Experience in a Technology-Based Instruction and Active Learning for a Manufacturing Course

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abstract
At Kansas State University, "Introduction to Manufacturing Processes and Systems" (IMSE 250) is a required course for students majoring in industrial engineering, manufacturing systems engineering, and mechanical engineering. It is also taken by students in other engineering disciplines, and humanities and sciences. It is intended to not only provide engineering students with technical knowledge for further study in their disciplines, but also expose humanities and social sciences students to manufacturing engineering. In past years, technology-based instruction and active learning have been employed to teach this course. This paper presents some experiences in this endeavor.

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Manufacturing
Manufacturing Education
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EXPERIENCE IN TECHNOLOGY-BASED INSTRUCTION AND ACTIVE LEARNING FOR A MANUFACTURING COURSE

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ABSTRACT

At Kansas State University, "Introduction to Manufacturing Processes and Systems" (IMSE 250) is a required course for students majoring in industrial engineering, manufacturing systems engineering, and mechanical engineering. It is also taken by students in other engineering disciplines, and humanities and sciences. It is intended to not only provide engineering students with technical knowledge for further study in their disciplines, but also expose humanities and social sciences students to manufacturing engineering. In past years, technology-based instruction and active learning have been employed to teach this course. This paper presents some experiences in this endeavor.

1. INTRODUCTION

"Introduction to manufacturing processes and systems" (IMSE 250) is an important course. It is difficult to teach due to the following reasons.

The first reason is the diverse background of the students. The students taking this course range from freshman, sophomore, junior and senior year. They came from quite different disciplines. As a student said in a mid-term feedback survey, "One thing I would like to suggest is that all of the students here are not studying engineering. So don't assume we are all the same." Table 1 shows the disciplines from which the recent semester's students came from.

<p>| TABLE 1. STUDENTS' MAJOR CURRICULA |</p>
<table>
<thead>
<tr>
<th>Code</th>
<th>Full Name of the Curriculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAE</td>
<td>Biological and Agricultural Engineering</td>
</tr>
<tr>
<td>CE</td>
<td>Civil Engineering</td>
</tr>
<tr>
<td>EE</td>
<td>Electrical Engineering</td>
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<tr>
<td>ENUN</td>
<td>Engineering Undecided</td>
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<tr>
<td>IE</td>
<td>Industrial Engineering</td>
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<td>ME</td>
<td>Mechanical Engineering</td>
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<td>MFSE</td>
<td>Manufacturing Systems Engineering</td>
</tr>
<tr>
<td>PARE</td>
<td>Architectural Engineering</td>
</tr>
<tr>
<td>ACJ</td>
<td>Agricultural Communications and Journalism</td>
</tr>
<tr>
<td>AED</td>
<td>Agriculture Education</td>
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<tr>
<td>AGBUS</td>
<td>Agricultural Business and Management</td>
</tr>
<tr>
<td>AGEC</td>
<td>Agricultural Economics</td>
</tr>
<tr>
<td>ASI</td>
<td>Animal Sciences and Industry</td>
</tr>
<tr>
<td>ATM</td>
<td>Agricultural Mechanization</td>
</tr>
<tr>
<td>BAPP</td>
<td>Business Administration Pre-Proffessions Program</td>
</tr>
<tr>
<td>ELP</td>
<td>English Language Program</td>
</tr>
<tr>
<td>PHSCI</td>
<td>Physical Sciences</td>
</tr>
</tbody>
</table>

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Students are also quite different in their prior knowledge of manufacturing. In a mid-term feedback survey, one student wrote "You may have presented the material too easily to us. We (students) generally need a little more in depth." In the same feedback survey, other students requested that "Don't move quite so fast." Some students have years of working experience in manufacturing environment, while some have never been on any manufacturing floor. There is a lab course, "Manufacturing processes laboratory" (IMSE 251), associated with this course, but not all the students take it. There is a lab course, "Manufacturing processes laboratory" (IMSE 251), associated with this course, but not all the students take it. Fig. 1 shows the responses from students to a survey question, "The pace of the course was ______" at the end of 2001 Fall semester. It can be seen that there are students at both extremes. It is quite a challenge to keep the students at one extreme engaged without losing the students at the other extreme.

The second reason for the difficulty is the vast scope of the information the course intends to cover. Engineering materials covered include metals, ceramics, plastics, and composites. Semiconductor materials are also covered. In addition to the four families of materials processing processes (casting, forming, machining and joining), heat treatment, powder metallurgy, and non-conventional machining processes are also taught. Material also covered includes silicon wafer manufacturing processes (crystal growth, lapping, grinding, etching, polishing) and semiconductor manufacturing processes (deposition, lithography, etching, CMP, etc.) Concepts of manufacturing systems are also introduced. This extensive coverage demands the instructor to have broader knowledge, and be capable of making appropriate judgment as to what topics to cover and how much of each topic to deliver. The instructor must also be able to explain whole processes rather than specifics about parts of processes. It is important that the instructor can integrate the processes into the manufacturing system as a complete unit.

The third reason is that this course is required for many students and not all of them are interested in the information covered by the course. It is challenging to deliver the information in an interesting or entertaining way.

Fourthly, the size of the class is large. Fig. 2 shows the enrollment of the course in recent three semesters. With so many students, some methods and techniques proven effective for classes with small sizes cannot be used.

This paper presents the authors' experience in dealing with these difficulties. Technology-based instruction and active learning activities have been employed in teaching this course. Some of these activities are discussed below.

2. ACTIVITIES EXPERIENCED

2.1 K-State Online

K-State Online is a course management system designed to deliver an interactive web-based classroom to students. Fig. 3 (on next page) shows the interface of K-State Online when a student logs-on to the course.

Use of K-State Online in IMSE 250 has extended and enhanced the course instruction, enabling students to take advantage of the flexibility of learning over the Internet. Assignments are completed and graded online. Students can
Welcome to the web site for IMSE 250! To the left you should see a navigational panel containing buttons to key areas of the course. Please take some time to explore the different sections of the course so you are familiar with the IMSE 250 website.

Figure 3. Interface of K-State Online when a student logs-on to the course.

Download class notes online. Also available online are various announcements, the gradebook, keys to quizzes, exams and assignments. Fig. 3 shows the different modules currently available for the course.

Students welcome the use of K-state Online. Here are some of their comments.

• "I like the notes online."
• "I like that a lot of this class can be done online."
• "Online is very convenient."
• "Putting PowerPoint online helps a lot."
• "I appreciate the old tests on the internet."

FIG. 3. INTERFACE OF K-STATE ONLINE WHEN A STUDENT LOGS-ON TO THE COURSE

2.2 Multimedia Presentation

This course has been taught in the technology classrooms. These classrooms are equipped with a large screen projector, computers with Internet connection, an opaque projector (ELMO), and an overhead projector. All class lectures are given through PowerPoint presentations with animation. Students enjoy the PowerPoint presentations. Considering that most students are visual learners [Barbe and Milone, 1981; Felder, 1993], many types of videotapes (most of these videos are from the SME Fundamental Manufacturing Processes series) have been used to show students various manufacturing processes (in addition to bringing samples to the classroom for "show and tell").

Students overwhelmingly welcome these practices. Here are some examples of what they say.

• "The PowerPoint is very helpful, the combo of the video and lecture with PowerPoint work very well."
To help you learn better, you would like to watch videotapes in class.

![Feedback Chart]

FIG. 5. FEEDBACK ON VIDEOTAPES.

- "I'm a very visual person and so seeing things in 3-D would really help."
- "I like to watch the videos. I learn more when I get to see what we are actually talking about. Since I am not in IMSE 251, the videos are the only time."
- "PowerPoint is good because it is easy to review."
- "The videos are very interesting by actually seeing real life of machining."
- "Videos demonstrating how process is performed."
- "The videos make it easy to visualize terms."
- "The videos make it faster to understand difficult material."
- "The videos help to tie all of the ideas together visually."
- "I like the videos. I think they provide a lot of information that you just cannot learn from a book."
- "I learned a lot from watching the video tapes. Those tapes are very interesting."
- "The video tapes we watch help because they are easy to understand."
- "Enjoy the videos, I have learned more through the videos than through reading."
- "I enjoy the video tapes in class. The material to me is not very interesting but the videos make it more interesting."
- "At first it wasn't all that interesting, but lately the videos + class become more interesting."
- "The videos are very good and informative. Definitely a good visual aid."
- "I like the videos, they are very insightful, and correspond with what we are doing in lab."

Most students would like to watch more videos in class, as evidenced from the result of the mid-term feedback survey in the 2002 Spring semester (Fig. 5).

### 2.3 Daily Quizzes

For each lecture, every student is given a quiz consisting of ten multiple-choice questions. These questions cover the main objectives of the lecture. Students mark the answers during the lecture. Students overwhelmingly welcome the daily quizzes. They praise the daily quizzes helping keep their attention by highlighting the main points of lectures. The quizzes also serve as study guides.

Students have made the following comments on daily quizzes.

- "The daily quizzes are very helpful, it highlights the important things we need to get out of the lectures and make good study guides."
- "I like the quizzes & the homework. They help me narrow down what might be on the tests."
- "The quizzes are helpful because they make you listen the entire time."
- "I think the daily quizzes are good. They give us points and are good way to ensure our attention."
- "I like the quizzes during class, because they help to remember the videotapes."
- "The quizzes help students have an idea of what will be on the tests."
- "Students are able to learn during lecture through the quizzes."
- "Daily quizzes are a good way to help students pay attention."
- "I like the fact that we have daily quizzes. It's nice to be graded on something other than just tests. Also, I like the quizzes because they acknowledge attendance. This also makes students less likely to skip class."
- "You are expected to show up for the lectures to take a quiz every day. If you don’t, it hurts your grade."

### 2.4 Guest Lectures

Occasionally, guest speakers are invited to lecture on specific topics. These speakers are mainly from manufacturing industries. For example, a guest speaker from Abbott Workholding Products gives a lecture on workholding. A guest speaker from Genmar Manufacturing of Kansas talks about boat manufacturing. A guest speaker from Coors...
Brewing Company presents manufacturing of beers and aluminum cans.

As discussed in Section 1, this course covers a wide range of topics and it is very challenging for one instructor to be an expert on all the topics. Occasionally, other professors give guest lectures on topics within their expertise. For example, Dr. Steve Hanna has extensive experience in composite materials and comes to lecture on composites.

Another benefit of guest lectures is to break the monotonic pattern if one instructor gives all the lectures throughout the entire semester. (However, it is also important that quizzes for guest lectures be equivalent to those for normal lectures.)

The feedback from students on guest lectures includes the following.

- "Having people come and talk about the processes they use in their factories (is helpful)."
- "Guest lectures were very beneficial."
- "I really like guest lectures I really like guest lectures."
- "I like the guest speakers, having more would be good."
- "The guest lectures were interesting."
- "I like Guest speakers – they are a good change of pace from normal lectures."

2.5 Active Learning Exercises During Lecture

As Felder and Brent [1999] pointed out, in conventional lecture classes, "most students are neither practicing nor receiving feedback on anything. They are just sitting there—sometimes watching and listening to the lecture, sometimes thinking of other things, sometimes daydreaming or sleeping. " It is a much different story if lectures are punctuated with brief active exercises that call on students—working individually or in small teams—to answer questions, brainstorm, summarize, or do anything else that they may subsequently encounter when doing assignments and exams."

An activity frequently used in this course is called TTYP (Turn-To-Your-Partners) that the authors learned from K-State LEA/RN program (teacher development program, the K-State Learning Enhancement Action/Resource Network (LEA/RN). This program is designed to help K-State engineering faculty learn about and incorporate active learning into their teaching). Table 2 shows a TTYP activity used when four groups of engineering materials (metals, plastics, ceramics, composites) are lectured.

Another active learning activity is "Identifying Similarity and Differences" described by Marzano et al. [2001]. Table 3 is an example of such activity when lecturing milling processes.

The response of students to TTYP activities is mixed. Fig. 6 (on next page) shows the votes from students at the end of the 2001 Fall semester. Some students say they like TTYP very much. Some examples of what they say are as follows.

- "TTYP and in-class quizzes are very good."
- "Partner discussions are good."
- "Talking to other people is great."
- "More interaction with each other."

| TABLE 2. TTYP ACTIVITY ON MATERIALS |
| Work on your own |
| (1) Write down one manufactured product made from each of the material groups (metal, plastics, ceramics, composites). (2) Why this type of material is used? |
| TTYP |
| (1) Discuss with your partner your writing and thinking. (2) Decide (together with your partner) one product to report. |
| Report to the class |
| (1) I tell the class which product you choose to report. (2) In your group’s opinion, why it is made from the type of material? |

| TABLE 3. IDENTIFYING SIMILARITIES AND DIFFERENCES OF UP AND DOWN MILLING |
| Characteristics | Up (conventional) milling | Down (climb) milling |
| Rotation and feed direction |
| Chip formation | Thin at the beginning and thick at the end; ... | Thick at the beginning and thin at the end; ... |
| Workpiece |
| Work holding and clamping |
| Surface finish |
We spent some time to have discussions and TTYP (Turn-To-Your-Partner) activities. Should I continue the practice next semester?

![Number of Votes](image)

**FIG. 6. STUDENTS' RESPONSE TO TTYP.**

However, some students do not enjoy the TTYP at all. Here are some examples of what they say.

- "I don't enjoy TTYP."
- "I don't like the "work in groups" stuff."
- "To be honest, I am not a huge fan of TTYP. I think that time could be used more efficiently for learning."
- "Maybe getting students to interact with others more than they do, perhaps ones they don't know."

### 2.6 Plant Tours

Several plant tours are organized by the student chapter of Society of Manufacturing Engineers, or the instructor to visit local manufacturing plants. The plants visited include Abbott Workholding Products, Farrar Corporation, Genmar Manufacturing of Kansas, Manufacturing Learning Center.

A lot of students like these tours. They say:

- "I really enjoyed the plant tours at Farrar and hearing the guest speakers. These outside sources were both helpful and enjoyable."
- "Plant tours give good hands-on look."
- "Plant tours are very good for exposure to ideas."
- "I think the tours are a good idea. I can't wait to go on one."

### 2.7 Integration with the Lab Course

There is a lab course that goes together with the lecture course. In the lab course, students obtain...
hands-on experience of using various manufacturing processes by making a machinist’s vise.

### 2.8 Extra Credit Activities

Opportunities are available for students to earn extra credits. They range from active participation in class exercises to online activities. The online extra credit activities are open for some time and will be closed when there are sufficient participants. Fig. 7 shows some activities with students’ responses. Some activities require students to search specific information from the Internet, some are case studies, and some are end-of-chapter problems from the textbook [DeGarmo et al., 1999]. Table 4 is the activity on non-conventional machining processes. This activity is open ended. There is no single “correct solution” to it.

Table 5 is an online extra credit activity associated with abrasive machining. Two examples of students’ responses are also included in the table. In the first response, the student used the knowledge of abrasive machining. This student received full extra credits for this activity. The second response has little to do with abrasive machining. The student still received some partial credits for the extra effort.

Many students actively participate the online extra credit activities. Here are some comments from the students.

#### Table 4. Online Activity Example 1

**Extra Credits Activity - Nontraditional Machining Processes**

If you have read, or heard about, some unique, interesting applications for a nontraditional machining process, please post here.

Please include the following information:
1. Type of the process involved
2. Application
3. Why this type of process is used
4. Where can others verify it (the source, such as page number and title of a book or magazine, name and date of newspaper, web http address)

The applications have been mentioned during class and the examples in the textbook do not count. There will be up to 2 extra credits for each posting.

#### Table 5. Online Activity Example 2

**Extra Credits Activity - Stair Wear**

Adapted from [DeGarmo et al., 1999]

Depending on the answers, up to two extra credit points are available.

Perhaps you have observed the following wear phenomena: A set of marble or wooden stairs shows wear on the treads in the regions where people step when they climb (or descend) the stairs. The higher up the stairs, the less the wear on the tread. Given that soles of shoes (leather, rubber) are far softer than marble or granite, explain:

(a) Why the stairs wear.
(b) Why the lower stairs are more worn than the upper stairs.

**Student Response 1**

The reason why stairs wear in the first place is from the friction and “wear and tear” of people walking on them. Even though the shoes are softer, the soles of them will have particles of sand, dirt, etc. that will scar up the surface of the stairs.

The reason why they are worn more at the bottom than at the top is because as the person walks up the stairs the particles of debris become dislodged. By the time the person is to the top, most of the dirt is gone therefore less scaring of the stairs.

**Student Response 2**

The reason for stair wear has a couple reasons. First is the way energy is transferred. At the top of the stairs as you descend, you have a lot of potential energy at the top and thus would increase your speed as you descend, and increasing the force you apply to each step on the way down, with force increase as your height decreases. And when you go up the stairs, as you approach the stairs, you are moving with great velocity in the horizontal direction, and thus as you ascend up the stairs, the force you apply to each step decreases as you ascend because force = mass * acceleration, and with each step your speed is decreasing and also is the acceleration. Also many times as you get half way up the stairs, you forget something so you have to go back down the stairs thus creating more wear.
• "The extra credit activities are very thought-provoking."
• "More extra credit homework like materials revenue online extra credit."
• "The on-line extra credit gave multiple people a chance at additional points."
• "I like the availability of extra credits."

3. CONCLUDING REMARKS

The authors are encouraged by the results of using the technology-based instruction and active learning activities in IMSE 250. The IDEA (Individual Development Educational Assessment) center [http://idea.ksu.edu] of Kansas State University conducts the end-of-semester student evaluation every semester for this course. The student evaluation on excellence of course for the past two semesters showed significant improvement. Fig. 8 shows the IDEA scores. It is hoped that the score will get even better in the future.

![IDEA Score](image)

**FIG. 8. IDEA SCORE ON EXCELLENCE OF COURSE**

Another encouraging phenomenon is the attendance rate to the class and plant tours. In the most recent semester (Spring 2002), the typical attendance rate of the class has been over 95%. For the most recent plant tour, 39 students attended.

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REFERENCES


