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Introducing Production Concepts – A Hands On Learning Experience

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Introducing Production Concepts – A Hands On Learning Experience

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Abstract

Introducing production concepts to engineering students can be quite challenging. The high resource cost of setting up and maintaining a production environment results in universities tending to teach theoretical concepts and rarely providing a hands on production experience. In this paper we describe a unique hands on production learning experience provided to sophomore industrial engineering students at Mercer University. These students design and develop the process and participate as production workers and industrial engineers for producing 3D yearbooks for the Georgia Academy for the Blind. These student experience first-hand production concepts such as process planning, manpower allocation, assembly lines, cycle time, fixtures, bottlenecks, rework, quality, etc… This experience is the first time some of these students have been exposed to and/or participated in production of an actual product.

Keywords

Production, Experiential Learning, Hands on

Introduction & Background

The US Bureau of Labor defines the profession of Industrial Engineering as "Design, develop, test and evaluate integrated systems for managing industrial production processes, including human work factors, quality control, inventory control, logistics and material flow, cost analysis, and production coordination"[1]. Other definitions include the term manufacturing operations in place of "production"[2]. However, a key term of any industrial engineering definition is production, where production can be defined as "the process of making … goods to be sold"[3].

Introducing and exposing students to production can be quite challenging. While production concepts can certainly be described and analyzed in a lecture format, experiencing production first hand is like the oft used phrase "a picture is worth a thousand words". Ssemakula, et al.[4], contend "The high cost of setting up a manufacturing facility means that universities usually have to make difficult choices about the resources they dedicate to courses in manufacturing. Consequently, many courses in Manufacturing Processes or related subjects are skewed towards theoretical concepts and offer limited hands on experience for the student (if any)". Thus internships or summer jobs at a production facility are an ideal means of exposure, but not all students have this opportunity. Videos of production and field trips to facilities can also be used to expose students to the topic, but this method only offers a small glimpse of the intricate planning, design and control required in today's complex manufacturing environment.

An alternative means of a consistent production experience for Industrial Engineering students is a hands on laboratory experience as part of the students' curriculum. One such lab is described by Ssemakula, et al.[4,5]. Ssemakula's lab spans several courses as Wayne State University which has students designing, machining and assembling a functional engine.

This paper describes another laboratory type experience used in an Introduction to Industrial Engineering course at Mercer University. This experience differs from Ssemakula's in one important aspect. The focus of this lab is to expose students more to production as opposed to manufacturing. In other words, the focus is on how to design a process to produce a quantity (or batch) of the same product, and on how process design, fixtures and manpower effect production efficiency and quality.

Educational Objectives for Hands On Production

The Introduction to Industrial Engineering course is a 1 credit course designed to introduce the industrial engineering to sophomore engineering students. Roughly the first 1/3 of the course introduces the profession including employment statistics, salaries, job assignments, famous graduates, etc. During the middle 1/3 of the course students read and discuss *The Goal: A Process of Ongoing Improvement* by Eliyahu M. Goldratt and Jeff Cox. The final 1/3 of the course is the hands on laboratory experience of designing and implementing a production process to machine, assemble and finish a batch of 3D yearbooks for students at the Georgia Academy of the Blind (GAB)[6].

This lab is designed to present production concepts as an experiential first time exposure. In-depth study of these concepts occur in subsequent courses during the students' junior and senior years. The educational objectives for this hands on production experience include the following concepts:

- Process planning
- Manpower allocation
- Process flow
- Assembly line
- Cycle time
- Learning curve
- Fixtures
- Quality control
- Scrap
- Rework
- Ergonomics
- Bottlenecks
- Data collection
- Process improvement

Each of these topics are briefly discussed and then experienced during the laboratory experience.

The Product – A 3D Yearbook for the Seeing Impaired

The 3D Yearbook product was first designed and produced by Dr. Sinjae Hyun[6] for the 2018 graduating class for the Georgia Academy for the Blind. The product consists of a simple hinged wooden box frame set that opens to display 3D images of each graduating student's face, a nameplate for each student and a plaque identifying the graduating class[7,8]. A yearbook is produced for each graduating GAB student, one for the GAB school and one for Mercer University. A total of 63 yearbooks have been produced over the last 5 years, see Table 1. Figures 1 and 2 below show examples of the yearbook.

Table 1: Number of students and number of yearbooks produced by year

Year	Students	Yearbooks
2018	7	9
2019	11	13
2020	17	19
2021	3	5
2022	15	17
Total	53	63

Figure 1: 2019 GAB 3D Yearbook

Figure 2: 2021 GAB 3D Yearbook

The Introduction to Industrial Engineering course is responsible for producing the wooden frames, applying a finish to the frames and assembling the box set. A separate student project team is responsible for scanning, modeling and printing the 3D heads and for producing and applying the labels and plaque.

The Production Experience

The production experience begins by students handling and observing the 3D yearbook from the previous year. They are then provided the specifications for the yearbook they are to produce.

Time is then dedicated for the class to produce a simple process plan. The process plan is a sequence of production steps. These production steps are then associated with a work station. Due to the nature of the product, the process plan is divided into 2 production days. The first day consists of machining the wood, assembling the frames and applying a finish to the frames. The frames require sufficient drying time, thus the 2 day process. On the second day of production, an inner back board and outer back board are installed, and two frames are assembled together with hinges and a clasp to form a box set.

Along with the process plan, manpower is allocated to each of the workstations. Other students are also assigned to positions such as data collection, material handling, and quality control / inspection.

During the process planning the class discusses the concepts of process flow and assembly lines. The students are also introduced to fixtures and jigs which have been designed to increase the productivity at different workstations.

Preparing for the day of production, safety is emphasized above all else. Next, the concept of learning curves are presented and the students are asked to experience firsthand how their cycle time reduces as they gain experience with their process step. Simple ergonomic concepts are discussed as well, especially if a student is attempting to perform a task using an awkward posture.

While production occurs, students become aware of scrap if a part is damaged during production and the concept of rework, if a mistake is made but can be corrected. Students also become acutely aware of quality if parts are not fitting well, or if the end product does not look good. These production workers experience firsthand what a bottleneck station is, witnessing where product backs up or where workers are idle. Students never seem to pass up the opportunity to point out which station is the bottleneck. Figures 3 to 8 depict examples of the hands on production in 2021 and 2022.

Figure 3: Raw Material Induction

Figure 4: Cut to Length

Figure 5: Frame Assembly

Figure 6: Finish Application

Figure 7: Drying Racks

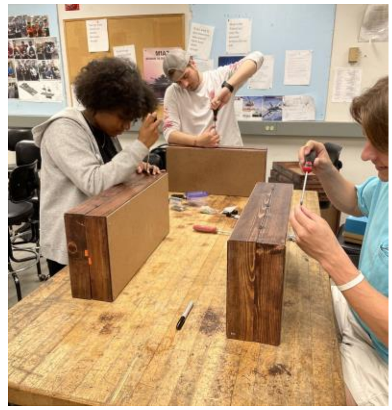

Figure 8: Final Assembly

Students not assigned to a production task observe the process and collect data. Specifically they are collecting cycle times at each station and are noting when quality, scrap or rework conditions occur. These students present their findings to the class on an ensuing day. An example table from their data collecting presentation is shown in Table 2 below.

After the production is complete, time is allocated in class to discuss possible process improvements. Example process improvement ideas from the 2022 class are captured in Figure 9 below.

Table 2: Example data collected and presented by students

Station	Cycle Time (sec)				Production/Quality Issues
1	198	94	77	46	
2	157	59	55	313*	*Board had to be reworked after issue occurred
3	568	255	132	204	
4	293	203	223	119	
5	136	151	38	87	
6	396	181	176	173	
Total Time (sec)	1748	943	701	942	
Average Time (sec)	1083.5				
Average Time (min)	18.06				

Station 1 – Prep 1"x3"x6' Boards
- Buy boards with no stickers.
- Select boards so you don't have to plane
- Sand whole boards, not spots
- Add labor as needed

Station 2 – Slot cut
- Make slightly deeper slot?
- Short cycle time, so help station 1 when possible
- Imperative to purchase straight boards else slot if problematic

Station 3 – cut sides to length
- Don't switch frequently between operators, give them a chance to get into a rhythm
- Blow out sawdust frequently so that jig fully seats, otherwise slight variation in side lengths is very problematic

Figure 9: Process Improvement Ideas

Conclusion

This paper presents a unique production laboratory experience for Industrial Engineering students. These students design, develop and participate in the production of 3D yearbooks which will be presented to graduates of the Georgia Academy for the Blind. This hands on experience allows students to experience various production concepts such as process planning, manpower allocation, assembly lines, cycle time, bottlenecks, reworks, quality, etc… This experience is the first time some of these students have been exposed to and/or participated in production of an actual product.

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