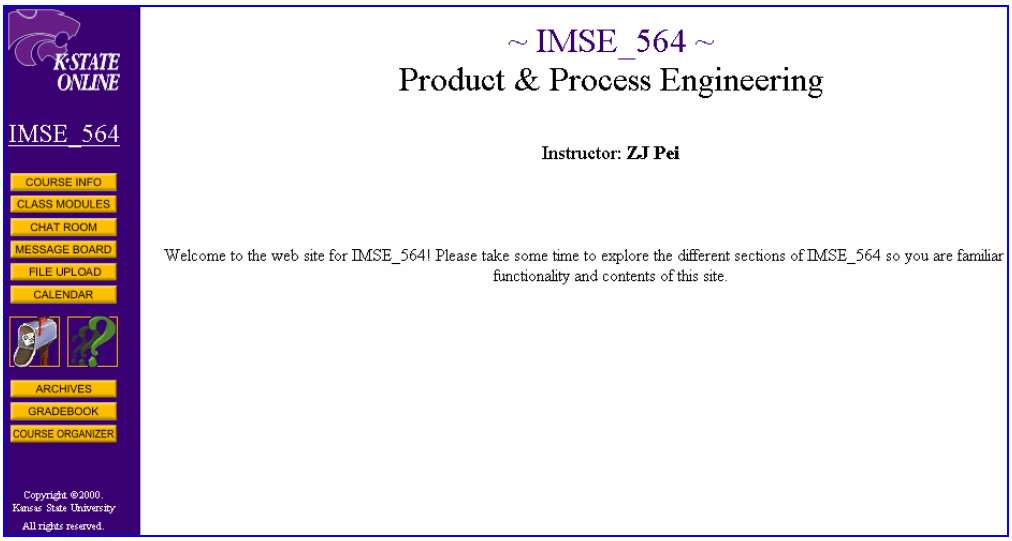

Fig. 3. User Interface for the students.

2.4 Frequent participation of industrial professionals in teaching

In creating the learner-centered environment, the curriculum of IMSE 564 was developed with significant considerations on students' needs. When asked about how the lectures could be better offered in class, the students expressed that they were really interested in listening to the voices from the real world:

- "Maybe have some guest speakers from the 'real world' that could give examples of their lean implementation."
- "Maybe bring in someone who is currently working with lean manufacturing to be a guest speaker."

With the help of the IMSE Department, guest speakers from diversified areas (manufacturing, electronics, military industry, and services) were invited to the classroom. The guest speakers gave vivid presentations on *Lean Manufacturing* implementation in their organizations. Their

practical experience as a senior manager, a researcher, or a shop floor manager often amazed the students.

2.5 Implementation of real world projects

In the learner-centered environment, learning is organized around projects that provide a real-world context and framework for learning [5]. In a project-based learning environment, student teams are presented with complex problems that focus and act as catalysts for what they need to learn [8]. The students of IMSE 564 were encouraged to start seeking *Lean Manufacturing* projects as soon as they could. The students formed several teams on their own with each team having three to four people. After they found the project sponsors (factories, administrative offices, hospitals, etc.) that expressed the interests in implementing *Lean Manufacturing*, the students would visit the sponsors' facilities, observe the production processes, and work with the sponsors' employees (operators, managers, administrators, etc.) to identify the practical problems.

For each project, the students were asked to focus on a couple of practical issues and try to solve them. A final report was required to finish by each individual student when the project was done. Two group presentations were set up as the projects went on. The first presentation was the interim progress report in which the students proposed their problem statement and goal, project scope, and project plan. After the presentation, the projects were better shaped with the instructors' help and each group started implementation. During the implementation period, meetings were held between the instructors and the students whenever it was needed. The problems occurring down the road were solved in these meetings. Finally, at the end of the semester, the students would make the final presentations to report their achievements to the whole class as well as to their sponsors.

The students were enthusiastic and active in these real projects, and were eager to apply what they learnt from school to the real world [9]. Fig. 4 illustrates an achievement after the students implemented 5S principles (Sort, Straighten, Scrub, Schedule, Score) of *Lean Manufacturing* in one project. Substantial improvement can be seen from the picture after 5S were implemented.

From the students' comments, the final projects helped them to:

- "Study and analyze the current manufacturing processes of the product."
- "Develop ideas to improve current manufacturing processes (using what they have learned from this class and other classes)."
- "Conduct cost analysis of implementing these ideas."

The learner-centered environment in IMSE 564 not only helped the students to grasp the knowledge, but also motivated them to gain self-confidence and professional preparation for their future. These benefits were reflected in students' evaluations on this class:

- "IMSE 564 is a class different than any others I have had. This is the only class where I got to apply my theories to a real company."

Fig. 4. An example of Lean Manufacturing projects by IMSE 564 students.

- "This project was a real good opportunity to go and recognize the theory we learn in class."
- "You will be able to apply Lean in a real world situation."
- "I felt like the majority of this course was directly applicable to my future career endeavors."
- "I feel that this class has adequately prepared me (through the course material and the lab project) for any future jobs I might undertake."
- "This class provided me with the best preparation. I learned a lot and it certainly prepared me well for applying my IMSE skills."
- "This class helps a lot to understand the real world situation for notions that seem to be far away from the reality in other class, you do not just talk, you apply it!!! There is no better way to prepare for your career."
- "IMSE564 has provided me with new tools to be successful."
- "I learned the most important things that will definitely help me in my future."

3. Conclusions

The introduction of learner-centered environment in IMSE 564 to teach *Lean Manufacturing* has shown encouraging results. This environment facilitated the students' learning. To create such as an environment, the following aspects have to be prepared or encouraged:

- Clear goals of teaching
- Careful selection of the teaching materials

- Group activities in the class
- Multi-media technologies
- Frequent participation of the industrial professionals
- Real world project assignments

The instructors will continuously improve this learning environment, and will explore the possibilities to extend what they learnt in teaching IMSE 564 to other engineering courses.

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