Evolution in Lean Teaching

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Abstract

Purpose	Describe efforts to evolve the application of Lean principles and practices to the process of teaching students in a graduate-level course, focused on "grading inside the process" and creating a pull system for the subject matter.
Design / Methodology / Approach	Builds upon the author's prior work in developing a Lean teaching pedagogy, which applies a wide range of Lean principles and practices to improve undergraduate and graduate teaching.
Findings	"Grading inside the process" and pull were successfully demonstrated in a graduate course. Pull is a useful method to achieve customization of student learning.
Research Limitations / Implications	Describes the results of one course taught for two semesters to a total of 34 students. Results are expected to be generalizable to other courses and larger student populations.
Practical Implications	Extends the application of Lean principles and practices in teaching to more closely mirror the types of improvements made during manufacturing shop floor kaizen.
Social Implications	Pull (demand) for information is facilitated by student participation in customization of course content based on their individual interests and needs.
Originality / Value	This paper describes novel application of additional Lean principles and practices to improve teaching in higher education.

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Introduction

Higher education (HE) has been under increasing financial pressure for some time due to declines in enrollment, higher operating costs, and cuts in government funding. The typical approach used by HE leaders to contend with such pressure is to increase tuition and fees and lay off staff and faculty. This simple formula is an uneducated solution to a fundamental problem faced by all organizations that operate in competitive commercial environments. Tuition increases with no concomitant increase in value displeases students, payers, and other stakeholders, while layoffs sacrifice good people for management's failure to understand and control institutional costs.

Some leaders of HE institutions are seeking an educated response to basic cost, quality, and service delivery problems. They have adopted Lean management (see Notes 1 and 2) to improve processes, though this has been limited mainly to administrative processes (Balzer, 2010; Doman, 2011; Waterbury, 2011; Svensson, 2015; Sunder M, 2016). Core academic processes remain largely untouched. Leaders give various reasons for excluding the academic part of the enterprise. But, it seems the real reason is that they do not know enough about Lean management to confidently explain it to skeptical academics and gain their support and participation. In short, top administrators would rather not deal with faculty, which they typically view as troublesome and largely out of their control. However, being in a leadership position means that one cannot shy away from such fundamental challenges.

Leaders' unwillingness to engage faculty in Lean management is unfortunate because academic work is the core value-creating activity in HE institutions. Administrators can be perfect in their Lean efforts in administrative processes and achieve perfect outcomes, yet the institution will still suffer because processes in the academic unit remain unchanged. It does not understand its processes in detail nor does it understand how to improve them, with the wholesome goal of making things better for both faculty and students, and also staff were academic and administrative processes intersect. Academic processes include, but are not limited to:

- Teaching
- Research
- New course development
- New program development
- Changes to academic programs and courses
- Academic advising

- Academic standards
- Academic assessment
- Academic integrity (misconduct)
- Institutional review board (human and animal studies)
- Faculty senate
- Research and grants
- Promotion and tenure
- Sabbatical leave

The lack of institutional leadership at any level to improve academic processes means that interested faculty are left to make individual efforts to improve their work processes. The focus is most often on teaching because that process is almost wholly under one's control (particularly in the United States). However, most faculty will not bother because there is little or no incentive to improve their teaching. Continuously improving one's teaching typically gains no recognition from institutional leadership. Extrinsic rewards such as higher pay, advancement, or new opportunities likely do not exist. Therefore, the pursuit of process improvement is largely motivated by intrinsic rewards. This may change in the future because successful Lean transformation in an organization requires a combination of extrinsic and intrinsic rewards.

Process Improvement

Higher education leaders are not alone in their inability to understand the association between processes and costs. It is common throughout all industries, due in large part to cost accounting systems and budgeting practices (Maskell et al., 2004; Emiliani et al., 2007). For example, if five teams of five people each were given a task to assemble an item consisting of 10 parts, each team would devise a different method of assembly resulting in varying levels of resource utilization. Team Two will create a process to assemble the item in 34 minutes using all five team members, while Team Five will create a process to assemble the item in 17 minutes with three team members. The latter will obviously be lower cost than the former, all other things being equal, as shown in Figure 1. The three people that Team Five do not utilize in their method are valuable resources can be re-deployed into other work areas.

Team 1 Method 1	Team 2 Method 2	Team 3 Method 3	Team 4 Method 4	Team 5 Method 5
Cost = 0.7	Cost = 1.0	Cost = 0.8	Cost = 0.9	Cost = 0.5

Figure 1. Different methods result in different costs.

In addition, continuous improvement leads to continuous learning, such that the simplest and lowest cost solutions result in the greatest learning – which is the result of numerous iterations of trial-and-error. To some, this may sound un-scientific, yet it is an appropriate and effective method for contending with the ever-changing nature of higher education: teaching materials, learning management systems, subject matter, student capabilities and interests, employer's interests, faculty growth and learning, and so on.

The key point in the example shown in Figure 1 is that costs are subordinate to processes. Change the process, and costs either go up or down, as does quality and other process performance indicators. HE leaders, like managers in other industries, consider the opposite to be true: that processes are subordinate to costs. This way of thinking promotes budget-cutting that is unable to discriminate between activities that create value for students and payers and those that do not. Cost accounting systems associate cost with operations, which is the part of the enterprise that creates value for customers. In HE, operations is the academic unit, though aspects of administration that interact directly with students can also be considered operations. Zero-sum (win-lose) budget cutting in operations invariably weakens the part of the organization that delivers what students want and pay for. It should be obvious that reducing the value, quality, and timeliness of the service will do harm, but evidence of this is often unseen by leaders due to the distance, both physical and hierarchical, between them and faculty and staff who create value. What leaders see are spreadsheets showing deteriorating financial condition.

The typical managerial view is that there is one best way to perform a process, and that the costs associated with the process are largely fixed. Therefore, the only way to reduce costs is to remove labor, typically through layoffs. The process remains unchanged, and the people who are left behind to perform the process are less effective and stuffer higher workplace stress. Management has two other options: 1) outsource the process to a lower-cost provider or 2) eliminate the process, even though it may be necessary in order to achieve, for example, student satisfaction. Regardless, the customer of that process is likely to encounter greater dissatisfaction. This, in turn, leads to a reduction in enrollments which leads to additional rounds of budget cuts and layoffs, and new increases in tuition and fees.

People who carefully follow managerial actions in times of crisis see this same pattern repeated in all industries, including higher education. This herd mentality is the road to failure, not the

path to prosperity, where failure typically means bankruptcy or merger with another organization in order to survive. Because the latter is complex and unfamiliar for HE institutions, their fate is more likely to be sudden bankruptcy or an orderly winding down of operations. Those HE institutions that survive will congratulate themselves for a job well done. But success is likely to be short lived as other threats will surely emerge and catch them unaware.

Unfortunately, it seems that most HE leaders are more willing to oversee the slow decline of the institution rather than adopt a new management method throughout the institution that can lead to renewal and prosperity. If one decides to do this, then they must be fully committed because there is much that is new to learn about leadership and management. For example, in the discipline of process improvement, a process is not considered to be improved if the number of steps in a process is reduced but costs remain the same (or if cost go down but quality is worse). This is called *kairyo* in Japanese, which means improvement on a single dimension. In contrast, *kaizen*, means to improve across multiple dimensions (see Note 3). In kaizen, all process performance indicators must be improved simultaneously, and the improvement must do no harm to people or the processes upstream or downstream of the improvement. Kaizen is how one learns Lean management and the interrelationship between the two principles, "continuous improvement" and "respect for people" (Toyota 2001). Therefore, kaizen is a critically important activity (Kato and Smalley, 2011; Emiliani et al., 2015; Wood et al., 2015).

HE leaders must understand that adoption of Lean management, whether in administrative processes or throughout the enterprise, requires personal engagement in kaizen and other processes improvement activities so that they learn the things that are necessary for them to lead faculty and staff effectively (Emiliani, 2015). Delegating Lean practice to lower-level personnel communicates to them that they, and their work processes, are the problem, and that it is not necessary for the leader to learn new things or perform their work any differently.

Improving Teaching

Since 1999, I have been engaged in applying Lean principles and practices to improve teaching in both undergraduate and graduate courses (Emiliani, 2004, 2005). The many and varied types of improvements made over a 15-year period have been summarized in a small volume published in 2015 (Emiliani, 2015a). The motivation was simply to apply what I had learned about Lean management in industry to teaching in order to improve the teaching process. I sought to

eliminate teaching errors, ambiguity, batching of assignment and evaluation, waste, unevenness, unreasonableness, and other problems that result in student (and professor) dissatisfaction and poor learning outcomes. The principles and methods used included reducing the batch size of information, level-loading assignments, visual controls, 5S, standard work, just-in-time, continuous improvement, and respect for people. The results of these efforts have been consistently favorable in terms of course evaluations and student learning outcomes (Emiliani, 2015a).

Over the last few years I have again become engaged in kaizen in industrial (manufacturing) settings. These experiences inspired me to apply what that I had learned in an effort to more closely mirror the types of improvements made during shop floor kaizen. This represents an evolution in teaching method that builds upon the application and learning from earlier principles and practices from the 1999-2000 through the 2014-2015 academic years. The changes made to one graduate course, as a pilot effort, include:

- Adoption of hybrid course format, where half the classes in a semester are face-to-face and the other half are online.
- The use of a learning management system (LMS) – basic functionality only
- Machine (LMS) evaluation of student assignments for 45 percent of the final grade
- Human evaluation only for those student assignments that require human judgment
- No lecture
- Face-to-face classroom time used for students to make or create something that reflects one or more core learning objectives
- Establishing information supermarkets that house subject matter content
- Creating student pull for information (subject matter) from the supermarket
- Continue to reduce information batching, eliminate queues, and improve flow

The objective was to improve the teaching process, student learning outcomes, and student satisfaction as measured by student course evaluations. This paper presents the new concepts that were put into practice in the 2015-2016 academic year. The impact of these improvements has been measured using student course evaluations, including student learning outcomes. While only one academic year's worth of data has been collected, it appears to be sufficient to identify trends and draw some preliminary conclusions. Readers are cautioned to understand that the methods and results presented here represent a snapshot in time and are never final. Improvements in teaching process are never-ending through trial-and-error.

Grading Inside the Process

Evaluation of student's work by the professor is typically performed outside of the learning process. This results in delays and disrupts the flow of learning, as students dislike gaps between assignment submittal and feedback. This is analogous to batch-and-queue processing in manufacturing (or service), where manufactured parts are inspected for quality in a department located outside of the value-creating process, which results in delays between inspection and feedback to the operator. Organizations that practice Lean management do something different. They quickly evaluate work within the process, at each step along the way, the result of which is to "build in quality," thereby eliminating defects, delays in feedback, and improving flow.

Traditionally, humans (professors or teaching assistants) evaluate and assign grades to students' assignments. Because this activity is burdensome to professors, they typically prefer to reduce the number of assignments that require grading; e.g. mid-term and final exam. Students prefer the opposite because poor performance on one exam can have a significant impact on their final grade. Students would rather have more grading opportunities, each one worth fewer points. This creates a tension between professors' time and interests and students' wants and needs.

A way to resolve this tension is to utilize the technology and functionality of contemporary learning management systems to create weekly assignments worth a few points each and which are automatically graded. This has the benefit of synchronizing the learning process and evaluation for a large portion of the final grade. But, this begs a fundamental question: What type of assignments can be created and graded automatically inside the learning management system and what type of assignments should be created and graded by humans? And, what is the proportion of automatic machine evaluation and human evaluation? To assure that learning objectives are achieved, it is probably a combination of the two, such as 50 percent for each. However, grading outside the process should not depend on any simple ratio. Grading outside the process should occur only when it is necessary to achieve learning objectives or if the LMS is incapable of automatically evaluating students' work or giving appropriate feedback.

My current practice is to create assignments such that about half of the final grade is based on human evaluation of students' work. The remaining portion of the grade is given through small weekly assignments called "quick checks." The name is taken from the method used to build in quality in a process using go/no-go gages. Right or wrong answers to subject matter questions

are machine-evaluated and graded with the LMS and give students appropriate feedback on their answers. The LMS eases some of the professors' burden for evaluating student work while reserving their time for higher-value assessment of student work that actually requires the judgment and subject matter expertise of a professor.

Making Teaching a Pull System

Teaching in HE is a push system, wherein faculty design courses with the information that they think students need to know. The subject matter is then pushed onto students bi-weekly or weekly through various types of classroom interactions and assignments. Figure 2 depicts the traditional approach, whereby the professor believes they possess the best solution to the problem of teaching students about a subject. The numbers 4 and 5 clearly indicate there can be only one answer or method for gaining knowledge about a subject, which includes traditional teaching methods such as lecture, mid-term and final exams, term papers, team projects, etc. Is this assumption correct?

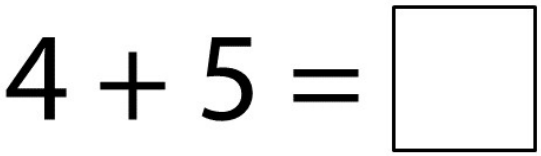


Figure 2 (see Note 4). Single solution concept.

The question is, can teaching be made more of a pull system, as is the case in manufacturing and service operations? Pull systems are a method of production where activity is initiated by a demand signal from a customer, rather than a producer's (professor's) forecast of demand. Pull systems have proven to be beneficial in terms of improving customer satisfaction by reducing the lead-time (wait time from order to delivery), improving quality, and customizing products or services to meet individual needs. From the producer's perspective, pull systems have benefits such as lower cost and greater responsiveness to changes in customer demand.

In the context of teaching, students' pull subject matter from the professor and from the information that the professor has supplied to the learning management system, called a "supermarket." Pull (demand) for information is based on student's individual interests and needs. The current method I use to generate the signal for information is a worksheet in which

students identify the answers that they seek from the course and the questions that they must ask in order to obtain the answers. Figure 3 shows the worksheet.

Personalized Discovery and Learning	**TM572 – Innovative Leadership**	Name: Date:
2. Questions I Must Ask Example of Question: "Who/What/Why/How.....?"		**1. Answer I Want From TM572 for Work and/or For Life** Example of Statement: "I want to know....."
• Up to 4 questions per box • Delete example questions below and think on your own • •		• No more than one Answer per box Delete example answer below and think on your own
• What does a leader have to believe in to be an innovative leader? • How must a leader behave to be considered by followers as an innovative leader? • What are the competencies that an innovative leader must master?		• I want to know what constitutes innovative leadership.
• • • •		•
• • • •		•
		No more than one page.

Figure 3. "Seek Answers by Asking Questions" template.

Students are given three weeks at the start of the semester to study and interact with the course materials in the LMS and identify the answers they seek and questions to ask. This assignment challenges students at the start of the course to think about what they want to get out of the course. They must ask themselves: "What are the answers that I need from this course to satisfy my interests or help me with my job?" "What useful answers can this course offer to me?" "What questions do I need to ask?" The assignment is evaluated and graded by me, not by the LMS, because it informs me of important information about current interests and subject matter that will be added to the course in future semesters. Students find this assignment both challenging and worthwhile, and also use it throughout the semester for reflection. This method mirrors how people learn, which is by finding answers to questions that interest them. Answers are the final step in the process of learning – that is until new questions arise.

Figure 4 shows a supermarket containing the different types of subject matter information that are placed into the LMS, including the professor, who also serves as an information resource to students.

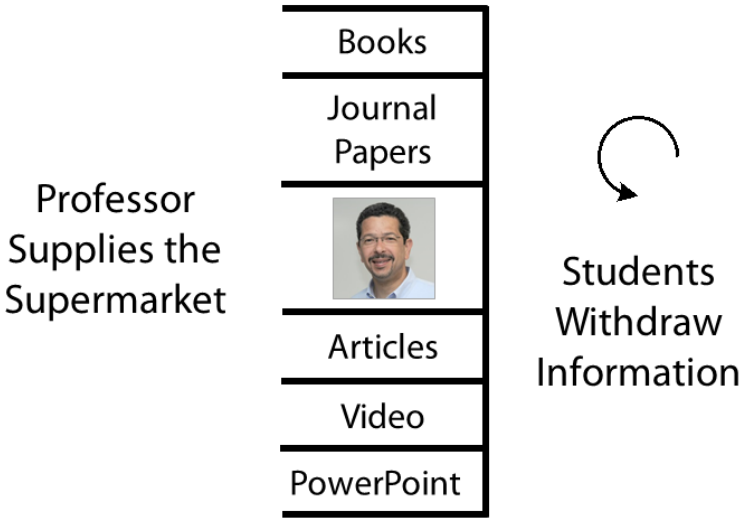


Figure 4. Contents of a course "supermarket."

Figure 5 shows the pull system. It begins on the right with the answers that students seek, which results questions. This, in turn, requires students to process information. But, before they can do that, they have to get information from the supermarket.

Figure 5. Pull system beginning with "Answers" that students seek from the course.

Figure 6 shows the complete pull process, from right to left. It begins with an assignment that is graded by the professor, followed by automatic grading by the LMS inside the learning process, and concluded with another assignment graded by the professor. Other assignments requiring evaluation by the professor are interspersed throughout the semester. As noted previously, classroom time features hands-on activities where students must make or create something in relation to the course's learning outcomes.

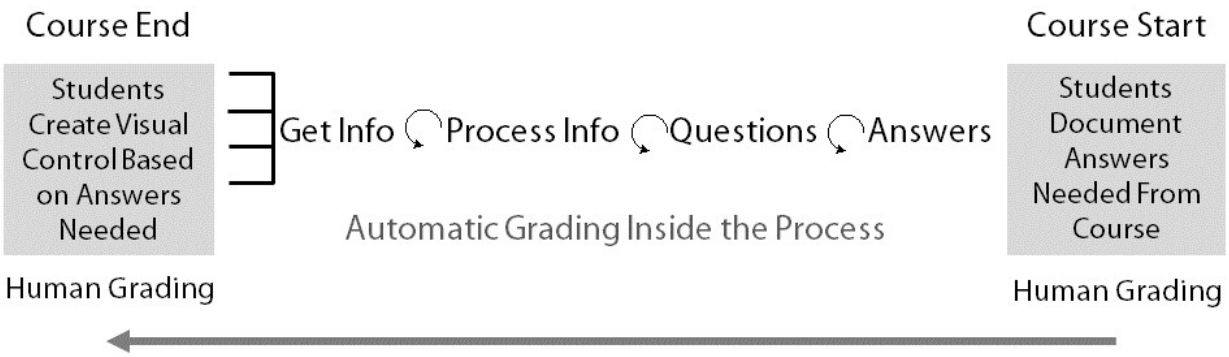


Figure 6. Overall view of pull system course design.

Figure 7 shows the concept that this new method strives to apply. The number 9 represents the primary course learning outcomes, which are specified by the professor, while the boxes represent infinitely different ways to achieve the learning objectives based on student's individual needs and interests.

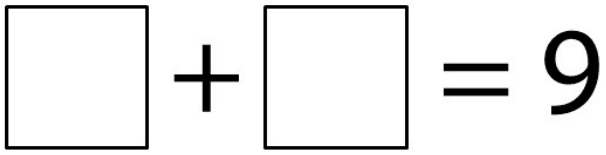


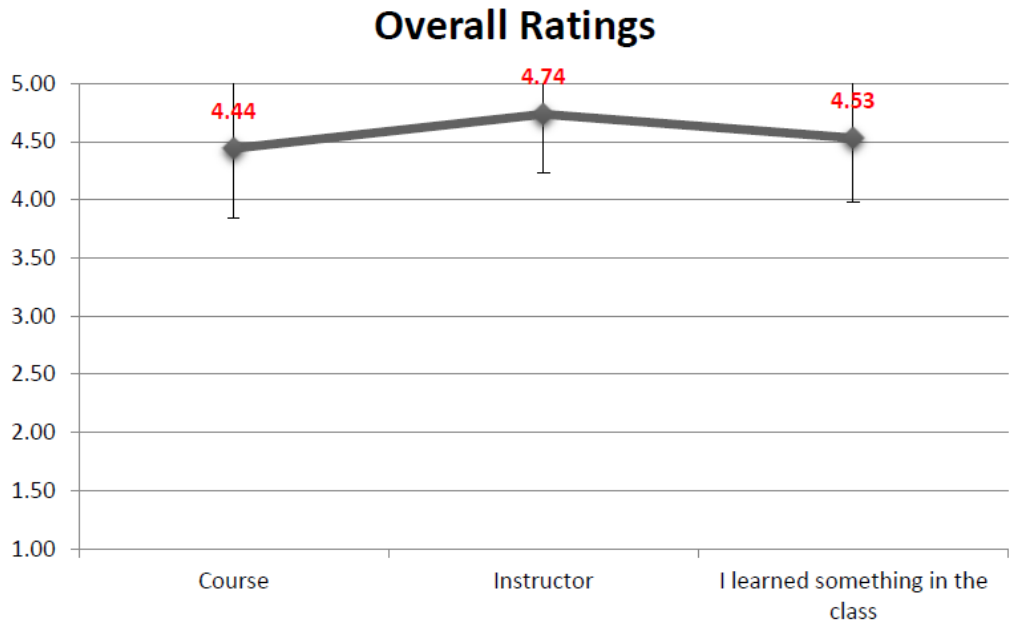
Figure 7 (see Note 4). Infinite solutions concept.

The objective is for students to learn a few very important things that they will remember and apply, rather than many things that they will forget soon after the course is over. To help achieve this, students have a final assignment to create a one-page "visual control" of what they learned in the course in relation to the answers they were seeking and the questions that they asked (see Figure 3). The purpose of the visual control, which is a combination of images and words, is to remind students of what they learned in the course and what they can apply in practice. At the end of the course, I also give students a visual control that I created containing words and images that share my perspective of some of the most important learnings that the course had to offer. They are free to use their own visual control, visual controls created by other students, or the one given to them by the professor. Students often post the visual control in their work area, which keeps them connected to the course for many years.

Student Course Evaluations

Figure 8 shows the results of the student evaluations. The ratings for the course and instructor are 4.44 and 4.74 respectively. This compares to my 10-year teaching average for all courses taught of 4.46 (variance = 0.54) and 4.61 (variance = 0.41), respectively. The scores for course delivery are relatively flat, while the course content scores show a significant drop to 4.15 in the category "Tests/quizzes are fair and represent the material covered." This reflects student dissatisfaction with the nine weekly "quick checks" that are automatically graded within the LMS and which accounted for 45 percent of the final grade.

Dissatisfaction with the weekly "quick checks" could be due to how the questions were set up in the LMS (e.g. multiple answer questions, multiple choice answers, true/false questions, etc.), the nature of the questions, connectivity of the questions to course materials, students' willingness to engage course content prior to attempting the quick check, and so on. For one particularly challenging weekly "quick check," students were directed to read a journal paper first. The LMS course statistics indicate that less than 10 percent of the students read the paper. It is clear that the age-old problem of getting students to study before attempting the assignments remains. It is also clear that there is a need to improve how "quick checks" are created and used within the LMS.



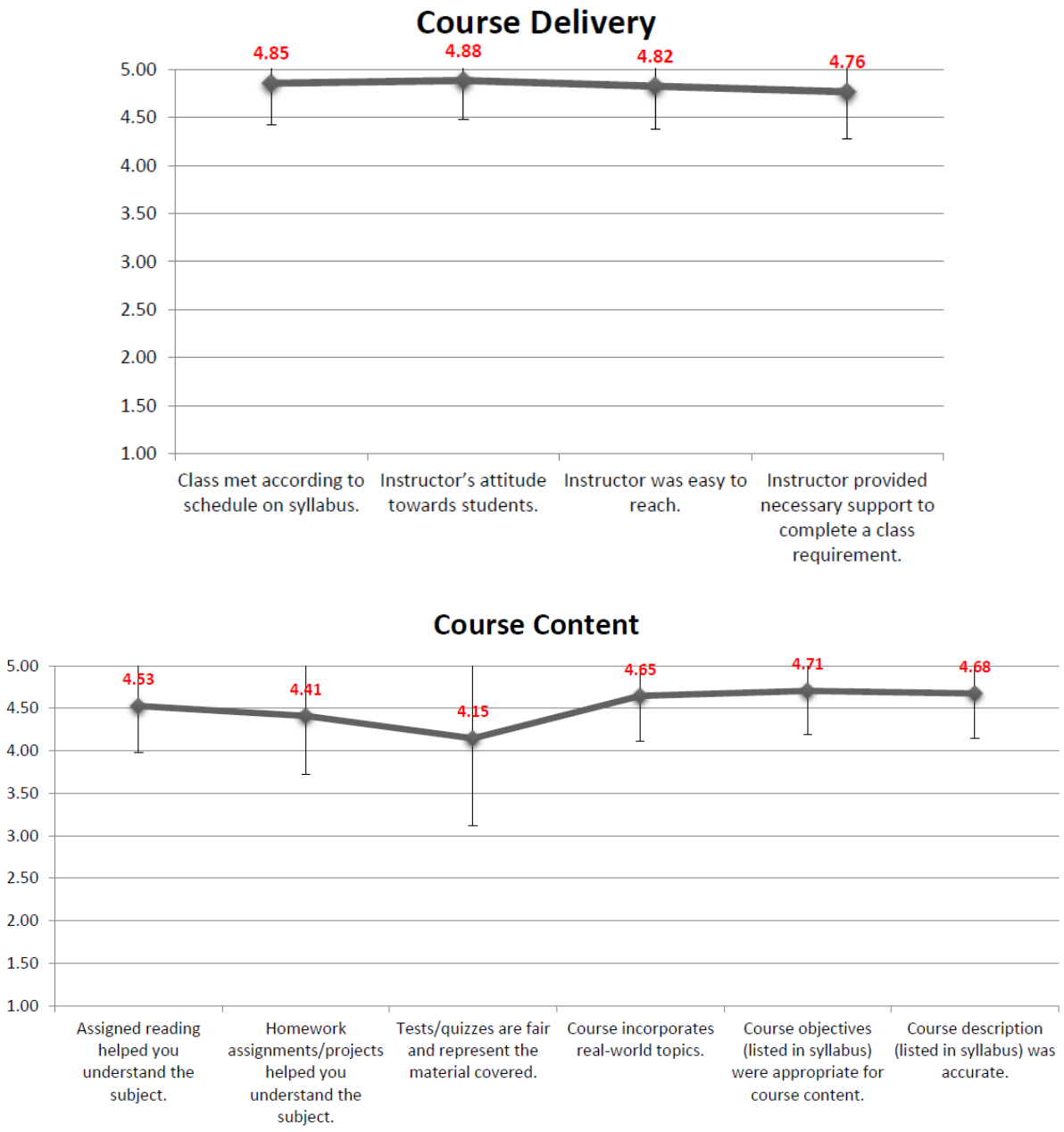


Figure 8. Student course evaluation data (n = 34 students).

Discussion

This establishment of a pull system in a graduate course was driven by a desire continuously improve teaching and try to align it better with the types of improvements made during kaizen on the manufacturing shop (or office) floor. The specific areas of focus were:

- To individualize student discovery and learning, and
- To propel students to take a more active role in achieving learning outcomes that are relevant to them

- To re-orient the professor's role to one who facilitates students intellectual and creative abilities, particularly when meeting face-to-face in the classroom
- Develop students' understanding *and* know-how in relation to the subject matter

It was also intended to help students break free of task-oriented coursework and move students toward higher learning in graduate education (Veblen, 2015). This is a challenge because students expect a repetition of task-oriented high school and undergraduate education at the graduate level, in part because this facilitates the achievement of an academic credential. Simply put, it is less work for students to perform tasks developed and assigned by professors than it is to think about and pursue one's own needs with respect to discovery and learning.

Pull systems applied to teaching higher education create new challenges with respect to student engagement and the amount of effort put forth to learn the subject matter. Students who are used to performing carefully-crafted tasks assigned by a professor face different intellectual demands that they likely have not faced in other graduate courses. It also challenges professors to put sufficient material into the supermarket to cover a board range of students' interests and needs, while simultaneously needing to avoid the temptation to create too large an inventory of information in the supermarket. Curation of information remains an important challenge for faculty, as the supply of information to the supermarket must be continuously adjusted.

It is clear that commercial leaning management systems such as Blackboard Learn can be helpful in establishing pull systems. However, learning management systems contain an abundance of features and functionality that are not particularly useful. They seemingly exist to enable professors to customize content on a student-by-student basis. The method presented in this paper, while early in its development, shows an alternate, simpler method to achieve similar levels of customization. The difference is that the student participates in the customization rather than the professor having to do it *a priori* (see Figure 2).

Conclusion

The intense financial pressure faced by higher education suggests that changes will occur across many dimensions of the enterprise. This includes challenging traditional teaching pedagogies and increasing pressure for online and hybrid courses that utilize the features and functionality contained in commercial learning management systems. Technology platforms are seen by administrators as a means to reduce instructional costs (e.g. labor and facilities) and transform a

capital- and labor-intensive legacy enterprise into a lower cost one with a more prosperous future. This follows a well-established pattern by managers in industry who, for over two centuries, have sought to reduce capital expenses and replace labor with more efficient machines.

In addition to competition from established higher education institutions, administrators face new, venture capital-backed startup competitors who believe they can teach students better than college and university faculty. Their potential for disruption is real and is taken seriously by forward-thinking higher education administrators, yet they may lack the capacity to move quickly enough to meet competitive challenges.

This paper and previous work (Emiliani, 2004, 2005, 2015a) show that here is much that can be done to quickly improve teaching processes via the application of Lean principles and practices, in concert with the technology afforded to faculty by learning management systems. This paper has presented the initial findings of efforts to more deeply integrate Lean principles and practices into the process of teaching. Initial results are encouraging and suggest that further development is worthwhile.

Acknowledgements

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Notes

[1] The term “Lean management” is understood as the sum of The Toyota Way, “Continuous Improvement” and “Respect for People” (Toyota, 2001) and the tools and methods of Toyota’s production system (Monden 1983; Ohno, 1988, Emiliani et al., 2015, Wood, 2015).

[2] Lean management is defined as: “A non-zero-sum principle-based management system focused on creating value for end-use customers and eliminating waste, unevenness, and unreasonableness using the scientific method” (Emiliani, 2008, p. 10).

[3] Kaizen is a Japanese word that means “change” (kai) “for the better” (zen). The context of change for the better is multilateral, meaning it must be non-zero-sum (win-win). Any change must be good for people within the process and for people upstream and downstream as well. To make an improvement at the expense of people or another process is not kaizen. Kaizen is often translated as “continuous improvement.” This is one of two bedrock principles in Lean management. The other is “respect for people” (Toyota, 2001), where people means stakeholders such as students, faculty and staff, payers, communities, and other stakeholders.

[4] Figures 2 and 7 are taken from a presentation titled (in Spanish): “El Toyota Way en Ventas y Mercadeo” (“The Toyota Way in Sales and Marketing”), 2007, by Toyota Global Knowledge Center http://slideplayer.es/slide/131475/ (accessed 30 May 2016), Slide No. 5, “¿Cuál escenario esta más identificado con el Toyota Way?” (“Which scenario is more identifiable with the Toyota Way?”). The equation 4 + 5 = □ symbolizes the existence of only one answer, while the equation □ + □ = 9 symbolizes the existence of infinite answers. In the context of higher education, this means there are infinite ways to achieve course learning objectives. Therefore, professors should never settle on one teaching method (4 + 5 = □). Instead, they should continuously experiment with teaching methods, in trial-and-error fashion, to learn what works well and what does not work well at any given point in time (□ + □ = 9).