AC 2009-1264: STUDENT PERCEPTION OF A SERIES OF ACTIVITIES IN A MANUFACTURING PROCESSES COURSE

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Student Perception of a Series of Activities in a Manufacturing Processes Course

Getting students involved in experiential activities in a manufacturing processes course is important to meeting the learning objectives; however, with limited facilities and classroom time, some creativity is required. Here, a series of activities was conducted during the entire semester and students were asked to comment of the value of the activities. An assessment survey was developed and administered to students at the end of the semester. The survey recorded the student's perception of the activities relative to each other and their value with respect to the course outcomes. The results provided insight to the student's favorites; what unique or personal opinions were formulated; which activities best enhanced learning; and student suggestions for improvements.

The objective of the Manufacturing Processes (IE314) course is to provide engineering students with basic information on materials and processing necessary to change stock materials into useful, value-added products. The course learning objectives state that the student will be provided with the tools to qualitatively describe: 1) the workings of a variety of processes, 2) the relative advantages and disadvantages associated with the individual processes, and 3) the interrelationship of a single process to other processes in the fabrication of a complete assembly or product. Some 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 15-week course is presented in a series of classroom lectures and experiential lab activities. The textbook used for this course is Materials and Processes in Manufacturing, E. Paul Degarmo, JT Black, Ronald A. Kosher, John Wiley & Sons, Inc., Ninth ed., ©2003. The course is held on three days per week for a 50 minute class with an extended laboratory period on Friday, allowing up to two hours for these activities. Each student was assessed by her/his performance on quizzes, exams, homework assignments, and written work associated with the lab activities.

The lab activities completed in this manufacturing processes (Spring 2007) course included:
a) "Attention to Detail" – writing and following directions for an everyday task,
b) Machine Shop Observation – turning and milling of three different materials using the same machining parameters with a worksheet,
c) Video Field Trips – viewing of technical videos independently with brief written report,
d) Industrial Field Trips – touring a manufacturing facility with a written trip report,
e) "Quick-n-Dirty" CNC Machine Activity – modeling the actions of a 5-axis CNC machine on simple component shapes with in-class reflection/ discussion,
f) Material Selection Activity- using materials selection software to validate the choice of material and manufacturing process(es) for a selected component with a worksheet,
g) Portable NDT (Non Destructive Testing) Kit – conducting an independent investigation with in-class presentations and reflection/discussion, and
h) Traditional Lecture.

Some of these activities are well-proven and the "Quick-n-Dirty" CNC machine activity, the material selection activity, the portable NDT kit will be highlighted in paper. All were timed to coincide with the lecture, reading and homework assignments.

The Experiential Activities: Description, student involvement and insight

As the first activity of the semester, students were tasked to write directions to 'unwrap a Hershey Kiss' and then reflect on the specificity of their written instructions. The goal here is to have students improve their powers of observation and "Attention to Detail", as they reviewed each others directions. With prompting from the instructor, the correlation between a machine tool and manufacturing process can be made and the need for very detailed directions on a process sheet can be highlighted. Class discussion can be easily carried out with respect to general issues, such as process sheets, work holding devices, lot size, worker skill, measurement, inspection, and automation.

The goal of the Machine Shop Observation is to have students perfect their observation and inquiry skills necessary for success on the shop floor. Often in an industrial situation, the engineer is not allowed to touch the machines, e.g., a union shop. So the engineer must use their technical knowledge, and their ability to observe and record important information about the process, in this case, turning and milling. Low carbon steel, aluminum and brass were selected for the dramatic differences in chip formation. The same machining parameters were used to make all the roughing and finishing cuts. The students are required to complete a worksheet, which included machining parameters, surface gage measurements, and general observations on chip formation, tool-work relationship, heat generation and work holding devices.

In order to provide a visual complement to the text and lecture, video and industrial field trips were held throughout the semester. A variety of videos on topics such as casting, welding, NDT inspection, injection and blow molding of plastics, were held on reserve in the library. Students could view them at their leisure (rather than in class). The trip reports provided accountability by the student and formal way to assessment their knowledge and involvement in the activity. Sample questions on video trip report are as follows.

1) Discuss the fundamental principle involved in plastics processing.
2) Describe two variations of the technology and the manufacturing process that you observed in the video.
3) List three issues or factors important to the implementation of the process described in question #1 and #2.
4) Describe examples of two parts (or components) that are produced using this manufacturing process and best illustrate the important factors in the process.

Industrial field trips are planned to coincide with the topics in lectures and in the readings assigned for homework. The logistics for getting the entire class to attend are a bit tricky and the location of the industrial facility must be within 20-25 minutes of the college. With a 1 hour tour, the trip can be completed in the 2 hour lab period on a Friday afternoon. The trip report provided accountability by the student and a formal way to assessment their knowledge and involvement in the activity. Sample questions on industrial field trip are as follows:

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

2) List and describe five issues or factors important to the implementation of the processes described in question #1.
3) If you were a new hire at the company, what information, resources or background information might you request?
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?

As the title suggests, "Quick-n-Dirty" CNC Machine Activity is very simple in-class lab to develop the student's appreciation for controlling the motion of a five-axis CNC machine. The goal is for students to gain insight on motion control systems and programming, workholding devices, and unique aspects of several part geometries. Students are presented with the text figure and machine tool photograph, as shown in Figure 1. Each group is assigned a part of certain geometry in this class (as shown in Table1); the seating arrangement dictates 6 teams of 3 students each. The students receive a package of ModelMagic[TM Crayola] and sheet of graph paper (to simulate the x-y table of the machine tool). Although rough, the student's arm simulates the z-axis, their wrist simulates the rotation or B-axis and their grip on the pencil acts as the w-axis. It takes approximately 1 ½ hours to complete in-class, with at least 45 minutes dedicated to reflection and discussion. The instructor prompts the discussion as each group reports their 'process methodology' to the class. As one might expect, the process sheets for the rectangular pieces include specific measurements (based on x-y grid lines) and little concern about the z- and w-axes or the rotation. However, the group with the 'dome' usually has no specific measurements and is very concerned with the z-, w- and rotation axes, and often, the 3-D diamond group can not figure out how to incorporate a workholding device into their process. The instructor can lead the discussion on concepts such as point-to-point control, straight-cut control, contouring control, and the 3-2-1 principle for workholding devices. A reflection paper is assigned to formally tie the activity to the concepts in CNC automation and manufacturing.

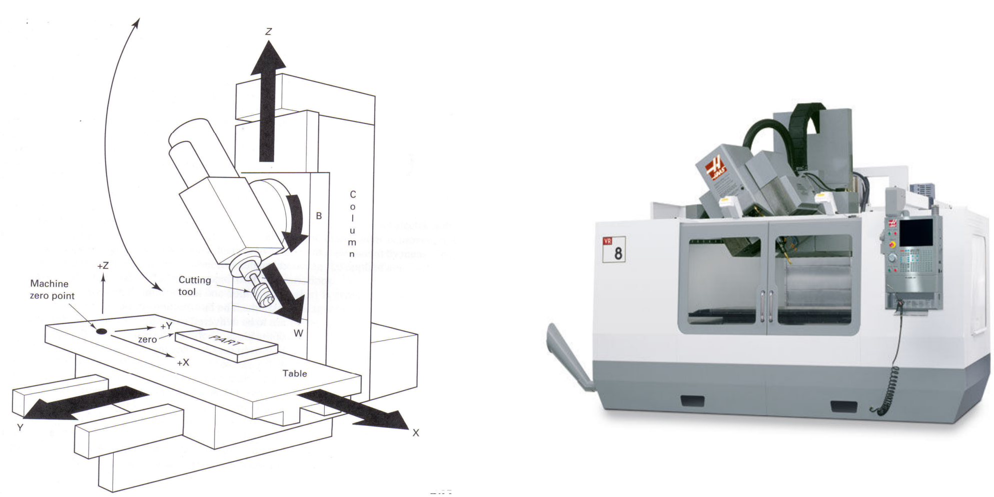

Figure 1. Schematic of typical 5-axis CNC machine[1] and machine center[2] used in manufacturing.

To support this in-class activity, the handout developed for the students is quoted;
"You will simulate a CNC machine tool by 'machining' your initials in your workpiece. Each group will have a different shaped work piece (Table 1). You must simulate each axis of motion and observe the steps you need to complete the job. Detailed directions for the activity are presented in class and the reflection paper for this activity will be posted on the on-line classroom.".

Table 1. The workpieces (approximately 2-3 inches cubed in size)

Group	Workpiece	Description
1	Cylinder	height 3-times the radius initials along length and group # on the end
2	Flat Plate	length x width x small thickness : initials on both sides
3	Dome	3 inch diameter – initials on inside and outside
4	Box (no top or bottom)	initials on each face
5	Cube	initials on each face
6	Diamond (3-D)	initials on alternating faces (top and bottom halves)

The discussion points in the reflection paper are as follows.

1) Discuss the purpose of this exercise as related to Manufacturing Processes and highlight the parts of the exercise that surprised you the most. (½ - 1 page).
2) Reflect on the 'steps' you took to accomplish your task (i.e., initials on selected shape) and write about the insight you gained as you tried to "simulate" an automated machine tool. (½ page).
3) Now, reflect on your impression of this exercise including the new information and insight you have gained. Write about the new insights you have gained and how this any help you evaluate 'manufacturing processes"' in industry. (½ page).

The Materials Selection Activity allows students to utilize software tools to provide solid technical support for choosing materials for industrial and consumer products. The students where instructed in the use of the CES EDUPack Materials Selection software[3] in a 2 hour laboratory session. The applications were provided in the text and included items such as a paper clip, head of a carpenter's claw hammer, jet engine turbine blade, frame of a 10-speed bike, and household dinnerware. Each student selected one application for analysis. A tech memo was the required deliverable with emphasis on supporting information from the CES EDUPack software. The assignment questions were as follows.

1) What are the normal uses of this product or component? What are the normal operating conditions in terms of temperature, loadings, impacts, corrosive media, and so on? Are there any unusual extremes?[1]
2) What are the major properties or characteristics that the material must possess in order for the product to function?[1] Specifically, identify the physical and mechanical properties needed for the functionality of your product. Use CES to help you identify reasonable choices of materials matching these properties.
3) What material (or materials) would you suggest and why?[1] Use CES information to justify your best choice (1 to 3 materials).

4) How might you propose to fabricate this product?[1] Use CES Process Universe to propose a manufacturing process and cite important factors for selecting the process.
5) Would there be any concerns relating to the environment? Recycling? Product liability?[1] Find environmental (ECO) information in Level 2 records in CES.

The quality of responses varied widely and many did not address question #2 properly, that is, did not the use of mechanical and physical properties to describe the material in the application. Many students assumed the common material for that application, looked it up in CES, and reported properties from the material record. Justification of the materials choices did not have the technical depth that the instructor expected. During the next cycle of this activity, the instructor will provide an in-class case study and an example of the type of analysis required for this case study. This is expected to improve the student's ability to think in "engineering terms", while evaluating processes and materials to rediscover ordinary products.

To encourage independent investigation, teamwork and class discussion, Portable Failure Analysis Kit activity was assigned to the class. Students were allowed to pick their own teams of two or three members. The goal was to gain knowledge in the principles, methods and equipment used in Non Destructive Testing (NDT). The activity was adapted from Case Study 11 in text and paraphrased: "You work for a large petroleum corporation with many sites and a variety of equipment. Failure occurs in pumps, valves, pipelines and storage tanks. Your primary objective of these investigations is to collect information, inspect the site, and acquire specimens and samples. Your present assignment is to design and equip a portable failure analysis kit for on-site investigations. Specifications are stated in the case study. [1]"

An example of a student solution to this design problem is shown in Figure 2. These students included simple equipment to perform visual inspection of surfaces, and measurement of feature size, and specialized equipment to characterize internal flaws and material properties. During the presentations from seven different groups students were surprised by the similarities and differences in each kit. Some kits contained specialized equipment such as the pipe scanner and boroscope; most kits contained generic items including a digital camera, flashlight, laptop computer, cell phone; and all kits contained practical items like batteries, safety glasses, pen and paper.

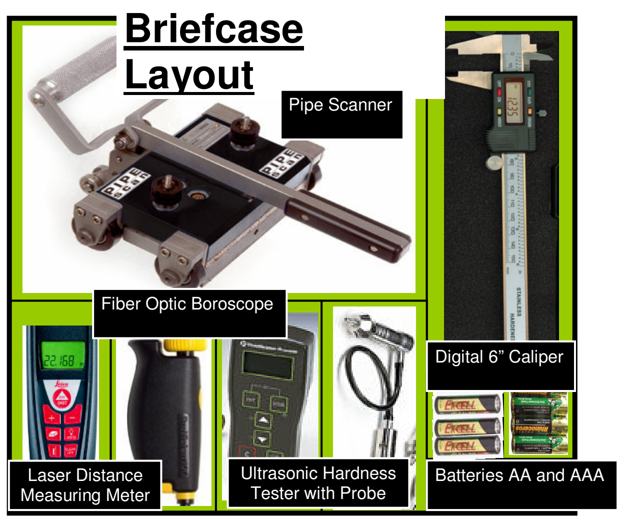

Figure 2. Portable NDT Kit : Student solution (Slide by: IE314 students Sean Salvas, Jason Eckenberger, Colin Stone)

Assessment : survey student based on course learning objectives

Student perception of these activities can obviously ‘make-or-break’ their effectiveness. So the question, “What do students think?”, is addressed through an assessment survey and the results are presented in this section. The class was comprised of eighteen students, who were juniors and seniors with majors in industrial, mechanical or biomedical engineering. The course learning objectives were restated on the survey. Six general assessment questions were posed to the students at the end of the semester and the insight gained from this group of students is summarized below. Specific student responses are found in quotations below responses.

Assessment Survey: Compilation of Results

#1: List those activities which you feel gave you the skills and abilities listed in the outcomes. To what degree do they succeed?

Most mentioned: (5 or more responses)

- Trip to sand casting foundry (Yankee Casting, Inc.)
- Lectures (with book, HW, take home exam)
- Portable Failure Analysis Kit (NDT)

  “…easy way to get the student who did not pay attention in class to actually do some of the reading in the book.”

Least mentioned: (less than 5 responses)

- Videos
- Clay (CNC simulation), Kiss (instructions), Data base (CES material selection)

#2: List those activities which you feel did not succeed in giving you the skills and abilities listed in the outcomes. To what degree did they not succeed?

Most mentioned → least mentioned

- Field trip to Hallmark Cards (5 responses)

  “not good for ME’s”….”It was just conveyors that moved boxes from one end of the plant to the other.”
- Videos (3 responses) • Clay (3 responses) “…already knew a great deal.”
- Kiss (1 response) • Lectures (1 response)
- 1/3 of responses said “…all activities helped…”

#3: List the activities which you feel gave you the best learning experience. Why?

Mentioned most → Least mentioned

- Reinforced lectures - Activity: Field trip to Yankee Casting, Inc. (14 responses)

  “… made information learned in class more clear.”

  “Much easier to grasp the concepts that were being taught.”
- Visual learning (4 responses) - Activity: Field trip to Yankee Casting, Inc.
- “Hands-on” (4 responses) - Activities: Field trips
- Use my creativity (2 responses) - Activities: Portable Failure Analysis (NDT) kit, CNC (clay) activity
- Insight to real world applications (2 responses) - Activities: Field trip to Yankee Casting, Inc. and Hallmark Cards

- Form a different mindset for standardizing work (1 response)- Activity: Unwrapping the Hershey Kiss

#4: List the activities which you feel could be modified or added to improve your learning experience. How?

Most mentioned → least mentioned

- Newer videos (5 responses)
- More trips (3 responses)
- Clay (2 responses) "3-2-1 principle okay, but want to write code."
- Machine shop observation (2 responses)
  "…ME…I have already done this…";, "…Want real world example from industry."
- Database (1 response) "… more clarity on how to do it."
- More quizzes (1 response)
- 3 responses stated "… good mix.."

#5: What qualities do you use when you say an 'activity' is a 'good' one?

Most mentioned → least mentioned

- Relates to material taught in class (11 responses)
- Useful, Interesting, Fun, Real world applications, Visual (5 responses each)
- Hands-on / Engaging (5 responses) "… would love to do it again…"

#6: What qualities do you use when you say an 'activity' is not an effective learning experience?

Most mentioned → least mentioned

- Not related to class/course material (12 resp.)
- Boring (6 responses)
- Don't remember details to write paper (4 resp.)
- Not beneficial to tests, etc. (2 responses)
- Doesn't have interest to our major. (3 responses)

Conclusion

The results from this group of students appeared to show students found favorites and had unique and personal opinions about the activities that gave them the best learning experience. Interestingly, some students cited traditional lectures and homework, and others selected field trips and independent investigations with in-class presentations as best activities for learning. So, students want a) activities to help reinforce or clarify the lectures, b) to see real world applications and c) the opportunity to show their creativity. Based on this assessment, the mix of activities was appreciated by students.

The instructor should a) continue industrial field trips and video field trips, b) increase the scope of the simpler activities, and c) modify the written deliverables. For instance, Material Selection Activity may be too technical and needs to include more instruction and the "Quick-n-Dirty " CNC Activity may be too simple with student's perception being that "they already know it". Future work will focus on improved assessment methods and increasing the student sample, as more sections of this course are taught each year. Additionally, new activities will be developed as the interests of the students changes, however, a mix of experiential learning activities will continue to be delivered, as indicated by the positive feedback from these students.

Acknowledgements
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Bibliography

1. Materials and Processes in Manufacturing, Degarmo,et.al. Wiley & Sons, Inc., Ninth ed.,©2003
2. www.haascnc.com/prod/CNC_large/49713_lg.jpg
3. CES EDUPACK Materials Selection Software, Copyright 2007 Granta Design Limited