Learning Lean: A Survey of Industry Lean Needs

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Abstract

We studied what business practitioners think graduates need to know about Lean. Our results showed that practitioners are not concerned about specific technical skills. Instead, they want graduates to possess a systems view of organizations and value streams. Implications for Lean education and a broader systems approach to professional education in general, are considered.

Introduction

Lean has been a prominent business strategy in the past decade (5), (7), (9). Lean practices are found in service and manufacturing firms, small and large business, and profit and nonprofit organizations (5), (10). A driving force behind many Lean initiatives is that globalization and technology have reduced producers' control over prices. Cooper (2) writes that recent "intensification of competitive forces limits the ability of companies to simply mark up prices based on cost increases. It has made cost control, rather than pricing power, the driving force behind corporate profit margins and earnings growth." Businesses must increasingly rely upon cost cutting, waste elimination, productivity improvements, and quality enhancements as strategic means to achieve profit objectives. There is a growing need for employees to participate in as well as lead necessary changes to existing business cultures, operating systems and practices (3). Lean methods address these concerns, and do work (1).

Lean is not widespread in higher education curricula. Stand-alone Lean classes are rare. Those that exist are usually operations management or engineering courses, are not multidisciplinary, and do not attract many students outside these two disciplines. Consequently, the vast majority of students leave higher education with little understanding of Lean. Many organizations invest a large amount of time and money to educate employees in Lean (7). Universities could help companies avoid some of this expense.

Academicians and practitioners met at a seminar at Ohio State University in August 2005. The participants created the Lean Education Academic Network (LEAN), a group of university educators seeking to promote Lean education in United States higher academia. LEAN also helps improve Lean education through sharing of knowledge and teaching materials, collaboration, and networking among colleagues.

Those at the initial meeting agreed that universities should know more about Lean, particularly what industry wants graduates to know about the topic. This project is a step to that end.

Survey

A pilot survey was circulated to 15 practitioners chosen by industry representatives at the first LEAN meeting. The survey was refined based on their feedback. A web-based version of the survey was then created.

The final survey was distributed with the assistance of the Lean Learning Center in Novi, Michigan, as well as the web site Superfactory.com. The Lean Learning Center provides a lean curriculum for industry professional development. It placed a participation invitation in its monthly electronic newsletter, which is sent to approximately 2,000 email addresses. The number of people who actually read the newsletter is unknown. The Superfactory.com, which focuses on helping readers achieve manufacturing and enterprise excellence, invited industry participants with a posting on its web site and a note in its monthly electronic newsletter. The Superfactory.com claims over 45,000 opt-in subscribers. Again, however, the number of people who saw the web posting or newsletter announcement is not known. The fraction of those readers interested in Lean, as opposed to some other aspect of Superfactory.com's coverage, is also unknown.

Responses

Forty-five completed surveys were received. People were able to respond anonymously, but were also given the option to provide an email address to receive a complimentary copy of the results.

We cannot compute the actual response rate, but there is little doubt that it was low. Therefore, we do not claim that the sample is representative of Lean practitioners. It may be that only those who are particularly interested in Lean education responded, and that they are somehow different from others.

Survey Results

Survey respondents held a broad range of job positions in companies of varying sizes and types. The diversity in job positions is noted by the 28 different job titles shown in Table 1. The range of company sizes and types is shown in Table 2. Most responses were received from people in manufacturing companies. Nearly half were from people working for companies with more than 1,000 employees.

Noted Job Titles	No. of Responses
President	4
Vice President	1
Vice President of Operations	5
Managing Director	1
Plant Manager	1
General Manager	1
Project Manager	5
Services Executive	1
Production Manager	1
Inventory Control Manager	1

Industrial, Quality, Manufacturing, or Systems Engineer	8
Systems Manager	1
IT Manager	1
Sales Manager	2
Supply Chain Manager	1
Engineering Extension Manager	1
Director of Purchasing or Director P & A Category Management	2
Continuous Improvement Mgr, Lean Leader, Operational Excellence Leader	5
Manufacturing Team Leader	1
Public Information Coordinator	1
Union Representative	1

Table 1: Noted Job Titles

Type of Organization:	Service	Manufacturing	Government			
Number of Responses:	11	30	4			
Size of Organization: (No. of Employees)	1-50	51-100	101-150	151-500	501-1,000	> 1,000
Number of Responses:	5	5	0	9	4	22

Table 2: Types and Sizes of Organizations

Participants were first asked to rank order from most important (low score) to least important (high score) ten broadly identified areas of Lean skills, knowledge, and expertise. Based upon pilot study results and anecdotal evidence from conversations with practitioners, these ten areas were chosen because of their importance as key building blocks desirable for graduating students to possess in order to make a quick contribution to a Lean program. Rank orders were requested as each of these items potentially represents a significant amount of course content. Namely, it may not be possible to include all ten of these broad areas in a single Lean course. The relative nature of the rankings should better enable educators to prioritize course content.

Second, participants were asked about three more specific Lean skills sets relating to particular business disciplines: (1) financial and accounting skills, (2) human relations skills, and (3) engineering, operations and marketing skills. These more specific Lean skill sets may be viewed as traditional programs of study (majors) commonly found in higher education. In addition to rank ordering, participants were asked to use a fine-grained Likert (FGL) scale, as depicted in Figure 1, to indicate the absolute importance of Lean skills within each of these three sets.

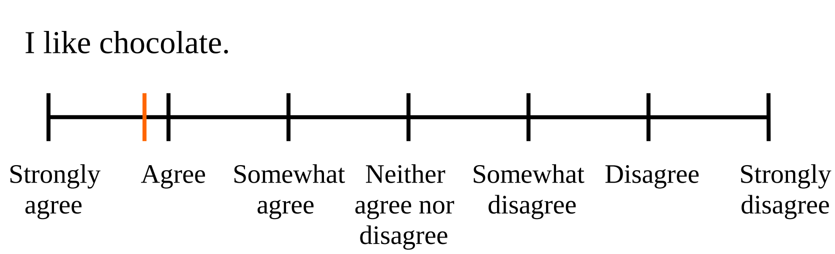

Figure 1: Fine Grained Likert Item

The traditional coarse-grained Likert scale forces respondents to choose among distinctive anchor points, usually five or seven. An FGL scale lets subjects select values between the anchor points. The sample scale in Figure 1 has over 100 different values. Mathieson and Doane (4) have shown that analyses of data gathered using FGL scales are more statistically powerful than analyses of data gathered using coarse-grained scales. Throughout this study, the FGL scale ranged from 1 (very important) to 7 (very unimportant).

Finally, participants indicated the importance of a variety of specific Lean concepts and tools commonly examined in existing college curricula. Both rankings and an FGL scale were used to solicit participant views of the importance of these specific Lean concepts and tools.

Survey Results Analysis

The median rank values for the ten broadly identified areas of Lean skills, knowledge, and expertise are shown in Table 3. No area was more important than "systems planning and thinking." This is consistent with our conversations with practitioners. Companies that implement successful Lean programs take into account the entire enterprise, from supplier to customer, and everything in between (11).

10 Broad Areas of Lean Skills, Knowledge & Expertise	Median Rank Value
Systems planning and thinking (e.g., seeing the business as a value stream)	3
Human Relations Skills (e.g., leadership, change management, team problem solving, etc)	3
Real world business knowledge and experience (e.g., internships or job experience)	3.5
Lean Culture (e.g., kaizen, PDCA, 5S/Visual management, etc.)	5
Lean Principles, Terminology and Tools (e.g., pull, takt, SMED, one piece flow, etc)	5
Stability and Variance Reduction (e.g., 6 Sigma, standardized work, TPM, etc)	6
Financial and accounting knowledge (e.g., cash flow, working capital, RONA, etc)	7
Delivery (e.g., time to market and lead time reduction, closed loop design, etc.)	7
Safety	8
Quality and other systems improvement methodologies (e.g., Malcolm Baldrige)	8

Table 3: Ten Broadly Identified Areas of Lean Skills, Knowledge, and Expertise

The respondents also perceived "human relations skills" and "lean culture" as important, with median ranks of 3 and 5 respectively. Lean implementations often change companies, threatening (or appearing to threaten) both corporate culture and customary ways of conducting work. Leadership and change management skills therefore command a premium. The Society of Automotive Engineers International notes that Lean is primarily about management, workers, and the trust that binds the two, and that these are the most important elements of a Lean system (6). This point underscores the importance of human relations skills for any Lean program.

“Real world business knowledge and experience” was also perceived to be important. Practitioners seek potential employees who can make a quick contribution. It is commonly argued that learning is best accomplished from one’s own experiences. This sentiment is echoed in the median rank value of 3.5 shown in Table 3.

In light of the observation that the production of defects is cited as one of the common forms of waste that Lean programs attempt to eliminate, it is interesting to note that “quality and other systems improvement methodologies” had the least important ranking.

In order to ascertain whether the participants’ rank values represent a statistical difference, a Friedman rank test of the individual’s rank orders for the these ten broad areas of Lean was conducted. Using a 0.05 level of significance, with nine degrees of freedom, the critical test value is 16.919. The calculated test statistic of 85.475 indicated a significant degree of differences in the relative importance among these skills as judged by the participants’ rankings.

After the ten general skill areas, respondents were asked about three more specific, discipline related skill sets. Table 4 shows the FGL means, standard deviations, and median rank values for first of these discipline specific sets, Lean financial and accounting skills. Both metrics, Likert score means and median rank values, demonstrate a reasonable level of consistency. Likert score standard deviation values are reported simply to allow the reader to infer the extent of consistency among the participants’ Likert score values.

The most important item was “enterprise view of money,” which had the lowest mean Likert score as well as the lowest median rank (recall that lower values mean higher importance). This echoes the “systems planning and thinking” concept. The skill rated second most important was an understanding of the time value of money.

Financial and Accounting Skills	Likert Scale Mean	Likert Scale Std. Dev.	Median Rank Value
Enterprise (total company) view of money	2.51	0.81	3
Time Value of Money	2.63	1.00	3
First in, First Out (FIFO)	2.70	1.21	4
Cash Flow	2.98	1.09	4
Working Capital	3.08	0.78	5
Return on Net Assets (RONA)	3.11	1.25	4
Activity-based costing	3.25	1.49	6

Table 4: Financial/Accounting Skills

Given the relatively small level of differences among the Likert scores of these particular skills, a one-way analysis of variance was conducted. The results of this analysis are shown in Table 5. With seven skill items comprising the comparative analysis, for the six degrees of freedom (d.f.), the critical value of the test is 2.13. As shown, the F-statistic calculated is 2.70 indicating a high degree of significant differences among these skills with a P-value of 0.01.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	20.24	6	3.37	2.70	0.01	2.13
Within Groups	371.05	297	1.25			
Total	391.28	303				

Table 5: Financial and Accounting Skills 1-Way ANOVA

Similarly, in order to better understand if the rank values represent a statistical difference, a nonparametric Friedman Rank test of the rank orders for the seven financial and accounting skills was conducted using a 0.05 level of significance. With six d.f., the critical value of this test is 12.59. The test statistic calculated to 13.96 indicating a significant degree of difference among the participants' rankings for this skill set. These results suggest that survey participants regard the "enterprise view of money" as the most important skill and "activity-based costing" as the least important.

Table 6 shows the results for the second of the three discipline-related skill sets, human relations skills. Again, there is much consistency between the rank order and FGL scores. "Leadership skills" was ranked as the most important by both the Likert scale mean and the median rank value. "Teamwork skills" was next on both metrics. "Basic problem solving skills," "team problem solving skills," and "change management" followed closely. "Negotiation and conflict resolution" was seen as least important in this skill set measured by both the Likert scale and median rankings.

Human Relations Skills	Likert Scale Mean	Likert Scale Std. Dev.	Median Rank Value
Leadership Skills	1.67	0.62	2
Teamwork	1.69	0.82	3
Basic Problem Solving Skills	1.77	0.71	4.5
Team Problem Solving Skills	1.79	0.90	4.75
Change Management	1.79	0.69	5.5
Interpersonal Skills	1.88	0.66	4
Logical Thinking	1.89	0.67	5
Negotiation and Conflict Resolution	2.17	0.87	6

Table 6: Human Relations Skills

A one-way analysis of variance was conducted among the Likert scores of these particular skills. The results of this analysis are shown in Table 7. With eight skill items comprising the comparative analysis, for the seven d.f., the critical value of the test is 2.04. As shown, the F-statistic calculated is 1.98, which is not significant at 0.05, but is close. Range truncation may explain this, since two of the Likert means are within one standard deviation and several others are close to one standard deviation of the end of the scale.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7.35	7	1.05	1.98	0.06	2.04
Within Groups	167.82	318	0.53			
Total	175.16	325				

Table 7: Human Relations Skills 1-Way ANOVA

A Friedman rank test of the median rank orders for the eight skills was conducted using a 0.05 level of significance. The critical value of this test is 14.07. The test statistic calculated to 38.11 indicating a significant degree of difference among the participants' rankings for this skill set.

Overall, the evidence suggests that there are significant differences in the ratings, so that "negotiation and conflict resolution" is perceived as less important than "leadership skills." It is interesting that the skill viewed as least important in this set was still perceived as more important than the most important skill in the financial and accounting skill set (2.51).

Table 8 shows the FGL means, standard deviations, and median rank values for the third discipline-related skill set: engineering, operations, and marketing. There were differences in the Likert and rank results. However, if the skills are split into two sets (high importance and low importance), then skills rated as high importance by the Likert scales were also rated as high importance by the rank values, and skills rated as low importance by the Likert scales were also rated as low importance by the rank values. "Standardization" received the lowest mean Likert rating, followed by "variance reduction." The item most similar to a systems view, "process thinking," received the lowest median ranking, followed by "translating customer requirements into specifications."

Engineering, Operations & Marketing Skills	Likert Scale Mean	Likert Scale Std. Dev.	Median Rank Value
Standardization	1.76	0.65	4.5
Variance/variance Reduction	1.94	0.59	7.5
Ability to Assess delivered value to customer	2.10	0.78	5
Process Thinking	2.19	0.83	2.5
Translating Customer Requirements into Specifications	2.20	0.96	3.75
Process Design	2.49	0.99	5.5
Lean Product Design & Development Time	2.50	1.00	6.5
Cellular Layouts	2.52	0.96	13
General Statistical Analysis	2.62	0.86	11
Lean Product Design & Development Costs	2.66	0.87	7.5

Debugging	2.73	0.95	10
Automation	2.77	1.19	10
Statistical Process Control	2.81	1.05	12
Pilot testing	2.88	0.93	10
Prototyping	3.13	0.98	11

Table 8: Engineering, Operations, and Marketing Skills

A one-way analysis of variance was conducted among the Likert scores of these skills. The results are shown in Table 9. With 15 skill items comprising the comparative analysis, for the 14 d.f., the critical value of the test is 1.71. As shown, the F-statistic calculated is 6.79, indicating significant differences. This result is suspect, however, given the large number of skills in this set relative to the sample size; there are about twice as many skills in this set as in the previous two.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	80.134	14	5.72	6.79	< 0.01	1.71
Within Groups	500.00	593	0.84			
Total	580.14	607				

Table 9: Engineering, Operations and Marketing Skills 1-Way ANOVA

A Friedman Rank test of the median rank orders for the 15 skills was conducted using a 0.05 level of significance. The critical value of this test is 23.69. The test statistic calculated to 113.83. This suggests that there are differences among the participants' rankings for this skill set.

The last part of the survey asked participants to indicate the importance of some Lean-specific concepts and tools. Table 10 shows the FGL means, standard deviations, and median rank value results. "Standardization of work processes" was perceived as important, which is consistent with the "standardization" item in the engineering, production, marketing skill set (see Table 8). Also note that "value stream or process mapping," which emphasizes a "systems viewpoint" of processes across a supply chain, was also important. Value stream mapping is a technique that operationalizes the whole firm concept.

Lean Concepts and Tools	Likert Scale Mean	Likert Scale Std. Dev.	Median Rank Value
Standardization of Work Processes	1.61	0.82	6
Value Stream or Process Mapping	1.68	0.78	5.5
Defect-Free Production (poka-yoke, jidoka)	1.74	1.16	7
Pull Approach	1.80	0.66	7
Takt Time	1.82	0.82	6
Cycle Time Reduction	1.90	0.89	8
Operator Involvement and Teamwork (e.g., quality circle or kaizen activity)	1.95	1.29	6.5
Visual Management	1.96	1.18	8
4W2H (what, when, where, why, how and how much)	2.08	1.24	12.75

One Piece Flow	2.16	0.87	6
Total Preventative Maintenance (TPM)	2.17	0.98	14
Kanban	2.19	0.83	10.5
Production Leveling (heijunka)	2.23	0.88	10.5
Process/Office Layout Design	2.23	0.99	14.5
Plan-Do-Check-Act (PDCA) Cycle (Deming Wheel, Shewhart Cycle)	2.25	0.98	13.75
Quick Changeover or SMED	2.37	0.74	11
Familiarity with complementary quality and productivity programs (e.g., six sigma, theory of constraints, TS16949, etc.)	2.60	1.36	16.5
3M's: Muda, Muri, Mura	2.71	1.55	12.5
Statistical Process Control (SPC) Tools	2.74	1.30	14.5

Table 10: Lean Concepts and Tools

A one-way analysis of variance was conducted among the Likert scores of these Lean-specific concepts and tools. The results of this analysis are shown in Table 11. With 19 items comprising the comparative analysis, for the 18 d.f., the critical value of the test is 1.62. As shown, the F-statistic calculated is 3.18, indicating a significant degree of differences. This too may be explained by truly important differences, or simply by the large number of items.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	62.50	18	3.47	3.18	< 0.01	1.62
Within Groups	639.22	585	1.09			
Total	701.72	603				

Table 11: Lean Concepts and Tools 1-Way ANOVA

A Friedman Rank test of the median rank orders for the 19 items was conducted using a 0.05 level of significance. The critical value of this test is 28.87. The test statistic calculated to 100.33. This suggests that there are differences among the participants' rankings for this skill set.

The quality related items ("familiarity with complementary quality and productivity programs" and SPC tools) were perceived as relatively less important. The same was found in the pilot study, which used a different sample.

Conclusions

The Lean practitioners we surveyed want university graduates to have a comprehensive view of organizations. This message is consistent throughout the data. Lean is more about people and processes than about specific skills.

A reasonable question is: Why is this whole firm view so important? Most people in firms work in specific functional areas, like manufacturing, accounting, human resources, and so on. Their jobs are defined by their managers, who should make sure that, when everyone does his or her particular job, everything fits together into a coherent whole. Why is it necessary for employees to have a whole firm view? Isn't this an issue just for the managers at the top, who design the firm?

Unfortunately, this simplistic command-and-control view of organizational design does not fit with the realities of today's cost cutting, globally competitive world. The goals and assumptions that drove a firm's design yesterday may not be true tomorrow. A job designed to achieve a particular outcome is threatened if that outcome is no longer relevant. Even worse, what happens when the goals of an entire company are no longer relevant?

Lean thinking is at its best in exactly these situations, when the parameters have changed, and business as usual will not work. The best Lean employees are those who can step outside their limited day-to-day roles, and ask difficult questions like: *Why* am I doing what I'm doing? How does it contribute to the firm's strategy? What needs to change if the company is to adapt? These questions demand a systems view of the business and its processes. Only when this perspective is in place can employees use their technical skills to help companies move towards the right goals, for only then will employees know what "the right goals" are.

Most academic curricula emphasize a somewhat deep, yet relatively narrow preparation in specific disciplines. This is necessary in many fields, of course. For example, competent computer programmers need to know about algorithms, databases, networks, interfaces, and so on. Their training involves much time and expense, and without it they will not be able to function in their specialties.

Lean requires something more, however. Specifically, it demands that people take a whole firm view of their companies. How can universities introduce students to this idea? Van Til et al. (5) discuss one approach. Oakland University's Pawley Institute offers an interdisciplinary Lean course team taught by faculty from the business, education, and engineering schools. Of course, this may require that faculty are willing to drop a course in their own fields from their curricula. This is not just an issue of organizational politics. Dropping a course means that the skill students would have learned are forgone. There is an opportunity cost to such decisions.

The whole firm view is not the sole property of Lean, however. Other disciplines also think it important. Management Information Systems (MIS) is an example. Consider a sales force automation system, where sales representatives carry a laptop into the field to access information on customer history, help customers configure products, enter new orders, check on the status of current orders, and so on. The data captured by these systems might be used by people throughout the company: sales representatives, sales supervisors, market researchers, engineers (e.g., to understand product configuration needs), auditors (e.g., reviewing travel costs), and so on. Creating systems like this requires a whole firm approach, so that information collected by one set of users can serve others.

Perhaps faculty in Lean would find kindred spirits in MIS, and in other fields that focus on business systems. This could be done formally through coordinated courses, or informally through *ad hoc* arrangements. Either way, students and their future Lean employers would benefit.

A second survey result is the importance respondents attached to human relations skills. To meet industry needs, universities must teach students Lean as a set of relationships, as well as a set of concepts and skills. Some faculty dismiss this as "fuzzy." Today's business world *is* fuzzy, in many different ways, from the uncertainty of the global market, to the angst of wrenching organizational change. Effective leaders deal with this fuzziness. If university faculty are to help graduates become effective Lean practitioners, they must face it too, even if it is unpleasant. The human element is essential in attaining the goals of cost cutting, waste elimination, productivity, and quality improvement. To think otherwise is, well, fuzzy.

As suggested in Table 3, a third important observation is the desire for prospective employees to possess real world business knowledge and experience. There are a variety of approaches currently being pursued in academia today, ranging from semester-long cooperative industry/academic projects which typically focus on a small portion of a firm's process (e.g., conducting a kaizen event), to internships, to other hands-on approaches. One example of a current university program that recognizes this concept is in College of Engineering at the University of Kentucky. The faculty there runs a Lean manufacturing "Boot Camp." This approach represents an immersive learning experience in which students work in a team-oriented environment and participate in hands-on, discovery-learning exercises where concepts introduced in the classroom are immediately applied. These exercises involve training factories, simulations, and field activities.

So far, we have considered what faculty can do to help prepare students for industry. It is reasonable to ask what industry can do to help faculty and students. Internships can be invaluable. They help students understand how real business differs from the clinical experiences of the classroom. Faculty can become interns as well, and improve their understanding of the challenges students will face. There can also be university/industry joint ventures, like UK's Lean "Boot Camp." The Applied Technology in Business (ATiB) program at Oakland University is another example. Students work in project teams over two years, usually for at least two different companies, finding solutions to real world business problems.

Some of these efforts require financial support. ATiB, for example, is a program at a public university that is funded by the private sector. ATiB graduates command a premium in the marketplace, not only because of their technical skills, but because they have worked on real projects for different parts of different organizations. They have more of a whole firm view than most graduates.

What Now?

There are two obvious directions for future work. The first is to explore ways of increasing Lean content in university programs. Examples have been given above, but there are more possibilities. For example, distance learning technology might allow universities and companies to offer cooperative, real-world courses across institutions.

The second set of questions involves the details of how Lean is taught. For example, researchers might develop virtual simulation tools to help students see different facets of a firm's operations. Students might play various roles, being customers, sales representatives, production managers, etc., all for the same firm. They might see what happens when the firm is challenged by loss of an important market, a sudden drop in the cost of a competing technology, a dramatic rise in raw material prices, and so. Tools like this take time to build, test, and refine. Joint university/industry efforts could make this happen.

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