Introducing Operations and Materials Management Concepts with a Classroom Production Activity

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Abstract

This active learning exercise has students build prototype products in order to learn materials control and manufacturing operations management concepts. Students go on to develop bills of material, create planned operations lists and bills of resources. Optionally, the exercise may be expanded to teach materials requirement planning (MRP) and rough-cut capacity planning (RCCP) techniques.

Keywords: active learning; product-process matrix; material requirements planning; bill of materials

1. Introduction

This paper describes the use of a hands-on activity that may be used in either a graduate or an undergraduate class to teach operations and materials control management concepts associated with setting up a production system. The exercise can be easily expanded to introduce the concepts of material requirements planning and rough-cut capacity planning. The exercise is designed for approximately sixteen students in an hour and fifteen minute class session but can be modified as needed. There are four planned activities in the project and two optional ones:

1. Designing a prototype product
2. Establishing a bill of materials
3. Creating a planned operations list
4. Establishing a product bill of resources
5. Simulating Materials Requirements Planning (MRP) (optional)
6. Simulating Rough-cut Capacity Requirements Planning (RCCP) (optional)

2. Review of the Literature

Active learning occurs when students are involved in their own learning. The term "active learning" encompasses a variety of classroom techniques including the use of games and simulations (Michel, Carter & Varela, 2009). Such exercises lead to improved student outcomes and a more productive use of classroom time (Michel, Carter & Varela, 2009). This is because students learn best when they are actively engaged (Heineke & Meile, 1995). These active learning exercises have the ability to inspire and motivate students (Auster & Wylie, 2006) which is reflected in the high rating that students give to the use of games in the classroom (Teach, 2003).

The use of simulations and games is widespread in accredited business programs (Faria, 1998). Many of these illustrate principles of operations management. Heineke and Meile (1995) even compiled a book of such games. Later (2000), they suggested guidelines for developing such activities. This included having students generate their own data, using simple materials, and maintaining a low stress environment. The following activities incorporate these suggestions.

3. Required Material

All of the materials required for this exercise may be obtained from a 'dollar' type store except for birdseed. Buy an inexpensive 5+ pound bag.

- Tools needed per team: scissors, scotch tape dispenser, tablespoon, pencil or pen, pad of paper, stopwatch, and ruler.
- Materials per team: roll of gift wrapping paper, self-stick labels (1 inch), 6 re-sealable poly bags, 6 gift boxes, 12 sheets tissue paper, 2 rolls of ribbon and birdseed.

4. The Exercise

4.1 Designing a Prototype

This exercise begins with a contest in which the student teams design a prototype product. Students are placed in teams of four. Each student – using the tools and materials above – is asked to gift wrap one of the boxes to create a prototype product design with the following instructions:

> "It is your job to gift wrap a box containing a poly bag containing 2 tablespoons of birdseed. You may choose to create the most attractive, high quality luxury product; or, to create an economically wrapped gift. Please take the next 10 minutes to create your prototype".

Once all members of a team have created a wrapped gift, each team selects the "best" prototype product from the samples produced (disagreements to be settled by the instructor). This prototype serves as the model and quality standard for all subsequent production.

4.2 Establishing a Bill of Materials

Once teams have completed Step 1, they are given the following instructions:

> "Please carefully disassemble your prototype package; and, using the ruler, create a bill of materials (BOM) for the packaging and all the components needed to make your product. The bill of materials can be thought of as a "recipe" for the product. Quantities per unit must be exact. Units of measure must be appropriate for ordering the materials. This may require measuring and approximating the amount of tape used in inches and then calculating the percentage of rolls of tape needed to build one product. If pre-preparation of some components is required (i.e. - creating cut lengths of ribbon), create a sub-assembly part number for the final end item."

This step should take about twelve minutes. Each team is asked to read aloud their bill of materials (see example in Appendix 1). By the third team's reading, the instructor may wish to reinstruct teams to call out only their differences to the two previous team's findings. (If a team appears to be struggling with this exercise, it may be helpful for the instructor to require that each team submit their bill of materials for review at the end of class. The instructor can then correct the bills and take follow-up action as needed).

4.3 Creating a Planned Operations List

In this step, teams build one unit of their product taking care to list each step of the production process, the tools used, and the time required for each operation (see example in Appendix 2). Each team will need access to a watch with a time-clock function for this activity. They are also allowed to introduce other tooling (both real and imagined) and to estimate the time that would be required for that process step if such tooling were available. The teams are given the following instructions:

> "Discuss, decide, and identify the number of steps necessary to make 1 unit of your product by the production process type you have chosen. List the production steps in sequential order needed to produce your product along with the tools necessary for that step in the process. Time or estimate the amount of time required for each step as the fraction of hours needed to make 1 unit per each production step."

This section should take about twenty minutes to complete.

4.4 Establishing a Bill of Resources

In this part of the exercise, teams create a bill of resources (BOR) for their product. Similar to a bill of materials, the bill of resources lists the total amount of labor needed to make one unit of the product along with the tools necessary for production (see example in Appendix 3). If desired, teams can optionally be directed to estimate the life of the tooling consumed by one unit of production in order to build in a preventative maintenance program into the BOR. Teams are given the following instructions:

> "Total the amount of labor per each operation from the Planned Operations list and record it on the Bill of Resource. List each tool required for the production process". (Optionally) "Estimate how much of the life of the tool is consumed by its use in the production process. For example, if scissors must be replaced or sharpened after every 500 units are produced, the quantity per unit will be .002. Add these tooling requirements as components on the BOR."

4.5 Simulating Material Requirements Planning (MRP)

In this step, teams will perform a simple MRP explosion to generate monthly material requirements for their product based on the capacity of their chosen production process type. Teams are instructed to:

> "Forecast the monthly inventory needs to allow the maximum utilization of your production process type without planning for safety stock or defects. This can be done by multiplying the quantity of each component needed to make one product by the monthly capacity of the process type. List each component and the amount of material that must be obtained for production".

This activity will take approximately five to seven minutes to complete. Upon conclusion, teams should read aloud the calculated material requirements to the class including the respective units of measure of the components.

4.6 Simulating Rough-cut Capacity Requirements Planning (RCCP)

In this last exercise, teams will use the Bill of Resources to calculate the labor (and optionally, the tooling) requirements to achieve one month's worth of production. This is a straightforward calculation based upon the capacity of the production process type multiplied by the total standard labor recorded in the BOR. Teams are instructed to:

> "Calculate the labor required to produce one month's worth of production. How many operators will be required in total to meet production requirements based upon a standard forty hour work week with no overtime? Round all fractions to whole numbers and be prepared to explain why you chose to round the total number of operators up or down".

Performing this team based activity should provide students with a brief experience in selecting and planning a production process along with some familiarity in planning production operations and materials requirements generation. The assignment is designed to be flexible and can be beneficial to understanding production concepts whether used in part or in total.

5. Summary

This simple in-class exercise has been used several semesters to effectively teach abstract and complex concepts in operations and materials management to both graduate and undergraduate students. Fifty four students have been surveyed and asked their opinion about the exercise. Students found the activity to be both enjoyable (81%) and interesting (80%). One student commented, "It was pretty interesting. The whole group was into it." Further, they recommend its continued use. They certainly suggest it is a more effective learning methodology than reading a textbook (85%), watching a video or listening to a lecture. Another student commented, "I feel that a hands-on project for one second beats a theoretical lecture for one hour."

References

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Appendix 1

Example Bill of Materials

Single level Bill of Material

Final Product:		Qty per	Unit of Measure	Description
Gift-wrapped birdseed		1.00	each	
	Components:			
	Gift box	1.00	each	4 x 6 inches
	Wrapping paper	1.00	sheet	18 x 24 inches
	Scotch tape	7.00	pieces	1/3 x 1 inch
	Ribbon	1.00	piece	21 inches
	Tissue paper	1.00	sheet	24 x 24 inch sheet
	Bow	1.00	each	Various colors, self stick
	Labels	1.00	each	1 inch self stick, white
	Birdseed	1.00	TBL	1 Tablespoon
	polybag	1.00	each	4 x 6 inch bag

Multi- level Bill of Material

Final Product:		Qty per	Unit of Measure	Description
		1.000	each	Gift-wrapped birdseed
Level	**Components:**			
1	Gift box	1.000	each	4 x 6 inches
1	Wrapping paper	1.000	sheet	18 x 24 inches
2	.....Roll	0.300	roll	2 x 10 foot roll
1	Scotch tape	7.000	pieces	1/3 x 1 inch
2	.....Roll	0.018	Roll	1/3 x 393 inch roll
1	Ribbon	1.000	piece	21 inches
2	.....Roll	0.175	roll	1/3 inch x 10 foot roll
1	Tissue paper	1.000	sheet	24 x 24 inch sheet
2	.....Pack	0.083	pack	12 sheets per pack
1	Bow	1.000	each	Various colors, self stick
2	.....Bag	0.100	pack	10 bows per package
1	Labels	1.000	each	1 inch self stick, white
2	.....Box	0.001	Box	100 label box
1	Birdseed	1.000	TBL	1 Tablespoon
2	.....Pounds	0.063	pounds	16 TBS per pound
3	.....Bag	0.013	bag	5 pounds per bag
1	polybag	1.000	each	4 x 6 inch bag

Appendix 2
Example Planned Operations List

Step No.	Operation Description	Labor Est. in Hrs.	Tooling
1	Measure out 3 level TBLs of mixed birdseed onto a small saucer	0.033	Tablespoon, saucer
2	Sort birdseed into 3 groups of approximately the same size	0.083	Tweezers
3	Place each sorted group of birdseed into individual poly bags (3)	0.017	Transfer using spoon
4	Press to close gussetts of polybags to secure seeds inside	0.008	
5	Prepare 2-piece gift box to receive polybags (unfold edges)	0.017	
6	Place the three individual, seed filled, polybags into box	0.004	
7	Place top on gift box	0.017	
8	Tape top of gift box to bottom of box (2 opposing sides)	0.017	Tape Dispenser
9	Unroll wrapping paper into large rectangle (~ 2 linear feet)	0.025	
10	Cut out 4 x 6 inch section of wrapping paper and place aside	0.033	Ruler, Scissors
11	Unfold and spread tissues sheets and position gift box in center	0.017	
12	Fold tissue sheets around box and tape to secure	0.017	Tape Dispenser
13	Place tissue wrapped gift box in center of 4 x 6 wrapping paper	0.004	
14	Wrap gift box with wrapping paper and secure paper with tape to match appearance of approved prototype product	0.05	Tape Dispenser
15	Peel backing and apply label to the wrapped box exterior with placement per approved prototype	0.004	
16	Unroll and cut off a 21 inch length of ribbon	0.017	Ruler, Scissors
17	Apply ribbon to wrapped box per approved prototype design	0.017	Tape Dispenser
18	Peel backing and apply bow to the wrapped box exterior	0.004	Tape Dispenser

Appendix 3
Example Bill of Resources

Step No.	Labor est. in hrs.	Tooling	Tool life in units
1	0.033	Tablespoon, saucer	N/A
2	0.083	Tweezers	50000
3	0.017	Transfer using spoon	N/A
4	0.008		
5	0.017		
6	0.004		
7	0.017		
8	0.017	Tape Dispenser	20000
9	0.025		
10	0.033	Ruler, Scissors	20000
11	0.017		
12	0.017	Tape Dispenser	20000
13	0.004		
14	0.05	Tape Dispenser	20000
15	0.004		
16	0.017	Ruler, Scissors	20000
17	0.017	Tape Dispenser	20000
18	0.004	Tape Dispenser	20000