Lean Manufacturing Principles Applied to the Engineering Classroom

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Lean Manufacturing Principles
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Lean Manufacturing principles are applied in the engineering classroom, both in pedagogy and in classroom activities and management. Muda is reduced both by the reduction in Muri and by the reduction in Mura. Value creation arises from the realization that the reduction of the Seven Wastes will naturally expose the universal drive toward Kaizen events, both by individuals and groups. Kaizen events are here described and analyzed with the insights of philosopher Charles Sanders Peirce (1839-1914). The focus is on intentional continuous improvement by eliminating wasteful actions and the exposure of existing value creating activities.

1, Muri and Mura cause Muda

Muri is the waste of Overburden which beleaguers people when working in environments that are uncertain or stressful. The causes of Muri can be various:

- Communication impediments
- Processes that are unreliable
- Maintenance which is postponed
- Demand that fluctuates
- Instructions which are ambiguous
- Equipment which is unreliable
- Workspaces which are inefficient or overburdened with unnecessary items

Mura is often called the Waste of Unevenness. Mura occurs when lumpy demand causes production workers to scramble to suddenly meet demand, often through resorting to inefficient and ad hoc solutions to exigent problems. Then, when demand slackens, the emergency disappears, and workers fail to prepare for the next emergency. Also workers fail to take measures to even out demand, and fail to take measure to even out their work as needed to meet long-term demand. Uneven demand will put stress on people and processes, driving up excess inventory and other wastes.

Muri and Mura cause Muda, which is often described with the Seven Wastes. Note that overburden and unevenness drive the waste of Muda; that is, Muri and Mura are the causes of the wastes of Muda.

Muda

"Muda is any activity or process that does not add value; a physical waste of your time, resources and ultimately your money. These wastes were categorized by Taiichi Ohno within the Toyota production system, they are;

1. Transport; the movement of product between operations, and locations.
2. Inventory; the work in progress (WIP) and stocks of finished goods and raw materials that a company holds.
3. Motion; the physical movement of a person or machine whilst conducting an operation.
4. Waiting; the act of waiting for a machine to finish, for product to arrive, or any other cause.
5. Overproduction; Over producing product beyond what the customer has ordered.

6. Over-processing; conducting operations beyond those that customer requires.
7. Defects; product rejects and rework within your processes.

To this list of the original seven wastes most people also add the following;

1. Talent; failing to utilize the skills and knowledge of all of your employees
2. Resources; failing to turn off lights and unused machines
3. By-Products; not making use of by-products of your process" [Lean Manufacturing Tools, 2017]

Muri, the waste of Overburden, is often seen in the engineering classroom in the situation where the professor lectures to the class for the entire meeting time. In this situation, the professor is overburden with teaching, while the students are overburdened with listening and absorbing the material.

Mura, the waste of Unevenness, is often seen in the conventional lecture classroom when the course material is presented to students only at lecture time. In contrast, the flipped classroom provides students with the learning material in advance, so that the material can be pre-processed and absorbed before arriving in the classroom; in fact, homework may be assigned before class time, and class time may be utilized to correct and perfect homework. The flipped classroom thus provides a much smoother delivery of learning challenges.

2, Links in the classroom: Structure and Management

Both the waste of overburden, Muri, and the waste of unevenness, Mura, can be alleviated in the classroom through the reorganization of communication pathways, which can be either formally allowed or informally encouraged.

When examining classroom communication pathways, it is important to be aware of the classroom structures that are created by different management paradigms.

Lectures and lecturing will cause the classroom to be arranged as shown in Figure 1, where the instructor as the source of information is shown as a black ball, and the students receiving the information are shown as white balls. This classroom arrangement obviously has the fundamental bases for overburden and unevenness: the instructor is overburdened with active duties, and the students are overburdened with passive duties. Further, there is marked evenness in the distribution of workloads.

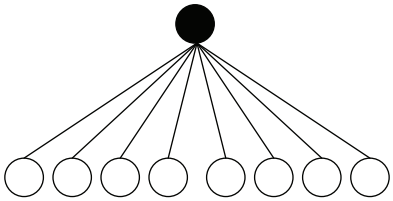

Figure 1: Lecture structure in classroom

Figure 2 shows a Peer-Leader structure which is still anchored in lecture, because the source of all information (black ball) is still assumed to the instructor. Of course, a peer-leader structure begins to allow the peer leaders to contribute their understanding of the instructor's teachings. The peer-leader classroom structure shows improvements in burdens and in the evenness of workloads, but its inherent hierarchical architecture preserve the failings of the pure lecture structure.

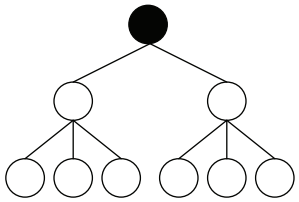

Figure 2: Peer Leader structure

Figure 3 shows a fully connected classroom where all persons, instructor and students, may openly talk to one another. Figure 3 assumes that the source of all information continues to be only the instructor, in which case it is only the dissemination and repetition of the information which is sped up via the full complement of evenly-spread interpersonal connections. The burden to produce original information still falls on the instructor, as does the burden to oversee that all participants remain on-topic.

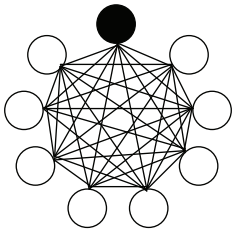

Figure 3: Fully Connected structure

Figure 4 shows a fully connected structure which immediately allows all participants to disseminate their own information (as black balls), which has the immediate effects of greatly diversifying and increasing the information content of the class. All participants share the burden of providing information content and co-instruction, and there is ideally evenness in the workload of teaching and learning. One possible disadvantage of this classroom structure is the risk of de-coherence as completely difference knowledge sets compete for the attention of the participants.

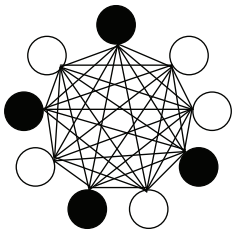

Figure 4: Flipped classroom structure

3, Semiotics of Charles Sanders Peirce

Charles Sanders Peirce (1839-1914) was an American philosopher, mathematician and logician. The cognitive philosophy of Peirce has three basic semiotic elements [Brent**,** 1998]:

1. Object
2. Interpretation [/Observer]
3. Symbol

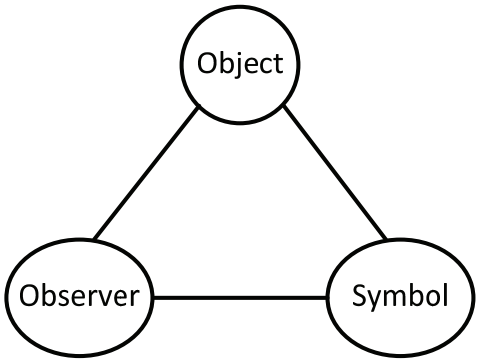

Figure 5: Three semiotic elements of Peirce

The 6 relations among the 3 elements, as pertinent to education, can be written as follows:
1a, Object is present to be observed and interpreted by the Observer
1b, Observer needs the Object to focus on the environment
2a, Observer/interpreter creates a Symbol for the object
2b, Symbol serves as a proxy of the object for the Observer
3a, Object provides a basis for the Symbol
3b, Symbol is a proxy for the Object in the world

Four Incapacities

The 3 semiotic elements of Peirce lead to deeper issues of the difficulty of human interaction with the world.

"Peirce (1868) argued that we have Four Incapacities:

1. No power of Introspection. All knowledge of the internal world comes by hypothetical reasoning from known external facts.
2. No power of Intuition (cognition without logical determination by previous cognitions). No cognitive stage is absolutely first in a process. All mental action has the form of inference.
3. No power of thinking without signs. A cognition must be interpreted in a subsequent cognition in order to be a cognition at all.
4. No conception of the absolutely incognizable." [Peirce**,** 2017]

For now, we will set aside the Four Incapacities and return to Peirce's 3 Semiotic Elements.

The addition of the 3 semiotic elements of Charles Peirce greatly increases the complexity of the interactions present in the Flipped Classroom Structure shown in Figure 4. It can now be seen that the interactions in Figure 4 are not merely between the human participants, but include interactions among symbols, as shown in Figure 6.

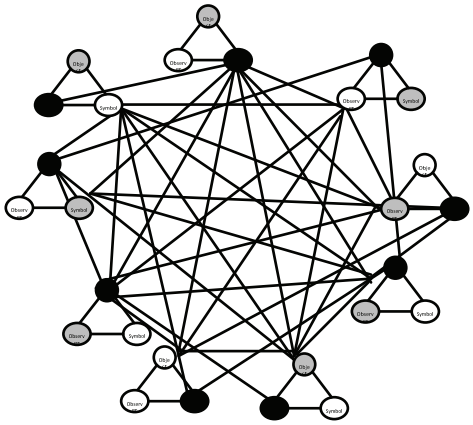

Figure 6: Fully connected classroom with Peirce's 3 semiotic elements

The variety of interactions in Figure 6 is described in part by the following interactions:

1. Observer indicates someone else's Object
2. Symbol is transmitted to another Observer/Interpreter
3. Interpreter talks to another Interpreter referring to someone else's Symbol
4. Symbols are combined and Observed
5. Symbol is Interpreted and followed by another Interpretation
6. … etc.

The inefficiencies present in these interactions are well-known to participants in human organizations, an can be termed as forms of communication Muda, involving inefficiencies in meeting of the minds. The transfer of participants' mental constructs is hampered by the Seven Wastes: Transport, Inventory, Motion, Waiting, Overproduction, Over-processing, and Defects. It will be to the benefit of us all when we find ways to alleviate these Seven Wastes by reducing Muri and Mura in human organizations and communications.

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