Theme-based Teaching /Learning: A New Approach in Teaching Manufacturing Processes

Dr. Masud Salimian, Morgan State University

Faculty at the department of industrial engineering, Morgan State University

Mr. Yaseen Mahmud, Morgan State University
Ms. Avis L. Ransom, Morgan State University School of Engineering

Early career engagement as a systems and logistics engineer by Department of Defense contractors, Avis Ransom, applied a bachelor's degree in chemistry and an M.B.A. in the management and development of technology and in the application of engineering to address DoD requirements. Following fifteen years of self employment as a business development consultant, she joined Morgan State University's School of Engineering. As Principle Investigator for a Department of Energy contract to transform the building services industry she works with a team to improve training and education for careers related to the high performance (energy efficient) building industry, develops related curricula, enhances career awareness and develops business strategies to help the industry transformation processes. She seeks to explore the postulate that the industrial engineering core competencies offer significant advantages when learning the complex set of skills and knowledge required to audit and analyze buildings for energy efficiency. As staff for the Dean of the School of Engineering, she develops projects, plans and implements strategies and develops and documents reports, newsletters and proposals.

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Introduction

One of the most challenging aspects of teaching manufacturing processes is the lack of laboratory equipment for the vast variety of the processes and techniques involved. In fact, economically, it is impossible to acquire the vast range of facilities and equipment to present even a small portion of the wide spectrum of those techniques. Additionally, new and improved processes with the focus on nanotechnology, green technology, and sustainable manufacturing require a whole new set of facilities and approaches. To rectify the situation, a theme-based approach has been introduced into an undergraduate manufacturing processes class with three main goals:

1. To get students involved in literature research around one major theme related to manufacturing;
2. To investigate, in some depth, the pros and cons of different approaches to the theme topic for the process under discussion;
3. Apply the knowledge gained to improve understanding of the complexity of the issues involved in manufacturing systems.

This approach was implemented in fall semester 2012. We selected the theme of "Energy used in manufacturing processes". Students investigated, wrote reports, produced presentations (both PowerPoint and poster) and discussed the role of energy in manufacturing. This included the cost of production, its environmental impact, and where savings were garnered through efficiency related to energy use. This theme embraces the idea of training 'energy engineers' who are skilled in assessing energy efficiencies and sustainability related to manufacturing. Laboratory experiments have also been developed using a multi-disciplinary approach to give students hands-on experience in energy measurements and economic calculations related to the cost of energy, given various processes. The use of this theme-based methodology will continue in the future with the introduction of such topics as: friction effects, automation, micro and Nano manufacturing, as well as other appropriate related themes.

Manufacturing Process and IE Curriculum

The undergraduate Industrial Engineering (IE) curriculum at Morgan State University (MSU) consists of 134 credits of which two major sequential core IE courses are related to manufacturing processes and technologies. They use the same textbook with the materials protion in the first course (IEGR309: Engineering Materials) and the processes portion in the second course (IEGR363: Manufacturing Processes). The courses are taken during the junior year, upon completion of the physics and chemistry background. The courses culminate into a Product Design course, another core IE requirement. They are also extensively used in several elective manufacturing based courses. Both courses are complemented with extensive hands on laboratory experiments to enhance student learning.

Traditional Challenges and Remedies

The main problems of teaching manufacturing courses are not in the breadth of the processes and the depth of the coverage that an instructor decides to present. The main challenge is how to present and discuss processes and technologies that do not exist in the school laboratories. Therefore, two specific challenges impede learning and make it difficult to maintain student attention. First, the majority of lecture time is spent explaining various pieces of equipment and processes that students have to visualize from two dimensional static images and second, the full extent of diversity, and complexity of processes. For example, many non-traditional and modern processes are done in environments where observation is not feasible such as Nano technology processes.

To remedy that, instructors tend to restrict themselves to processes that they generally use in the lab facilities and equipment available to them (casting, machining) along with video demonstrations. Some that can afford it may also tour a manufacturing facility.

Theme Based approach

We have designed and implemented and experimental approach based on the concept of a theme-based course delivery method. For fall semester 2012 we selected the theme of “Energy use in Manufacturing Process”. The selection came about due to our involvement in efficient use of energy in commercial and industrial research through a research grant shared by several universities of which Morgan State University is also a member. Additionally, the presence of an energy concentration and a well-equipped laboratory facility with a track record of over a million dollars of funded research was also a major factor.

Course Delivery

The course was delivered in an active learning mode where each student was responsible for the following assignments:

1. Preparation: Study the textbook, view 3 to 5 videos related to the processes to be discussed and take notes to enable participation in class discussion.
2. Actively participate in class lecture: Instructor led lecture and discussion engages students and shares various points and observations.
3. Preform and Present Research: Use World Wide Web, on the assigned theme as it relates to the process covered in the lecture, and make presentations.

The following discussion highlights two major experimental parts of the course.

Enhancing Course Delivery

In an effort to enhance student learning, increase understanding, and expand exposure to a large number of manufacturing concepts beyond our ability to demonstrate, we have introduced the use of videos of processes as part of the course requirements. The inclusion of videos is a continuation of the use of multimedia [1] [2] in our course delivery methods. The instructor of the lecture portion of the class has a webpage [3] that includes supplemental class materials and the lab instructor also has a webpage [4] (Figures 1 and 2) that shows the basic outline of the labs hands-on aspects, equipment, and procedures.

Figure 1 Lecture Webpage

Figure 2 Lab Webpage

Although, the use of videos in classrooms is not a new phenomenon, see how the growth of YouTube as an academic source [5]. The way we incorporate it is new. In traditional formats videos are shown during the class period, with students viewing them often for the first time. In our approach videos are not incorporated into the class time, they are assigned to be watched prior to the class. Students are asked to view them in preparation for the class lecture and they are discussed emphasizing the energy use during the class which may then involve showing only parts of the videos.

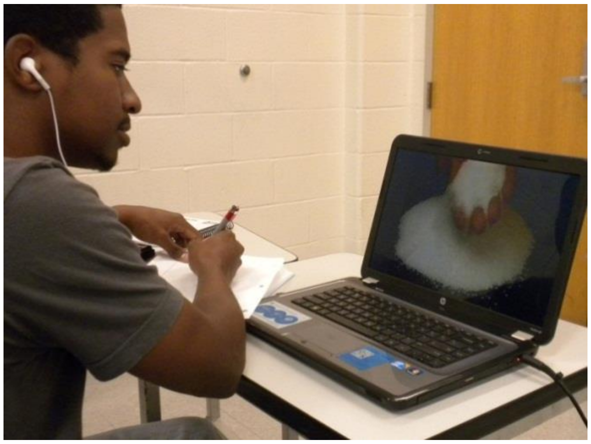

Figure 3 Taking notes while viewing video

Figure 4 Instructor and student

The teaching methodology and delivery of the lecture is changed from *defining processes* to discussing *how* and *why* of processes as well as viewing the energy related questions in the demonstration viewed. Students are incentivized to view multiple videos by increasing the assessment value of their class participation. These efforts are strengthened by the lab work in a coordinated environment between the course and lab instructors.

Why Energy Theme?

Our contention is that before you can introduce energy conservation you must first increase energy awareness. In an urban context the ubiquitous nature of energy doesn't focus attention on the cost of that energy. On the personal level, it is usually those who pay the bills that walk around turning off lights or devices left unattended. On a societal level we have municipalities in the US, in the face of fiscal restraints, deciding they can no longer afford street lights [6].

Energy austerity is having a world-wide impact as indicated by France where the need to reduce public expenditures may be met by turning off the lights in Parris, the city of lights [7].

Attempting to raise energy awareness in the home with a juvenile creates those mundane intergenerational arguments about why every electrical device owned must be on at all times.

College age students are just beginning to face economic realities. Economic choices made due to their independence force a monetary consciousness; however that starts with tuition, room and board. Were students on campus asked to pay utilities (electric, water, and heat) as a separate charge in addition, they might consider that 1000 watt gaming computer's operational cost is in addition to its purchase price.

During the Eisenhower administration with the advent of nuclear power the populace was encouraged to believe that the world would have "energy too cheap to meter" [8]. A later generation was raised on the science fiction of Star Trek, where energy needed to run the replicator and all the societal needs and systems was supplied by fusion reactors based on matter/anti-matter reaction regulated with dilithium crystals with a battery backup system. Such a society never has to consider the cost of operating the phase-canon or face hard choices based on energy cost.

An effort was made in the Manufacturing Processes class to raise energy awareness using a theme based approach to the energy cost related to the processes, thus the pricing of the products produced.

Learning Assessment

In order to assess student learning and compare it to previous classes we used a combination of surveys, feedback, and report/test performance. Since, class lecture and lab have two different instructors, who in cooperation with each other designed the course, we were able to acquire both lab and lecture feedback. Since the same two instructors have been responsible for these classes for over a decade, we were also able to compare the student performance based on grades. Finally, the judgmental evaluations of the instructors were also obtained. Appendix A includes a case study of a writing assignment and a survey conducted at the end of the semester with its analysis and discussion underpinning our conclusions.

Conclusion

The results indicated enhanced learning and an increase in overall interest of the students to do research. It reduced student anxiety about research and created a positive outlook to manufacturing education. It also allowed students to responsibly participate in communities of learning and be productive members of teams as most presentations were performed by teams. The approach, not only allowed us to cover the extent of the content we covered before, but by having students involved in the class and their interest we were able to cover more processes in greater depth.

On the other hand, the improved learning did not significantly result in a higher grade average of the class (from 2.8 for past 3 years to 2.95). In analyzing the results we believe this may be due to higher level of expectation by instructors.

Appendix A

Case Study of Assessment

A writing assignment in the last third of the semester asked students three questions:

1. Given a world population of over 7 billion; I want you to look at latest available data on energy consumption of countries per capita. List the top five per capita energy users. Give a gross percentage assessment of their energy mix (renewables, nuclear, fossil fuels, etc.). Include your reference sources.

2. Pick an industrial process and make suggestions regarding what improvements `energy engineers' can contribute to increase energy efficiency and cost savings.

3. You are a founding member of an energy consulting company that specializes in cost reduction though energy audits and process optimization in manufacturing.

You are making a presentation to the international chamber of commerce, which includes many potential clients, on your area of expertise within the company. They want to know your philosophical approach to managing world energy requirements in the near future given the competitive environment for non-renewables worldwide. Please give an overview of your presentation.

The assignment was open-ended following the energy theme structure. The responses to question one varied around two approaches. One group of students followed instructions and reported their findings which included a number of energy producing countries with very small populations, thus increasing their per capita ratio. However, one third of the class assumed that given, class discussion, the true measure was the gross energy users in the world. This discussion mirrored the debate at the Doha Climate Change Conference - November 2012.

As expected, many students, given the traditional processes covered in this class, chose steel production and related processes as the industry in which to make contributions to energy efficiency and cost savings. However, other industries received some attention including: textile, oil refining, redesigning motors, and open-pit mining. These results in particular were of interest because they were not covered in-depth during the class. However, students were beginning to see a greater canvas for energy savings.

The use of self-visualization helps elicit greater creativity in student responses. A number of students remarked that the idea of 'global warming' requirements would spur their work in energy efficiency, and renewables. Other students listed their ‘philosophical approach to managing world energy requirements’ as: use of nuclear power both fission and or fusion; use of on-site renewable sources, inclusive of biofuels; and use of traditional industrial engineering techniques, such as applied optimization.

Survey

At the end of the semester to assess whether the new course strategy has had a positive impact on student energy awareness and an increase in their interest related to energy cost in manufacturing, a survey was administered. This survey (Creswell, 2012) included instructions and information for the respondents as why the survey was conducted and how its outcome may impact future course delivery methods.

Table 1 represents the results of the survey. The survey was designed to elicit statistics in three different areas of concern

1. Assess awareness of energy cost before taking the class.
2. Verification that the energy videos and topics discussed had an impact.
3. Feedback for either improvement or discontinuing the experiment.

It was structured to primarily investigate if the videos were having an impact and to verify that students were viewing the videos since they are not monitored and the activity is outside of class. More than half of the class responded, 9 of the 16 students completing the course, (56%). The basic ideas received positive feedback and were evident in the student responses.

Table 1. Tabulated Survey Results

Question	**Strongly Agree**	**Agree**	**Disagree**	**Strongly Disagree**	**NA**
I was very conscience of energy cost in my personal life before attending this class.	**11%**		**56%**	**33%**	
I was aware and supported energy efficiency as a policy before the class.		**56%**	**33%**	**11%**	
Having had Engineering Economy, I have always thought about energy related cost.		**33%**	**56%**	**11%**	

After watching videos of various types of manufacturing processes, I am more aware of energy cost as part of production.		**100%**			
If I were working in manufacturing, I would be able to bring ideas centered on energy cost reduction to the discussion.		**100%**			
The energy themes in this class have increased my awareness of the need to design and improve energy use as a professional concern.	**11%**	**56%**	**22%**		**11%**
I believe energy is not that significant a factor in the production of a product.			**44%**	**56%**	
Cheap energy will be available to industrial for the foreseeable future and conservation should not be a primary concern for new manufacturing engineers.		**33%**	**44%**	**11%**	**11%**
In the near future, on the global and national level there will be a need for ‘energy engineers’.	**22%**	**67%**			**11%**
As we move towards sustainable manufacturing (green manufacture), a major emphasis will be reduction and savings in energy use and environmentally friendly energy production processes.	**11%**	**89%**			
Because of this class, I realize I can achieve energy savings immediately by implementing changes like switching to compact fluoresce bulb (CFB), changing the HVAC filter, etc.		**56%**	**22%**	**11%**	**11%**

Sustainable design concepts need 'energy engineers' to incorporate ideas of related to energy savings into the life cycle of the product, from manufacture, though use, to disposal.	**22%**	**78%**			

Analysis of Survey Results

Looking at the first three questions which were meant to assess the students' prior awareness level, most students knew the terms from popular media exposure but were not personally vested.

Questions four and five were unanimous among respondents and matched the lab instructors general assessment for the entire class that the videos had a very positive impact in increasing students understanding of energy used in various manufacturing processes. The response to question six bolstered the idea of the theme-based approach with supplemental videos having a beneficial effect on the increased energy awareness of the students.

Questions seven through twelve demonstrate that the students have familiarity on both a personal and professional level of the need for energy engineers in the future.

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