Session 3257

Industrial Engineering Made Simple

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Abstract

Many high school students these days do not quickly recognize or identify Industrial Engineering (IE) procedures, practices, and products. Recruitment of qualified students into IE programs requires continuous planning, publicizing, and networking. Traditional recruitment efforts have included high school visits, brochures & flyers, and university-sponsored workshops. However, these techniques have only achieved mediocre success.

Currently, a need exists for new promotional materials that utilize visual tools and provide a "hands-on" approach. We have developed several exercises that successfully introduce IE. Two such exercises are explained in this paper. The first exercise demonstrates the differences between Assembly line and Cellular Manufacturing by engaging the students in various stages of a production line. The students are then asked to study the effects of different strategies as they manufacture a simple product. The second exercise introduces Mechatronics. Students are asked to build a model car that responds to a source of controlled light. In limited trials, these exercises have proven successful.

Introduction

As academicians, we work in the community a great deal to help students gain a better understanding of the field of engineering. We have spoken to a wide range of students from elementary to university levels, and we always receive the same reaction: students are unaware of the industrial engineering field. Although most students can identify electrical, mechanical, or civil engineering responsibilities, few understand or have even heard of industrial engineering. Furthermore, even some other engineers have limited knowledge of the industrial engineering field. The reason for this lack of knowledge, we believe, lies in the complexity of industrial engineering applications. IE impacts a diverse range of industries from banks and securities firms to fast food restaurants and car manufacturers. The increasing need for IE promotional materials has encouraged us to develop innovative exercises two of which are explained in the following sections.

Exercise 1: Assembly Line vs. Cellular Manufacturing

In this exercise, students are introduced to the vast discipline of industrial engineering. One area of particular importance is manufacturing. Through this exercise, students learn the critical differences between assembly line and cellular manufacturing. This exercise enables them to see, experience, and document the effects manufacturing strategy has on throughput, cycle time, quality, cost, ergonomics, and workplace layout.

For this manufacturing activity, we choose a "product" (Figure 1). This "product" is a simple description of an industrial engineer's primary responsibility. The objective of this exercise requires students to simulate cellular and assembly line production of a "product." Students then assess the performance of the production line under various conditions. An extend alternative could be, "IE is concerned with the design, installation, and improvement of integrated systems of people, material, information, equipment, and energy by drawing upon specialized knowledge and skills in the mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design to specify, predict, and evaluate the results to be obtained from such systems."

Industrial Engineers
determine
the optimal way to get a
job done considering methods,
people, time, money, material,
and equipment.

Figure 1: "Product"

Materials needed:
- 2 stopwatches
- 40 sheets of lined paper
- Red, orange, green, blue markers/chalk (a set of 8)
- Red, orange, green, blue overhead transparency markers/chalk (1 set)
- Overhead projector and slides or chalk board

Process:
1. Select 8 students to serve on assembly line.
2. Select 4 students to serve on cellular assembly.
3. Select 2 students to monitor time with stop watches.
4. Separate groups, sit "assembly line" participants side by side and "bend" them around to simulate an assembly line. Create a circular formation for the "cellular" participants.
5. Discuss the field of industrial engineering with the students and clearly display the definition in color on a chalkboard or projector. Then thoroughly explain the activity's objective.

6. Before handing out any materials explain that the assembly line participants will write only their portion of the "product" and then pass it on to the next person. The cellular participants will write the entire sheet, changing markers in between each segment.
7. Distribute one marker, alternating in color, to each of the assembly line participants.
8. Distribute one marker of each color to each of the cellular assembly participants.

Exercise 1.1

Explain that the goal is to manufacture 8 sheets of the "product": 4 via assembly and 4 via cellular. With 8 operators together manufacturing 4 "products" (assembly line) and 4 operators manufacturing one "product" apiece (cellular).

- Ask the students which method they think will be faster. (Most will say the assembly line.) Ask how much longer it will take? Before beginning the exercise, ask if the students themselves have any questions.
- Give 4 sheets of paper to the first person in the assembly line. Give one sheet of paper to each of the cellular manufacturers.
- To begin the exercise, have one student monitor the amount of time it takes for the first sheet and the final sheet to come through the assembly line, and have the other student monitor the final sheet of the cellular manufacturers.
- Place the times on the board. Do not discuss the results in detail yet. (The cellular manufacturing should produce the four sheets faster because of the lead-time of the first sheet in the assembly line.)

Exercise 1.2

The second exercise will be to manufacture 32 sheets of the "product": 16 via assembly and 16 via cellular. Now with 8 operators together manufacturing 16 "products", and 4 operators manufacturing 4 "products" a piece, ask the students which method they think will be faster, and why.

- Give 16 sheets of paper to the first person in the assembly line.
- Give 4 sheets of paper to each of the cellular manufacturers.
- Repeat the first exercise, have one student monitor the amount of time it takes for the first sheet and the final sheet to come through the assembly line and the other student time the final sheet of the cellular manufacturers. Place the times on the board. Discuss the results in detail. Why was the assembly line faster in the production of 16 units, but not 4 units? Depending on the group's interest in this activity and time remaining, discuss throughput, quality, ergonomics, cycle time, setup time, robots vs. humans, workplace layout, standardized work, bottlenecks, hourly vs. piece pay, assembly line balancing, JIT, etc.
- Allow each student to keep one copy of the product so she/he will have an IE definition on hand for later reference.

This activity can be expanded to include more students simply by creating parallel assembly lines or cellular assemblies. Excess students can also serve as observers of the activity, report on the results, and/or lead the discussions.

Mechatronics and Industrial Engineering

Mechatronics is a combination of mechanics, electronics and information technology intended to raise the intelligence level and flexibility of products and devices[1].The increasing need to develop interdisciplinary programs in Mechatronics has caught the attention of some educators. Part of this need is to create an understanding of how new technologies influence the traditional methods of designing products and manufacturing systems. Some educators have proposed an interdisciplinary faculty team for teaching Mechatronics at undergraduate institutes.[2] The interdisciplinary nature of Industrial and Manufacturing Engineering Departments provides a suitable base for Mechatronics programs. Currently, Cal Poly in San Luis Obispo is developing a Mechatronics focus within the Industrial and Manufacturing Engineering (IME) program. While lower-level courses introduce the Mechatronics concepts, new upper-level courses will provide opportunities to gain expertise in specialized areas of Mechatronics.[3-5]

At Cal Poly, we are always looking for opportunities to motivate junior-high and high school students to study engineering. For the last four years, Cal Poly and the Society of Manufacturing Engineering have co-sponsored "hands-on" type workshops that have introduced manufacturing and industrial engineering disciplines to hundreds of junior and high school students. Documentation on the earlier workshops can be found at http://www.calpoly.edu/~salpteki/excite.html.

The second documented exercise was designed to introduce Mechatronics as a special area of interest within Industrial Engineering.

Exercise 2: Smart Car

In this exercise, we ask students to build a car that moves when a light is directed towards it. The students work together as an interdisciplinary engineering team to build a "smart car". We provide each team with a kit, which includes all the components needed to build a model car. A handout with pictures explains the exercise and shows the details of the assembly process (Figure 2).

Materials needed:
Figure 3 details the list of components needed in each kit. Over the years of conducting this exercise, we have accumulated enough parts to build 11 cars (10 teams + 1 model). Be aware, you must prepare the kits in advance and it is quite time consuming.

Process:
1. Clearly explain the activity's objective to the teams.
2. Ask students to form teams of 3-4.
3. Distribute kits to the teams.
4. Ask them to assemble the mechanical components first (Figure 2).
5. Instruct them to write, compile, and download the C program to the microprocessor (Figure 3).

6. Ask them to complete the assembly process by wiring electronic components to the MiniBoard.[6]
7. Provide them with a power supply and have them test their cars with a flashlight.
8. Assist them in troubleshooting if needed.
9. Use a flashlight to check the functionality of each car.

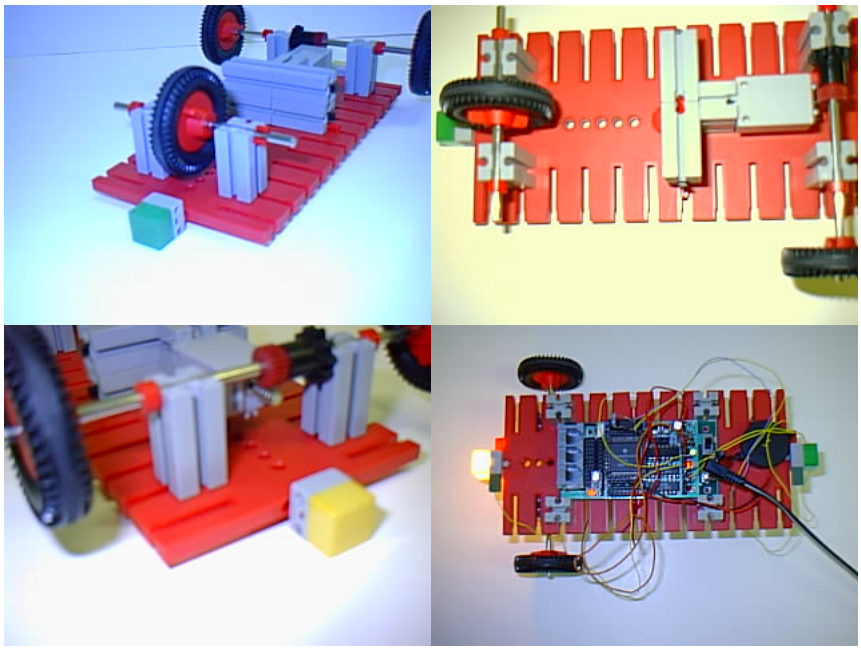


Figure 2: Assembly process of the Smart Car

Exercise 2.1

Ask the students about the changes they would need to make if a new design specification is added, such as having the car move forward by responding to light, and backward with no light. Ask them to implement these changes. (Hint: Modifying the program could accommodate this change).

Exercise 2.2

Ask students to make changes in order to have the light bulbs (one light bulb in the front of the car and one in the back) turn on and off pending the direction of movement. (Hint: New components should be wired. The program should be modified).

Exercise 2.3

Ask teams to find the effects of several changes: New threshold value (200 instead of 100), different sensors, different wheel size in front, different wheel size in back, etc.

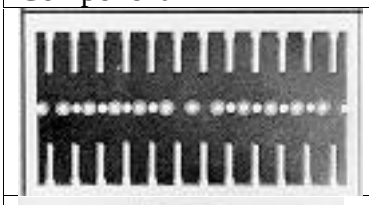
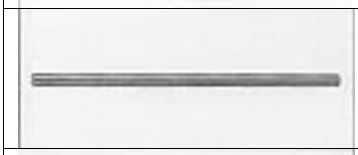
Component	Part #	Quantity	Description
	31001	1	Baseplate 180x90x5.5 Red
	31003	8	Building Block 15 15x15x15
	31003	8	Building Block 30 30x15x15
	31015	3	
	31018	3	Tire 45
	31040 35697	1 1	Axle 90 Axle 200
	31047	1	Cog wheel Z10
	31062	1	Mini motor 6V
	37679	1	Clip 5 with Spring Ring
	38413	2	Plastic Axle 4 30 Long
Light Bulbs, Cover and Stands		2	
Light Sensor		1	
Mini Board		1	
Power Supply		1	

Figure 3: Component list for the Smart Car

Through these exercises, students are able to see, experience, and document the effects mechanical, electronic, and program changes have on the car's performance. This method of introducing the "design" concept of engineering provides an effective "hands-on" exercise. This exercise could also be used in introducing team-building concepts.

```
#include<mboard.h>
#define WANT_MOTORS
#define WANT_BEEPER
#include<mbintsvc.h>
main()
{
    while(1)
     {
          off(1);
          while (analog(1)<100)
          {
               motor(1,16); }   }  }
```

Figure 4: C Program for the Smart Car

Conclusions

Industrial Engineering (IE) is still not widely recognized among junior high and high school students. Recruitment of qualified students into IE programs requires a lot of time and effort. The exercises documented in this paper have been successfully used by the authors in introducing Industrial Engineering and Mechatronics to junior high and high school students.

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Deena Daggett is a first year doctoral student at Georgia Tech in Industrial and Systems Engineering. She obtained her B.S. in Operations Research and Industrial Engineering from Cornell University and M.S.I.E from Stanford University. She worked for seven years as an engineer at the General Motors Technical Center in Warren, Michigan in various capacities. She is currently consulting in her hometown of Washington, DC in the area of public school engineering curriculum development and improvement.

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Sema Alptekin is the Department Chair of Industrial and Manufacturing Engineering at Cal Poly, San Luis Obispo. She has a B.S. and an M.S. in Mechanical Engineering, and a Ph.D. in Industrial Engineering from istanbul Technical University. She received the Society of Manufacturing Engineers' Outstanding Young Engineering Award in 1988. Her research and teaching areas are Mechatronics, Lean Manufacturing, and Fuzzy Logic implementations.