AC 2011-921: PROMOTING AWARENESS IN MANUFACTURING STUDENTS OF THE NEED FOR SIMULTANEOUS IMPLEMENTATION OF LEAN SIX-SIGMA AND ACTIVITY BASED COSTING

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Promoting Awareness in Manufacturing Students of the Need for Simultaneous Implementation of Lean Six-sigma and Activity Based Costing

Abstract:

Most present day discrete product manufacturing companies make a wide range of products and are continuously seeking to be the best they can be. In the globally linked supply chains of today, the best approach they can take is to reduce variation and waste of all resources utilized in their processes through the adoption of Lean Six-sigma principles.

The central premise of Lean Six-sigma is to only give the customer what they want, when they want it. In doing so, manufacturers need to allocate the correct cost for resources consumed to their customers to stay competitive. Trying to apportion the correct cost to customers is not possible utilizing the standard costing method that most discrete manufacturing companies presently utilize. To rightly charge customers for the services provided to them, Lean Six-sigma requires that the customers be charged based only on what all processes were utilized to satisfy them. Applying Lean Six-sigma principles in discrete manufacturing, hence absolutely requires that firms adopt activity based costing (ABC) or Lean costing, but this fact is not brought forth to students when teaching about Lean Six-sigma.

This paper elaborates on why the connection between Lean Six-sigma and ABC or Lean costing is important if firms are to achieve the promise of creating world-class processes. It also shows how the two concepts should be simultaneously brought to the attention of students to enhance their understanding of waste elimination and variation control in the real world. Teaching the concept of Lean Six-sigma without ABC is detrimental since without the right capture of costs it is difficult to ascertain whether the improvement has been worthwhile or not.

Introduction:

Globally competitive companies everywhere these days want to cut cost and provide outstanding value and service to their customers. Lean manufacturing and Six-sigma which started as two distinct philosophies with their individual set of tools have of late merged into one combined concept of Lean Six-sigma, which manufacturing companies are adopting to satisfy the ever-increasing and changing needs of the modern consumer.

Lean manufacturing has been defined as "a systematic approach to identifying and eliminating waste (non-value-added activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection," [1]. Principles of Lean processes were first identified by Womack, Jones and Roos, [2] [3], when they conducted their five-year, five-million dollar study on the differences between American and Japanese automobile manufacturing companies. In the report that they compiled for the study, that later was published as the book titled "The Machine That Changed The World," they elaborated on how automobile manufacturers in Japan seem to be using less resources to produce the same output compared to American manufacturers. In the report they first coined the term, "Lean manufacturing," by

saying that the Japanese seem to be really lean in the consumption of resources to produce automobiles, and it seems that they are pursuing what can be called *Lean* manufacturing [4].

Six-sigma methodologies were initially formulated by Motorola to aid in improving their cell phone market share, and is a business philosophy and initiative that enables achievement of world-class quality and continuous improvement, along with the highest level of customer satisfaction [5]. Today, Lean manufacturing and Six-sigma have joined forces to become Lean Six-sigma with a powerful array of business tools that can be utilized by companies in their pursuit of waste elimination and variation reduction in products and processes.

Many universities have adopted instruction in Lean manufacturing, Six-sigma or Lean Six-sigma, but what is not brought forth to these students is that companies pursuing to become world-class in terms of productivity and profitability will not be able to achieve much if the costing system implemented in a company is not allocating the right amount of cost to the right customers. To really eliminate waste and reduce variation from the customer's standpoint, you need to only charge what the customer's product or service truly costs you. If you overcharge customers, they will seek a different provider, and if you undercharge customers, they will flock to you as you are providing them products or services below cost, which will ultimately force you out of business.

Hence, product pricing through the use of a good manufacturing costing system truly makes or breaks a company in terms of allowing it to grow and prosper by charging the right price for the right product. Standard costing, where a standard rate is used for all labor along with a factor for all overhead based on the amount of labor, is a costing system that works well if you only have one type of a product or product family. Today, as the range of product complexity and customization in any manufacturing company is broad, standard costing is the not the right system to use.

By using the standard costing system in a company which has a wide variety of product offerings in terms of functionality and complexity, results in a disproportionately higher cost being assigned to simpler products, and disproportionately lower cost being assigned to customized or special products. This results in the company attracting less desirable customized/special products as they are under-cost, and diverting regular or commodity type products which are more desirable in terms of profitability to competitors as these are over-cost. This pushes a company into to a vicious death spiral.

To avoid this from happening, companies seeking to avail the benefits of Lean Six-sigma should adopt activity based costing (ABC), where customers pay for what they get; no more, and no less. In ABC, the premise is to charge everything that you do on all products in the right proportion to the right customer.

Costing a Product Using Standard Costing:

To understand how the costing can be skewed in a job shop manufacturing a wide variety of products, let us assume that a sample machine shop has the following employee costs as shown

in Figure 1. The machine shop hires six employees who work for a total of 10,840 of the 11,440 hours that they are paid per year. Using standard costing, the average cost per employee will be the total cost for having the employees of $250,908 divided by 10,840 hours. This comes to a direct labor rate of $23.15 per hour.

The other costs needed to come up with an overhead cost factor for standard costing are the mortgage cost for the equipment and the other overhead costs as shown in Figures 2 and Figure 3 respectively. The mortgage cost is calculated at an interest rate of 5% per year compounded yearly. The total of the mortgage cost for the equipment and the overhead cost is $89,126 plus $224, 143 or $313,269. Assigning this to the total employee hours of 10,840 comes to $28.90 per hour. Based on these numbers, each labor hour for the machine shop will cost ($23.15 + $28.90) = $52.05 per hour.

To compare costs derived by using the standard costing system and ABC, let us consider a sample product made by the job shop as shown in Figure 4. The machining times for this sample part are estimated for a batch of 175 pieces, and shown in Figure 5. The total time for making this product in the shop is 26.54 minutes. Using the standard costing system, the cost that will be assigned to this product is $52.05 x (26.54/60) = $23.02.

Costing a Product Using Activity Based Costing System:

Let us now attempt to use ABC or Lean costing to come up with the cost for the same product. In ABC, all operations and activities that a customer is ready to pay for are identified and assigned a cost figure. If a cost item can be specifically tied to an operation or activity, it is assigned to that cost center. If not, the common costs are assigned to the cost center based on some measure that allows us to proportionally assign them. A good means to do this is to use the floor space occupied by the cost center if the common cost to be allocated is utilities, which is fairly proportionate to the floor space occupied by the equipment.

To do this, we look at the layout of the shop which is shown in Figure 6. Figure 7 shows how the total utility costs are allocated to each cost center or equipment based on the area occupied. The total cost of maintaining the equipment is the total of the allocated utility cost plus the mortgage cost for each piece cost center as shown in Figure 8. To correctly allocate the total costs based on the hours for which the facility is planned, we need to have come up with an estimate on the Takt requirement for each cost center or piece of equipment, which is shown in Figure 9.

Next, we calculate the cost per hour for the equipment work centers and round them to the nearest adequate number as shown in Figure 10. Next, we take the net hours that we estimate the employees will work for in the year and come up with the rounded cost for each employee or class of employees to allow us to come up with a direct labor cost to charge as shown in Figure 11. Next, we come up with the cost for the sample product as it moves through the various work-centers, and is handled by different employees as shown in Figure 12. The total equipment cost for the sample product comes to $15.99 and the total operator cost for the product comes to $3.91, for a grand total cost of $19.90

Conclusions:

We see that the product cost calculated using standard costing of $23.02 is 15.7% higher than the one calculated using ABC. This could very well mean the difference between a company getting the job and losing it in the globally competitive world of today.

This concept was implemented at a small job shop and tooling company in Goldsboro, North Carolina shown in Figure 13 [6]. The results after 2 years of implementation have been that the company has started getting more jobs that they can turn out quickly, and have stopped getting complex jobs that became bottleneck in the shop floor. Also, they have noticed that if they do get the complex jobs, they are getting well compensated for processing them.

Having an understanding of the shortcomings of standard costing for students and implementers of Lean Six-sigma can mean the difference between processes truly realizing the potential benefits or not. After having deployed an effective ABC system, it is also essential that students and implementers of Lean Six-sigma compare the estimated times to the actual times and create a close loop to let the quoting personnel know how much is the variation, and how to compensate for it to stay competitive. A root cause analysis as to why there is a variation between the estimated cost and the actual cost should be undertaken, and the goal should be to strive to bring the actual processing time as close to the quoted times. Also, the assumptions that go into the setup of the ABC system should be evaluated on a regular yearly basis.

Lean Six-sigma and ABC, done simultaneously and well allows manufacturers to quote exactly what each customer is asking and ready to pay for. With such a system in place, if the customer thinks that the price quoted is too high, the manufacturing company is better off letting the job go to the competitor. Accepting it for a lower quoted price would make the company operate at a loss. Only when a supplier and customer are ready to bear the right cost will they both prosper, keeping their supply chain robust and competitive.

An appropriate costing system plays a major role in creating a world-class supply chain, and students and implementers of Lean Six-sigma should be made aware of this in the very beginning to allow them to realize the tremendous promise of Lean Six-sigma to give and charge the customer only what they want and are ready to pay for.

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Name	Hours/ year	Totals	Vacation Hrs.	Sick Hrs.	Net Hrs/year
John	2080	$65,440	80	40	1960
Jack	2080	$49,840	80	40	1960
Brice	2080	$49,840	80	40	1960
Tom	2080	$40,480	80	40	1960
Nick	2080	$29,248	80	40	1960
Jill	1040	$16,060	0	0	1040
Total	11440	$250,908	400	200	10840

Figure 1. Employee Costs for Job Shop

				5% p y c y
Num	Work Center	Market Value (MV)	Life in years (N)	Equip cost per year (Amortized)
1	Programming	$5,000	3	$1,836.04
2	Engineering	$12,000	4	$3,384.14
3	Purchasing	$4,000	6	$788.07
4	Machine M1	$85,000	5	$19,632.86
5	Machine M2	$125,000	5	$28,871.85
6	Machine M3	$90,000	5	$20,787.73
7	Machine M4	$20,000	7	$3,456.40
8	Shipping	$60,000	7	$10,369.19
	TOTAL	$401,000	TOTAL	$89,126.28

Figure 2. Mortgage Cost for Equipment for Job Shop

Phone	$4,882		Small tools	$785	
Power/gas	$13,315		Operating supplies	$91,544	
Rent	$33,450		Freight	$8,796	
Auto	$7,300		Waste disposal	$1,497	
Advertising	$3,000		Business meals	$725	
Taxes & Licenses	$33,400		Public relations	$497	
Dues & subscriptions	$2,228		Travel	$990	
Office supplies	$2,891		Continuing education	$954	
Professional fees	$2,700		Safety equipment	$269	
Postage	$985		Medical reimnursement	$1,392	
Repairs	$3,917		Bank charges	$554	
Janatorial	$3,300		Bad debt	$75	
Grounds maintenance	$3,425		Salesman travel	$550	
Dumpster	$722				
	$115,515			$108,628	$224,143

Figure 3. Overhead Costs for Job Shop

Figure 4. Sample Product Manufactured by the Job Shop

		Times in minutes		
Operation #	Description	Lot Time	Individual Time	Time per piece
1	Engineering	120		0.69
2	Programming	45		0.26
3	Purchasing	30		0.17
4	Machine 1		12	12.00
5	Machine 2		8	8.00
6	Machine 4		5	5.00
7	Shipping	75		0.43
		270.00	25.00	26.54

Figure 5. Processing Times for Sample Product

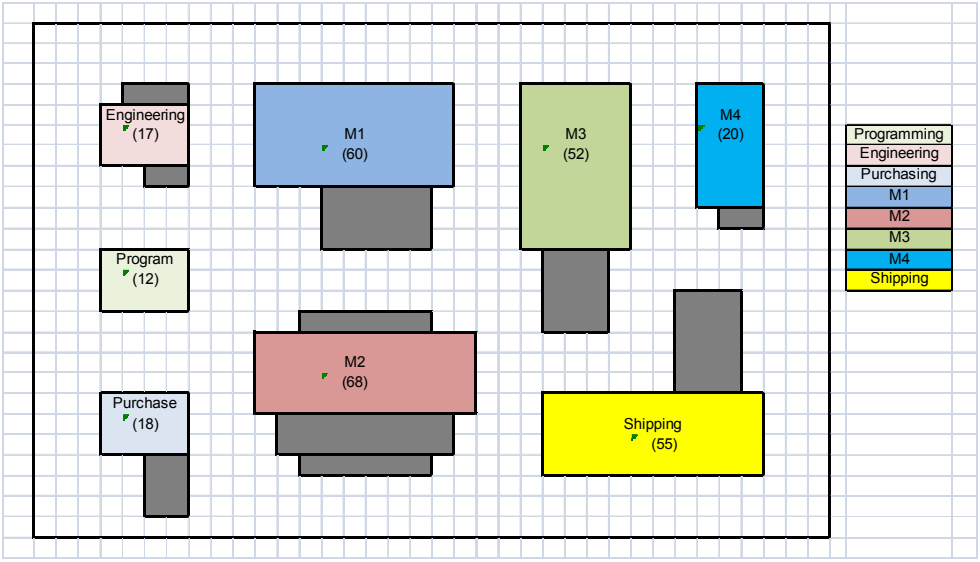

Figure 6. Layout of Job Shop

Num	Work Center	Area occupied in sq ft	% of space occupied	Fixed cost per year (FC)
1	Programming	12	3.97%	$8,906
2	Engineering	17	5.63%	$12,617
3	Purchasing	18	5.96%	$13,360
4	Machine M1	60	19.87%	$44,532
5	Machine M2	68	22.52%	$50,469
6	Machine M3	52	17.22%	$38,594
7	Machine M4	20	6.62%	$14,844
8	Shipping	55	18.21%	$40,821
	TOTALS	302	100.00%	$224,143

Figure 7. Apportioning of the Overhead Cost Based on the Area Occupied

Num	Work Center	Fixed cost per year (FC)	Equip cost per year (Amortized at 5% APR)	Total Cost
1	Programming	$8,906	$1,836.04	$10,742.39
2	Engineering	$12,617	$3,384.14	$16,001.46
3	Purchasing	$13,360	$788.07	$14,147.59
4	Machine M1	$44,532	$19,632.86	$64,164.58
5	Machine M2	$50,469	$28,871.85	$79,341.13
6	Machine M3	$38,594	$20,787.73	$59,381.89
7	Machine M4	$14,844	$3,456.40	$18,300.30
8	Shipping	$40,821	$10,369.19	$51,189.93
	TOTALS	$224,143	$89,126.28	$313,269.28

Figure 8. Total Cost of Equipment Cost Centers

Num	Work Center	Total Cost	% Use	Hours per day	Hours per year (H)
1	Programming	$10,742		1.00	250.00
2	Engineering	$16,001		4.00	1004.00
3	Purchasing	$14,148		7.00	1757.00
4	Machine M1	$64,165	85.00%	6.80	1706.80
5	Machine M2	$79,341	90.00%	7.20	1806.20
6	Machine M3	$59,382	90.00%	7.20	1806.20
7	Machine M4	$18,300	45.00%	3.60	903.60
8	Shipping	$51,190	80.00%	6.40	1606.40
		$313,269			10840.20

Figure 9. Total Cost and Estimated Use of Equipment Cost Centers

Num	Work Center	Total Cost (TC)	Hours per year (H)	Cost per hour w/o operator = TC / H	Rounded Equip cost per hour
1	Programming	$10,742	250.00	$42.97	$43.00
2	Engineering	$16,001	1004.00	$15.94	$16.00
3	Purchasing	$14,148	1757.00	$8.05	$8.00
4	Machine M1	$64,165	1706.80	$37.59	$38.00
5	Machine M2	$79,341	1806.20	$43.93	$44.00
6	Machine M3	$59,382	1806.20	$32.88	$33.00
7	Machine M4	$18,300	903.60	$20.25	$20.50
8	Shipping	$51,190	1606.40	$31.87	$32.00
		$313,269	10840.20		

Figure 10. Cost Per Hour and Rounded Cost Per Hour

Name	Hours /year	Totals	Vacation Hrs.	Sick Hrs.	Net Hrs/year	Cost per hour	Rounded Cost per hour
John	2080	$65,440	80	40	1960	$33.39	$33.50
Jack	2080	$49,840	80	40	1960	$25.43	$25.50
Brice	2080	$49,840	80	40	1960	$25.43	$25.50
Tom	2080	$40,480	80	40	1960	$20.65	$21.00
Nick	2080	$29,248	80	40	1960	$14.92	$15.00
Jill	1040	$16,060	0	0	1040	$16.06	$16.00
Total	11440	$250,908	400	200	10840		

Figure 11. Cost Per Hour for Employees

Op. #	Description	Cost center	Time per piece	Equipment cost	Operator	Operator rate	Time per operator	Operator cost	
1	Engineering	$43.00	0.69	$0.49	John	$33.50	0.69	$0.39	
2	Programming	$16.00	0.26	$0.07	Jack	$25.50	0.26	$0.11	
3	Purchasing	$8.00	0.17	$0.02	Jack	$25.50	0.17	$0.07	
4	Machine 1	$38.00	12.00	$7.60	Brice	$25.50	3	$1.28	
5	Machine 2	$44.00	8.00	$5.87	Tom	$21.00	2	$0.70	
6	Machine 4	$20.50	5.00	$1.71	Nick	$15.00	5	$1.25	Total cost
7	Shipping	$32.00	0.43	$0.23	Jill	$16.00	0.43	$0.11	
				$15.99				$3.91	$19.90

Figure 12. Cost Based on ABC for Sample Product

Figure 13. Company where ABC was Implemented [6].