AC 2010-1611: ACTIVE LEARNING TECHNIQUES FOR ENGAGING FIRST YEAR STUDENTS IN A MANUFACTURING PROCESSES COURSE

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Active Learning Techniques for Engaging First Year Students in a Manufacturing Processes Course

Abstract

This paper deals with the instruction and testing of first year students taking manufacturing process courses by determining and raising all students to a common level of understanding prior to covering specific manufacturing processes, the use of active learning techniques, and a unique testing procedure. Through the use of a tailored quiz, instructors can determine the student's current level of understanding relating to manufacturing, and part design. The questions and subsequent discussions allow the instructor to establish a common foundation that each manufacturing process can be built upon. Issues relating to a manufacturing companies department structure and their interrelationships are also presented at this time. Industry like projects and testing methods are detailed along with the resulting benefits. Also discussed is the use of active learning through the use of Mind Mapping and by leveraging the student's use of the Internet and exposure to engineering entertainment media. Mind Mapping is used both by the student and the presentation of material by the instructor. All of these topics have been used for the teaching of eight sections over the past two years. Student feedback has been shown to improve the understanding of material and help improve problem solving.

Introduction

This paper deals with the course delivery of a Manufacturing Processes class consisting of first year students in Mechanical, Manufacturing, and Undeclared Engineering Technology programs. This class is the student's first exposure to manufacturing engineering and exposes them to current manufacturing technologies. Part design and its impact on manufacturing is stressed throughout this course.

Students starting college have very diverse backgrounds, experiences, and expectations. This diversity can hinder an instructor's ability to reach each student effectively and equally. The techniques detailed in this paper have been shown to increase student learning and understanding of material, develop problem solving skills, and expose our students to real industrial issues.

Today's students are the savviest generation relating to personal electronic communication through the use of personal computers, cell phones, and the Internet [1]. They have been referred to as "digital natives," "net geners," "netizens," or "homo zappiens." Whatever they are called, they are the first generation to have been immersed in digital media [2]. Their exposure to electronic media and communication instruments offers a great opportunity for instructors to widen the base of subject related information, expose them to technical resources that are used by industry, and give them an opportunity to develop decision making skills [3].

We are considered "digital immigrants" and must alter the way in which we instruct students in order to maximize their learning. This change should not take place because it is what they have been exposed to. Rather, this is the environment that they will encounter during their careers [3].

Some questions that arise are:

- Although they have large amounts of digital experience, do they have an understanding of how they can use these resources for their benefit in education and industry?
- How can we, as educators, maximize the effectiveness of our courses by leveraging the "digital natives" strengths?
- How can their digital experience help them in their decision-making or problem solving?
- What will make our classroom presentations more interesting and more interactive for our students?
- How can the testing methods and projects we employee, give our students opportunities to be exposed to what industry tasks will be like?

This paper details some proven methods in which we can effectively engage our students that will make them feel that they have input to the course, leverage their communication and technology experience, and allow them to develop a strong understanding of what industry expects of their future employees.

Current Student Knowledge Base

Instructing students is often difficult without understanding the student's background or exposure to a topic. Students that are beginning their education at the university level, come from varying backgrounds and with different levels of understanding relating to the field of Manufacturing Engineering. The discrepancy in this level of knowledge is impacted by many variables such as the middle and high school that they attended, their access to personal computers, availability of media relating to engineering, varying amounts of hands on experiences, their country, and culture.

A determination of the student's previous knowledge and experiences should first be explored. This is done through the application of a short quiz during the first course session. Each question is used to establish a level of understanding of real world issues that relate to parts and their manufacture. After collection and recording of quiz responses, the instructor will review each question by engaging the students in an open discussion; this happens the second class. The students raise many significant points and positions that lead to many learning opportunities that the instructor can leverage. Besides the establishing of a common foundation, it also allows the student's to experience the classroom expectations that the instructor has relating to the running of the class.

Initial Quiz

Below are the questions and the learning points taken from each.

<u>Question 1: Have you ever worked with lathes, mills or drill presses?</u>

- Hands-on experience with machine tools

- Inputs that are required to operate machine tools
- Consumables
- Costs
- Operator training
- Part geometries
- Secondary operations
- Safety

Question 2: What are your learning expectations of this course?

- General discussion of manufacturing families

Question 3: Which is a larger tolerance zone?

a. ± .005
b. + .000 / - .012
c. + .006 / - .002

- What is a tolerance
- Why are there tolerances
- Assembly issues
- Costs associated with tolerances
- How does a tolerance effect a manufacturing process
- Inspection
- Part variation

Question 4: If a hole is measured to be .250" and its mating shaft is measured at .250" will the shaft fit into the hole?

- Fits
- Impacts of design decisions on manufacturing
- Costs

With the previous discussion in tolerances, many students now offer to change their mind on their first response to this question. They begin to understand how the decisions made in the design stage can have positive or negative impact on manufacturing costs.

Question 5: If one part is made multiple times by the same person, of the same material and lot, on the same day in succession, on the same machine, will these parts be identical?

- Manufacturing variability
- Tool wear
- Material variation
- Six Sigma
- Equipment costs
- Inspection

The students are now beginning to realize and understand that there is variability in ALL manufacturing processes and that steps must be built into the process in order to minimize these issues.

<u>Question 6: If you measured one feature on one part three different times, will the part measure the same time every time?</u>

- Instrument variation
- Operator variation
- Part variation
- Sampling

They begin to understand all of the variables that are possible with measurements and how to determine the correct value.

<u>Question 7: What is the purpose of a counterbore?</u>

a. Creating an enlarged hole with a flat bottom so that a bolt head or nut rests below the surface.
b. Boring a hole on a flat surface.
c. Creating a counter for the boring tools to be stored.

- Introduces assembly techniques
- Design intent
- Product agency approvals

<u>Question 8: A lathe and milling machine are examples of:</u>

a. Metal forming equipment
b. Consumer goods
c. Producer goods

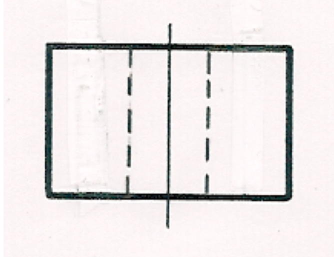
- Types of parts
- Industries and their varying requirements
- How does the industry effect the manufacturing processes
- Why do the costs of parts from different industries vary
- Consumer, Medical, Heavy Industry, Military, Aerospace

By looking at the part requirements needed for each industry, the understanding of tolerances, fits, finish, and quantity required, the students begin to understand the parameters that are to be investigated in the selection of an appropriate manufacturing process.

<u>Question 9: Manufacturing is the conversion of raw materials, energy and purchased components into producer or consumer goods.</u>

a. True
b. False

Question 10: What does the drawing on the board represent?



- Drawings and sketches.
- Interpretation of requirements
- Need to clarify or ask questions
- Design intent
- Legality of drawings and its implications
- Role of manufacturing engineers in design decisions
- Concurrent engineering
- Shop floor personnel and their knowledge

The drawing is a simple, single view sketch that can be interpreted as having at least three different meanings.

With the class having concluded the initial quiz and review, all of the students should be very close to same level of understanding of basic information that relates to all manufacturing processes. Individual processes are now ready to be described, but, in what order and how should we present the topics?

Presentation Order of Manufacturing Topics

The topic presentation order is important for the students understanding of part manufacturing. With any part, materials or pre-forms are developed which will be further processed into the final part. Therefore, the processes should be taught in a sequence that the students see the natural progression from raw material to the finished part.

Casting and deformation processes are taught first as this brings material close to the final part configuration. These pre-forms are further worked on by secondary operations. Most secondary operations consist of material removal processes such as turning, drilling, boring, plating, painting, or further joining.

Through surveys conducted at the end of the course, students revealed that the order that the processes were presented help in their understanding of a manufacturing flow, therefore they were able to grasp and visualize the process throughout each of its steps.

Typical vs. Active Learning Instruction

What is a common thread between today's students? Communication. This generation communicates, writes, and reads more than any other generation before it. This is not to say that they all write in proper English, or that they are reading material of great length. But they do read more than any other generation and they also have much to say [1]. Why can't we take advantage of this "expertise" for the benefit of learning?

The typical way in which we present information about manufacturing processes has changed very little from the way most of us were taught. Students listen to a lecture, do readings, see pictures, watch a video, tour manufacturing facilities, investigate parts, and possibly spend time in a lab "making chips." Students are expected to sit, listen, and answer as they are approached. We also test in ways that are consistent with the way we were tested. Why don't instructors involve their students more in discussions rather than having them simply listen or test them in a way consistent with how industry solves problems?

Active learning is a technique that can pull the students into the material, the discussions, the disagreements, and the learning. They will feel as though they have a say in the direction of the class [2]. But do they really drive the class? Is the teacher truly giving up control of the classroom or is it being controlled stealthy, allowing the students to feel empowered? Testing is changed to being project based in which understanding of the material can be judged as opposed to validating memorization of material. Let's look at a learning technique for students and a problem-solving tool that is being used in industry.

Mind Mapping

Mind Mapping (MM) is a technique that allows students to visually see the connections or links between topics, subjects, or tasks. It is being introduced to students at the high school and middle school levels and should be taken advantage of at the university level. This technique is now becoming widely used in industry also.

The manner in which MM is used during course delivery allows the student's inputs and the instructor's information to be seen in one map although the instructor's notes remain hidden until discussions are concluded. The class utilizes active learning with much interaction and the points and topics raised by the students are input to the MM software during the discussion.

Here is an example of how to use MM in a class that has been proven to be very successful, not only for the students, but for course presentation also.

Homework's are different than the typical assignments of reading and answering questions. The class is still given a reading assignment based on a process, but they are not asked to answer any particular questions. Instead, they are asked to list 10 points about the process or topic that they consider interesting or of importance. Eight of these points can come directly from the readings and two must come from Internet resources. Proper references must be included with each point of interest.

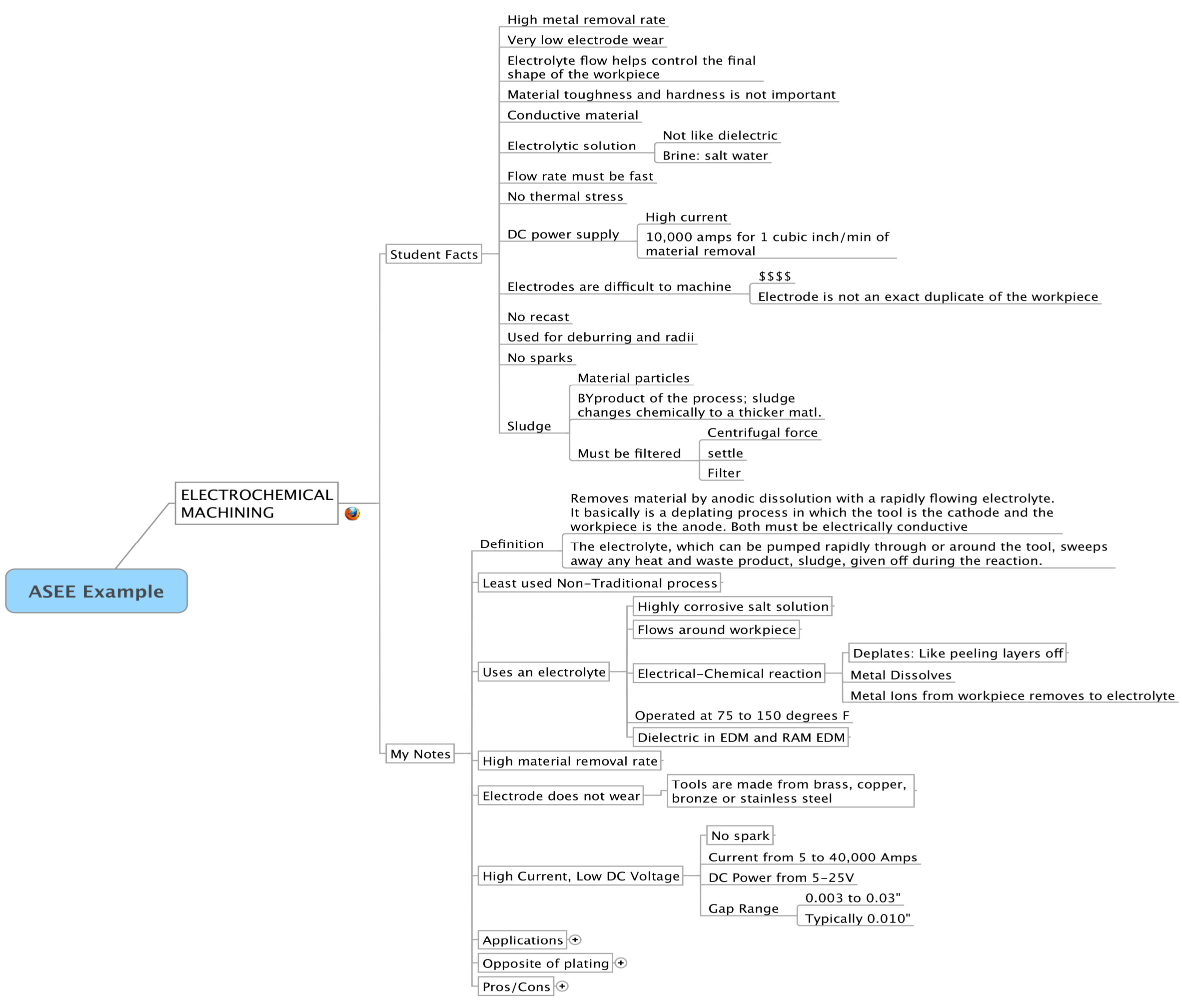
They are also required to investigate and select two pieces of manufacturing equipment required for the process. The only guideline for equipment selection is that one has to be "low end" and the other "high end." As there is never a consensus among the students on what is considered "low" or "high" end, instructors can use it to drive discussions that will cover cost, speed, repeatability, maintenance, operator training, energy consumption, and material size capacity.

Students must submit a copy of their work to the instructor and they are to keep one for themselves so it can be referenced during the class when the instructor asks the student to share the points they felt were important. Many of the students do come up with common facts, but the logic behind the selection is often different which leads to teaching points that can be taken advantage of.

As the class progresses, each of the student points are input to the mind map which is on display for the entire class to see. By showing the information in the mind map, connections between ideas and facts will be visually displayed.

During class preparation, the instructor is required to place the material to be covered during the class into the mind map. This material remains hidden from the students during the homework discussion. When all of the inputs from the students have been heard, discussed, and put into the mind map, the instructor material is then opened for viewing in the mind map.

This is an example of a mind map from a class:



The interesting outcome of this process is that consistently, 90 to 95 percent of the material that was to be presented by the instructor has already been covered through the student's inputs and subsequent discussions. Instructors can shape the remaining discussions to cover the material that was not brought up by the students. Feedback to this style of classroom delivery has been overwhelming in its approval:

- "I was able to see the connections between ideas."
- "The class was very interactive and interesting."
- "It was better than just listening and taking notes."
- "Wish all my classes were run like this."

A side note about the using MM software in class is that all students can see the same information and relationships as everyone else. This can be a significant benefit for those students that have a hard time taking notes or are impaired in some manner. The mind map can also be distributed for the student's use, which tends to keep them in the discussion as opposed to spending their time taking notes.

The instructor never truly gives up control of the class and the students participate in a way that demonstrates their understanding or beliefs of the material. It is an act of discovery on their part, which drives excitement and possible passion for the material [2]. It's has increased learning and, per some students feedback, "fun."

Project based on Engineering Entertainment Media

Today's students have been exposed to greater amounts of casual engineering information than ever before [1]. There has been an explosion of informational entertainment relating to engineering and particularly manufacturing processes in the past 5 years. Our students have been exposed to this and may have been the driver for them to continue their education into engineering. Why shouldn't instructors take advantage of this "baseline" knowledge and leverage for the student's advantage?

Students are asked to investigate the manufacturing processes used in an episode of "How It's Made" which is a program that is shown regularly on The Discovery Channel and is available on the Internet. It shows all of the manufacturing processes that are needed to build a particular product. The processes that are to be analyzed from these shows are those that are being taught in the class.

Each student is required to select a product that is of interest to them and complete the following list of deliverables:

1. A COMPLETE list of all of the steps in the production of the product they've selected.
2. A listing of the manufacturing processes from the show that we are covering or have covered in the course.
3. Each manufacturing process from class must be fully defined or explained demonstrating their full understanding of the process.
4. A listing and short description of any processes that have NOT been covered in this course.

5. List and describe any other process that they feel might be suitable in the manufacture of the product. If they do not feel it can be improved, they must describe why.
6. What suggestions do they have in order to manufacture the product more effectively?

This gives the students an opportunity to select products or parts that are of interest to them, which gives them, added incentive to understand the process. Feedback relating to this type of project has been very positive, as a large portion of the students has already been exposed to these shows. Those that have never seen the shows previously are now exposed to these "learning opportunities."

Industrial Simulation

In industry, parts made by Rapid Prototyping will often be available for employees to look at and gain ideas relating to the manufacturing required. So if this is the way industry is providing information for decision making available, why shouldn't our students be exposed to this technique?

A project is presented as a real work assignment. Acting as the department head, a rapid prototype part is presented to the students. The manner in which it is presented is consistent with industry procedures [3].

As the students get an opportunity to examine a rapid prototyped part, no other information is offered to them. As they have had an opportunity to learn about product specifications and the sequence of steps required to bring a concept to fruition, they must develop the questions that will allow them to evaluate the processes and steps required to deliver this part on the established schedule.

Allowing time for the students to reflect on the part and what they have learned in the class, they start to ask the questions about the product requirements that will allow them to successfully select the correct process [3].

The following is a list of the deliverables for this project:

1. Select the material required for the part.
2. Describe why this material was selected and is considered suitable for this part.
3. Select a process that is compatible with this material.
4. Define this process completely.
5. List and describe other processes that may have been suitable to choose from and explain why each of these processes was not chosen.
6. Fully describe ALL of the steps required to make these parts.
7. Select real world machinery required for the production of this part. Include product information sheets and pricing from the manufacturer of the selected equipment.
8. Estimate the amount of material required for this process and define the cost of this material from current day prices.
9. Define any other costs that you feel should be considered for inclusion in this process to determine an estimated cost for this part.
10. Calculate the estimated cost for the part. Show your calculations.

11. Define the schedule chosen for the making of theses parts and explain your reasoning thoroughly.
12. Complete an Executive Summary for the report.
13. Offer suggestions that could improve the capabilities of a current manufacturing process.

As the first step in this process is to determine a material for the application, they utilize information they have learned in a concurrent materials course. The determining of the material is done with the full cooperation of the instructors in both courses and establishes a relationship between these courses. A different rapid prototype part is offered later during the course without the project steps being specified. This verifies the students understanding of the process steps to bring a part into production.

Testing using Slideshows

A learning objective for manufacturing classes is to judge the ability of a student to identify how a part was made. In order to effectively determine this, a part should be made available for all of the students. How do you make sure that each student has a part to examine? Do you purchase a part for each student? The obvious answer to this is that it is normally impossible to do because of the number of students and the budget requirements to purchase parts. How can you get over this hurdle?

One or several parts are distributed around the classroom in order to give each student an opportunity to investigate the part for weight, finish, material, and detail. Once everyone has make some initial conclusions about the parts, detailed photographs of the part are displayed on the room's video display for referral during the test. This allows each student to refer as needed to the photographs refreshing their thoughts and validating their ideas for the questions asked. This is a new twist on traditional testing that allows students the same opportunities that they will see in industry for making decisions.

Project Based on Current Products

During each course offering, a part is selected that is made with a combination of processes that have been investigated. These parts often utilize a new technology or a variation of a process. The students are given these parts to investigate and determine exactly how they are made. During one of the sessions, the results of the investigation are collected and shared much like the typical class described above.

Paradigms and Process Improvements

Throughout the class, students should be challenged to discover improvements for current processes. Often, questions are asked relating to the process; why one technique is better or done in a certain sequence. When these types of situations arise, instructors should encourage or offer the student an opportunity to investigate their ideas. This will very often open itself to research opportunities. This is a win-win situation for the student and the instructor.

Recommendations:

- Establish a solid foundation of information that is relevant across all processes through the use of a quiz on the first day and the review of that quiz on the second class thereby establishing a base from which to grow the subsequent processes.
- Leverage the student's knowledge and experience using the Internet, media, and exposure to engineering entertainment.
- Allow the class to become very interactive while maintaining control by driving the discussions toward class objectives. Today's students lose connection with the instructor very quickly using simple lecturing.
- Let the students feel that they have input in the direction of the class and take advantage of these inputs by recognizing them as learning opportunities.
- Incorporate Mind Mapping Techniques.
- Teach the processes in the order that they take place in industry.
- Incorporate engineering entertainment into project work.
- Simulate industry applications as much as possible.
- Use media in your lessons and testing.
- Encourage recommendations to processes while offering opportunities of research and support. Open the avenues to process evolution.
- Encourage students to find a process that interests them and encourage them to come up with potential research topics relating to that topic.

References:

[1] D.Tapscott, *Grown Up Digital: How the Net Generation is Changing Your World.* New York: McGraw-Hill, 2009

[2] T. McCain, *Teaching for Tomorrow: Teaching Content and Problem Solving Skills.* Thousand Oaks: Corwin Press, 2005

[3] C. Fadel, B. Trilling, *21st Century Skills: Learning for Life in Our Times,* San Francisco: John Wiley & Sons, 2009