122nd ASEE Annual Conference & Exposition
June 14 - 17, 2015
Seattle, WA
Paper ID #12977

A Study on the Students' Perceptions of the Applicability of Lean Principles at Universities

Dr. Muhammad Jahan, Western Kentucky University

Dr. Muhammad Jahan is an Assistant Professor at the Architectural and Manufacturing Sciences Department at Western Kentucky University (WKU). His research interests include advanced manufacturing, lean manufacturing, micro- and nano-machining, SPM-based lithography and materials. Prior to joining at WKU, he worked at the Institute for Nanoscience and Engineering at University of Arkansas. He received his BS and PhD in Mechanical Engineering from Bangladesh University of Engineering and Technology and National University of Singapore respectively. He has published more than 50 papers in refereed journals and international conferences and contributed to books, and been involved in several internal and external funded research projects in these areas. He has received numerous research awards including 'Best Paper Award - ATMAE 2014', 'Outstanding Paper Award – SME, 2012,' 'A.M. Stickland Best Paper Award – IMechE, 2010,' and 'Most Downloaded Paper – Elsevier, 2010.'

Dr. A. Mark Doggett, Western Kentucky University

A. Mark Doggett is an Associate Professor and the Coordinator for the Master of Science Degree in Engineering Technology Management at Western Kentucky University. His interests are in the area of technology management practices, lean, theory of constraints, quality, and systems thinking. His research includes various decision-making and problem-solving strategies, and the development of distance learning approaches.

A Study on the Students' Perceptions of the Applicability of Lean Principles at Universities

Abstract

Lean principles are well-established business management strategies, which are applied extensively in manufacturing and production industries to continuously improve value by reducing wastes. This paper investigated the applicability of lean principles at universities using the perceptions of undergraduate students at a higher education institution. The perceptions of the students were collected over a period of two years as a part of class assignments and discussions for a Lean Manufacturing class. The students' opinions and comments concerned broad areas of stability, standardization, *jidoka*, just-in-time, employee involvement and customer focus. The majority of the students focused on the various categories of waste (*muda*) and unevenness (*mura*) in a university system. Some of the identified waste involved poor campus layouts, uneven scheduling of classes, poor understanding of curriculum, inadequate communication between faculty and students, and improper management of facilities resources and inventory. The students also focused on the waste associated with instructional modes at the university system, asserting the need for more online and competency-based education. The students opined that universities can implement lean principles to a certain degree by being customer focused, applying continuous improvement, reducing *muda* in *mura*, continuously involving students, faculty and staffs, and above all emphasizing a lean culture.

Introduction

'Lean' is defined as the "set of tools that assist in the identification and steady elimination of waste (*muda*), the improvement of quality, and production time and cost reduction"[1]. It is a customer-focused knowledge-driven business philosophy that provides value to the customer by continuously simplifying processes and eliminating waste.[2] In brief, the lean production system means doing more with less – less time, less space, less human effort, less machinery, less materials – while giving the customers what they want.[3] Although the lean production system was introduced and developed in Toyota from 1950 – 1970[3], it became popular in sectors besides production industries.

With the publication of two books: *The Machine that Changed the World* by Womack, Jones and Roos[4] and *Lean Thinking* by Womack and Jones[5] the term "lean" became very popular across different business sectors other than manufacturing and production. Since then, more companies in different sectors are investigating the feasibility of implementing lean principles to eliminate waste and continuously improve their value. In recent years, there have been extensive researches on the feasibility of applying lean principles in various activities other than manufacturing industries. A significant number of research works have been reported on the applicability of lean in construction.[6-8] Besides manufacturing and construction industries, the applicability of lean management strategies in various profit and non-profit organizations, such as government,[9] the public sector,[10] healthcare, [11-13] and service industries[14,15] has also been investigated.

In recent years, the higher education institution (HEI) has become an important area of consideration for the lean researchers to investigate the applicability of lean manufacturing principles. Traditionally, the purposes of the higher education institutions (HEIs) are to teach and to conduct research and build/prepare the workforce for the nation. Although the higher education sector is considered to be one of the most immutable sectors, its manner of operation has changed considerably over the last two decades.[16] The organizational environment of HEIs has changed fundamentally due to the significant increase of students who now attend college.[17] In addition to education, universities now need proper management policies to deal with changes in student's perceived needs. At present, students not only value the education, but also care about on-campus accommodations, state-of-the-art facilities, technologies used in instruction, and overall the costs of their education. Therefore, a significant number of HEIs are focusing on improving the education experience as well as services to the students. At the same time, university budgets are shrinking, forcing these HEIs to continuously eliminate unnecessary expenses and wastes.

Literature review

Several studies have been carried out focusing on different aspects of establishing lean at HEIs. Comm and Mathaisel presented a case study on the applicability of lean sustainability concepts to universities.[16] They developed and administered questionnaires to 18 public and private universities and analyzed the survey results. They found that the focus in higher education is now primarily on cost reduction. Most of the universities started budget containment initiatives without proper knowledge/consideration of lean principles. Still, they were often successful in reducing waste, improving operational efficiency and overall improving sustainability. Comm and Mathaisel reported another similar exploratory study on lean sustainability practices in higher education.[18]

Cristina and Felicia[19] also published a paper on implementing lean at a higher education university. They presented models of three universities from the USA and UK that successfully implemented lean. In the models, they presented the detailed step-by-step procedures followed by those universities in their journey to become a lean university. Barroso, Santos and Carravilla[20] also presented a similar report/paper with several case studies on how lean can be implemented in the HEIs beyond the classroom boundaries. In their paper, they suggested some core areas at HEIs where applying lean principles can possibly reduce waste. In a similar study, Isaksson, Kuttainen and Garvare[21] reviewed the opportunities of applying lean principles in higher education and research. Their study presented how traditional university education and research are performing compared to lean principles with a focus on value flow analysis. Francis[22] presented a similar study on the applicability of lean in Canadian post-secondary institutions as a means to offset ongoing funding shortfalls and enhance efficiencies.

Maguad[23] proposed lean principles to reduce/eliminate wastes in the HEI with the goal of overall cost reduction and revenue enhancement. Moore et al.[24] presented a case study of University of Central Oklahoma on becoming the lean university. They discussed the step-by-step process of applying lean principles, including problem identification, design of lean tools, applying lean, and evaluating the benefits of implementing lean. A similar case study was presented to implement lean six sigma at a foreign university; Tshwane University of Technology, South

Africa.[25] Hines and Lethbridge[26] also presented a report on development and creation of a lean university.

Besides the applicability of lean principles at universities, there have been studies on implementing lean in the classroom and laboratories. Tatikonda [2] reported that by applying lean principles, it is possible to refine the course content to enhance student understanding. He applied the lean tools to design, teach, and assess accounting courses that helped students gain a better knowledge and skills required by the employers. In addition, the applicability of lean manufacturing to university laboratories was investigated by Sreedharan and Liou.[27] It has been reported that students working on lean projects and following lean in laboratories gain knowledge that could help them in their career. After applying lean, the laboratories become well organized and more functional. In a similar study, Rizbi[28] presented a case study of applying lean six sigma in a laboratory. In this study, the author presented a process of improving an experiment by identifying the wastes and then applying improvement based on value stream mapping.

The numerous studies cited reinforce the applicability of lean at universities, both in classroom and outside classroom. However, these studies represent a professors' view or report of successful lean implementation. Those studies reported expert opinions on the subject matters. Conversely, few studies have considered the students' opinion on the applicability of lean at universities or which areas of the universities the students think worthy of consideration. Therefore, the present study aims to investigate the undergraduate students' perception on the applicability of lean principles at universities. The perceptions of students were collected and analyzed as a part of an undergraduate Lean Manufacturing class.

Methodology

The perceptions of the students were collected over a period of two years as a part of class assignments and discussions for a Lean Manufacturing class. This junior level class was offered equally using face-to-face and online instruction. In the last two years, this junior level class was offered in all 4 semesters and the same question on the applicability of lean at universities was asked.

Towards the end of the offering of Lean Manufacturing class, the students were asked to express their opinion on:

"Can lean principles be applied to the Universities or Higher Education Institutions"?

Each student was required to mention at least three areas where they thought lean could be applied. The students were required to provide logic and/or explanations behind their selection. It was assumed that at the end of the semester, the students have a better understanding of lean principles and their applicability in manufacturing industries. Therefore, the question on the applicability of lean at universities assessed their understanding of the course content and their ability to apply it in another context.

The perceptions of the students were then analyzed and related to the popular House of Lean Model.[3] The students' opinions and comments concerned broad areas of stability, standardization, *jidoka*, just-in-time, employee involvement and customer focus.

Brief overview of House of Lean model and lean tools

The House of Lean has evolved since its two primary pillars of just-in-time and *jidoka* were first identified.[29] Originally, the term autonomation (literally translated as automation with a human touch), was used to describe the textile equipment invented by Toyoda Sakichi, which was capable of automatically stopping when a defective condition was suspected. This "intelligent automation" embodied the *jidoka* principles of autonomous control, root cause analysis, problem-solving, and visual management. The second pillar, just-in-time, was developed from Toyoda Kiichiro's study of Ford's manufacturing techniques. To deliver products or services in the proper quantity exactly when they are needed, a synchronized flow system that uses little resources and time is required.[30]

The pillars rest on the foundation of a stable production system, which prevents chaos resulting from chronic interruption, unplanned stoppage, or lack of standardization. It ensures each step in the process is available, capable, and adequate of producing what is required when it is required.[5] The heart of the lean revolves around employee engagement and involvement in a highly charged atmosphere of autonomy, but always with clear objectives. Individuals are expected to continually contribute new ideas and better ways of doing their jobs. Respect for people, equipment, and facilities is paramount. The goal of the House of Lean is depicted by the roof, which consists of providing the customer with the highest quality, lowest cost, and shortest lead-time products or services while eliminating waste.[3]

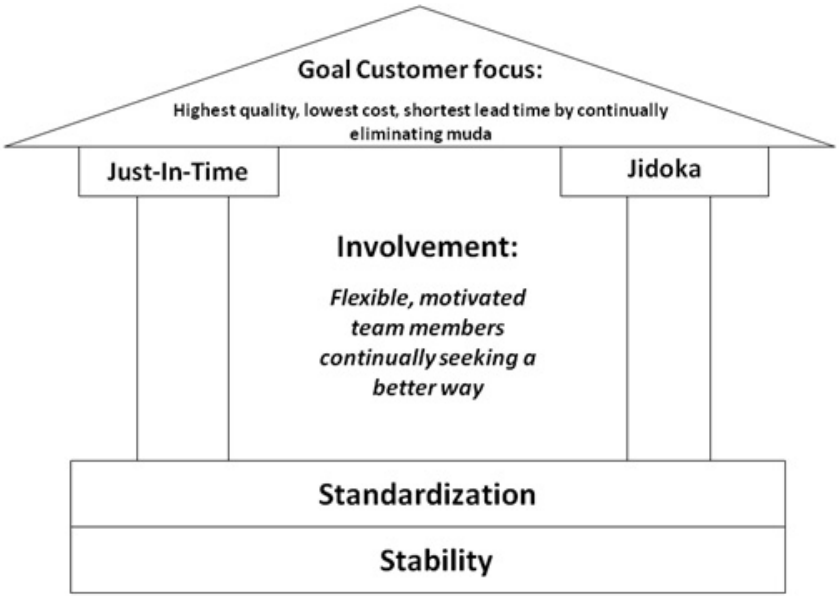

Figure 1: House of Lean Production, An image of the Lean Production System, as illustrated in the book *Lean Production Simplified* by Pascal Dennis.[3]

Results and Discussions

In the following sections, the students' perceptions on the applicability of lean principles at various key areas of university are presented. The perceptions were analyzed based on the popular House of Lean model by Dennis.[3] The key lean activities were grouped into different parts of the house such as: stability, standardization, *jidoka*, just-in-time, employee involvement and customer focus. There are many lean activities that belong to more than one category and also there is overlapping of lean activities across the different parts of house. Table 1 shows the summary of key lean activities and their relative importance as perceived by the students. In addition, a representative quote from each key points is also listed in the table to explain what students are proposing using those key points.

Table 1. Summary of the content analysis: list of key points, their relative importance and representative student comments

Item	Number of times mentioned	Representative comments
Online classes	12	"Online classes would help lean the university by lessening the demand for actual classrooms and the university could offer more classes with fewer professors."
Campus layout	11	"The distances between buildings create waste by increasing the amount of travel time to get from one place to another."
Waste reduction	10	"Students switch majors more than once and waste time taking unnecessary classes. Offer a placement test to help students decide on what they should major in before they get into college."
Class scheduling	7	"Have major classes offered more than once a year for flexibility."
Time to degree	7	"The long semester is a waste of time. If I take a class every day, I can finish the course in three weeks."
Space	7	"There are too many unused spaces in buildings around campus."
Continuous improvement	7	Continuously improve education and facilities because there is always something new."
Customer driven	6	"The real customers of universities are the future employers of the students"
Curriculum requirements	6	"Simplify confusion of major requirements."
Work flow	5	"Simplify university systems such as financial aid, billing, and receivables. Most of these have bad infrastructure."

Student dining	5	"Mura can be reduced by staggering the times classes let out."
Student involvement	5	"Teachers and students work together to share experiences and information that will result in a better understanding for the future."
Value	4	"Less investment. Does that building really need to be remodeled?"
Energy consumption (HVAC)	4	"Have all the students that need dorms during the summer move into one dorm hall and turn off the electricity in the rest of the empty dorm buildings"
Communication	4	"Improve teamwork between employees and enhance the communication among the various divisions."
e-books	4	"Ebooks and rentals are starting to become a popular alternative to the traditional text books."
Culture	4	"Training that empowers staff to make changes every day."
Quality driven	3	"The university should not accept students randomly. They should make tests and request a high GPA."
Paperwork requirements	3	"Lean the process of admissions paperwork. Too much time is wasted with applications and transcripts"
Maintaining facilities	3	"Students should do the preventive maintenance and cleaning of the machines."
Gen-Ed requirements	2	"Lessen gen-ed requirements. Gen-eds were high school level; college is focused on a career."
Recycling	2	"Efforts to eliminate wastes and become more sustainable, from recycling to knowing inventories to not wasting electricity."
Employee involvement	2	"Make the process less stressful by reducing the task load on employees. This would eventually result in a improved and harmonized work environment."
Parking	2	"Parking in areas away from campus with shuttle service to the main campus or satellite campuses with low volume."
Traffic	2	"Reduce vehicular traffic around campus."
5S	2	"Students learn the proper tools and how to clean their workplace after finishing."
Tutoring	1	"Provide tutoring to students rather than just require remedial courses."
Multi-use equipment	1	"Order machines that can perform more than one function rather than machines that can only perform one task."
Six sigma	1	"Applied to classroom and maintenance of facilities."

Customer focus

In lean manufacturing, the core goal is to provide the highest quality to the customers, at the lowest cost, in the shortest time by continually eliminating *muda* or waste.[2] Customer focus is the top priority in lean manufacturing. According to the students surveyed, the customer focus is also one of the top priorities for implementing lean at universities. It was found from the study that students perceive themselves as products and industries as the customers in the system. The students mentioned the importance of being customer-focused both directly and indirectly. The students, in their discussions, mentioned the keyword 'customer focus' at least 6 times directly. For example, one student mentioned:

"The first step of becoming lean starts by determining what the customer (or employers) wants, then the universities could rethink their products, or students in this case, and how to better shape them to suit the employers better. Companies have certain skillsets and things that they look directly for in students that they hire and it is the universities' responsibility to provide the students with those."

Most of the students opined to improve the quality of education based on the industry requirement (being customer-focused) by reducing various types of waste. It can be seen from Table 1 that waste reduction is considered to be one of the top priorities of students (mentioned 10 times) where they think lean can be applied. Besides mentioning the keyword 'waste reduction' specifically, the students mentioned many important areas of concern that could be interpreted as different types of *muda*. For example, 'campus layout' is related to transportation *muda* and 'scheduling of class' is related to motion and waiting *muda*. Table 2 presents the interpretation of students' perceptions into different types of *muda*.

The students also perceived that the 'quality' of education or product (students) could be improved by implementing lean across all resources (facilities, faculty and staff). The students also perceived that the quality of product could be improved by being customer (industry-focused) and giving priority to their requirements. The students considered the customer requirements as 'value' and suggested that value stream mapping can be performed to see what exactly the customers (employers) are willing to pay for. This can be done by eliminating unnecessary courses and modules and by adding modules with skillsets demanded by industries. The students believed that quality management and improvement tools can be applied in the education environment also. One student commented:

"The American Society of Quality has been partnering with schools to improve the quality of education since mid 1990s. The "ASQ program Koalaty Kid Club" has been developed to continuously improve and maintain quality of education for K-12 institutions."

Another important key point of students' focus was the mode of instruction and method of delivering the classes. The students were very interested on the waste associated with instructional modes at the university system, asserting the need for more online and competency-based education (mentioned 12 times). The students perceived that the 'online mode of class instruction' and/or 'competency based education' should be given the highest priority to reduce

the *muda* significantly and to become customer focused. A few student example comments in this regard are provided below:

"Online courses are in my opinion the way of the future students. Having the majority of the courses offered as online courses would enable the university to cut cost on their product. This would also eliminate the need to have a cap on the number of students who can take a given course."

"In the twenty-first century colleges have to modernize their classes in order to accommodate adults who are returning to school. This has lead to online learning in order to accommodate working adults schedules."

"If universities offer more online classes they could do that with fewer professors. Online classes would help a university to be lean by lessening the demand for more class rooms."

Besides online classes and mode of instruction, the student also mentioned about using e-books and renting e-books instead of buying hardcover textbooks. One of the students commented:

"One way that universities can demonstrate lean is through the use of text books and required reading materials. E-books and rentals are starting to become a popular alternative to the traditional books. Not only does it help reduce the cost, but also use less material, which is the key characteristics of lean."

Table 2. Interpretation of different types of *muda* at a university based on students' perceptions [adapted from the model by Liker[31]]

Type of waste or *'Muda'*	Interpretation from University perspective	Examples
Transportation/Conveyance	Students goes from home/dormitory to university, transport between classes, transport of university facilities	Traffic, too much distance, too long time, less transport compared to students, etc.
Inventory	Too much items for instruction, too much inventory for storage at the department, etc.	Unplanned storage of paper, pen and consumable items, Improper use of machine, etc.
Motion	Student walking from one class to another class, improper arrangement of facilities, looking for classrooms, etc.	Poor arrangement of laboratory components, poor campus layout, space more than necessary, etc.
Waiting	Waiting for enrollment in courses, waiting for class to start, waiting for teacher, waiting for assignment	Lack of workflow, waiting for parking space, registration restriction, etc.

	feedback, etc.	
Over production	Facilities more than necessary, classes not full, graduating more students than jobs available, etc.	Student dining excessive food, offering classes without enough students, etc.
Over processing	Excessive paperwork, unnecessary course contents, etc.	Gen-Ed requirements, too much paperwork, too much energy consumptions, etc.
Defects/Correction	Failing the course, Not gaining competencies from a course, etc.	Failed students, failed course objectives, students drop, etc.
Knowledge disconnection	Poor understanding between faculty and students	Poor communication, less involvement, etc.

Stability

After determining the customer focus, any company or institute should stabilize them. Without the stability, improvement is impossible.[3] In order to maintain stability, the key areas considered are the 5S, visual management and total productive maintenance (TPM). In the students' discussions, many different sectors in the universities were named that need to be stabilized in order to implement lean. The students mentioned about the 5S and maintenance both directly and indirectly. It can be seen from Table 1 that the students mentioned '5S' and 'maintenance' at least 2 times and 3 times respectively. However, they mentioned 'recycling', 'energy consumption', 'multi-use of equipment', and 'student dining' a total of 12 times, which are closely related to stability. In all of these areas, 5S and total productive maintenance could be applied to improve the stability and to start implementing lean principles. In addition, the students also suggested applying six sigma to the laboratories and other facilities for proper maintenance. For example two of the students commented about facilities management and TPM:

"The facilities maintenance is another example of a service that in part can utilize lean. Wastes that can be reduced include idle workers and resources: gas, electricity, supplies etc. Breakdowns of equipment could also be reduced by applying TPM practices. A 5S event could be practiced once or twice in a year to clear out wasted space and inventory."

"In universities labs, students could perform the preventive maintenance that include practicing 5S and periodic cleaning of the equipment."

Standardization

After things are stabilized it is important to standardize them at institutions or companies. Although the students did not mention the standardization at the universities directly, there are many comments that indirectly suggest the standardization of various things at universities. For example, the students suggested standardizing various academic matters such as general education requirement (2 times), paperwork requirements (2 times), curriculum requirements (6 times) and so on. The students suggested a review of the current requirements and revise them based on customer (employer) demands. The students suggested reduction of the non-major requirements and to focus more on the core courses. They also urged standardization of them

across the universities. In addition, the students suggested standardizing all student policies. For example, one student commented:

"The university can use lean to improve processes in administration. One example would be calculating the time it takes for the financial aid office to process a student's paperwork so that student can get his money to pay for books before class starts."

The students also emphasized standardization of the '5S' and 'maintenance' policies at the laboratories and throughout the campus. The students suggested making posters of 5S and visual management for maintenance of equipment in the laboratories and classrooms. Those are clearly examples of applying standardizations that would help implementing lean at universities. Some of the students' comments in this regard are:

"One of the ways to make 5S work is to make a poster of 5S and elaborate a little what each mean and what is the order, so staff or students can easily follow it."

"Six sigma can be applied at maintenance and other offices. The maintenance people could keep the chart in their office so that it could be always in front of them and will give them more chance to follow."

Just-in-time

In lean manufacturing, just-in-time means producing the right item at the right time in the right quantity.[3] According to the students' perception, the just-in-time principle could be applied to many different areas at universities. At present, the retention and graduation rate is one of the biggest concerns for all universities. Most of the universities are unable to help all the students to graduate at the same time, who enrolled at the same time. The interpretation of this in terms of lean manufacturing can be "incompletion all the products at the right time from the raw materials, thus creating defects". One of the students commented regarding this:

"Another great way to make the university lean would be to get students to graduate on time. The admissions office should help students decide what they want to major in before they get to college. The could offer a placement test that would provide students a better idea of subject they would like to study."

The students perceived that online classes could reduce their waiting time for grades. The students believed that by introducing more online classes, universities could practice just-in-time principles that would help universities implement lean. One student commented:

"A lot of online classes have online tests that are immediately graded as soon as the students turns them in. This cuts down the time that professors have to spend grading tests and assignments. By having online tests the professors can also improve the quality of their lectures by putting more time and effort into them."

The students also believed that the proper scheduling of classes would help maintain the proper flow of students, following the just-in-time principle. For example, the scheduling of classes should be done in advance so that the students can register for the classes just when they need it,

so that all the students can graduate at right time. The students also emphasized on time management of equipment and machinery in the laboratories and to integrate multi-use equipment when replacing older or obsolete equipment.

Jidoka

In lean manufacturing, *jidoka* means making defect-free processes by continually strengthening process capability, continuous improvement and feedback. [3] The term jidoka also suggests that if a person sees any defect during a process, he/she should immediately stop the process and correct the process. In this study the students mentioned the importance of *jidoka* and the way *jidoka* could be applied in different areas at the universities. Although very few students mentioned about the term *jidoka* directly, many of their perceptions indirectly suggests implementing *jidoka* in various areas at universities. As can be seen from Table 1, the students mentioned 'continuous improvement' of quality of education and facilities. The students also suggested that the continuous improvement should be practiced on a daily basis rather than once-in-a-while. For example, one student commented:

"The lean team should be always looking to find new ways of implementing continuous improvement, which should be part of our daily life, not a one-off event."

The students also stressed on reducing the waste at university dormitories and classrooms by taking immediate action when there is any non-lean activity observed. As can be seen from Table 1, the students promoted taking immediate actions on waste in energy consumption, recycling the wasted energy. The students also suggested practicing 5S and six sigma for continuous improvement of facilities.

The students also emphasized on introducing '*poka-yoke'* and 'zone control' at different university administrative departments. Although the students did not use the terms directly in their perceptions, the different defective/unproductive processes at the administration and finance department at universities suggest corrective actions.

One of the students proposed 'tutoring' services for the current students by former students or graduate students that would help certain students needing extra consideration, and would help in reducing the number of drop-out students. The student commented:

"Another way the university could benefit from lean is by setting up an effective system at the learning center (TLC) at universities for helping students through tutoring. This would greatly help students who really need help and reduce dropping-out."

Involvement

In lean manufacturing, the successful implementation of all lean activities greatly depends on the proper involvement of both employees and employers. Similarly, at the university, the success of implementing lean would depend on the involvement of university administration, faculty and staff and the students. As shown in Table 1, the students mentioned 'students involvement' and 'employee involvement' 5 and 2 times, respectively. The students also emphasized proper communication among the professors and students (mentioned 4 times). According to the students' perceptions, 'knowledge disconnection' *muda* could take place due to the lack of

proper communication between the instructors and students. Some of the comments emphasizing communication between students and instructors are given below:

"Involvement, which is very important in lean thinking, will work greatly in university because when the teachers and students work together and share experiences and information that will result in a better understanding for students."

"Getting students involved with feedback in their education makes them a part of the system. This approach would encourage students to be critical thinkers."

"Knowledge disconnection could be from a student to professor, a student to student, or even a professor to professor that could cause a waste of time and create frustration."

The students urged engagement of the students in different lean activities besides faculty and staff. The students also proposed offering lab courses and some undergraduate courses through graduate students, which would eliminate the costs associated hiring more instructors. The students also suggested that there should be proper communication between the customers (future employers of students) and the university. The university should involve the industries in curriculum design. One student commented:

"There should be knowledge connection, and collaboration between the university and its customers in developing proper curriculum and continuously improving the delivered product".

The students believe that the *kaizen* (continuous improvement) principle can be applied at almost every area of universities by involving all the related parties: employers, administration, faculty, staff and students. One student commented:

"Kaizen principle is another way that lean could be applied to university. If it would be possible to apply kaizen to the university, the administration, teachers and students could solve problem together and given their opinions to ultimately feel more involved."

Based on the above discussions in the results and discussions section, a revised House of Lean model applicable to the university environment is proposed in Figure 2. The model includes the summary of all lean activities grouped into different sections/parts of the lean house. This model would provide a guideline to the future researchers who want to explore the applicability of lean at the university system.

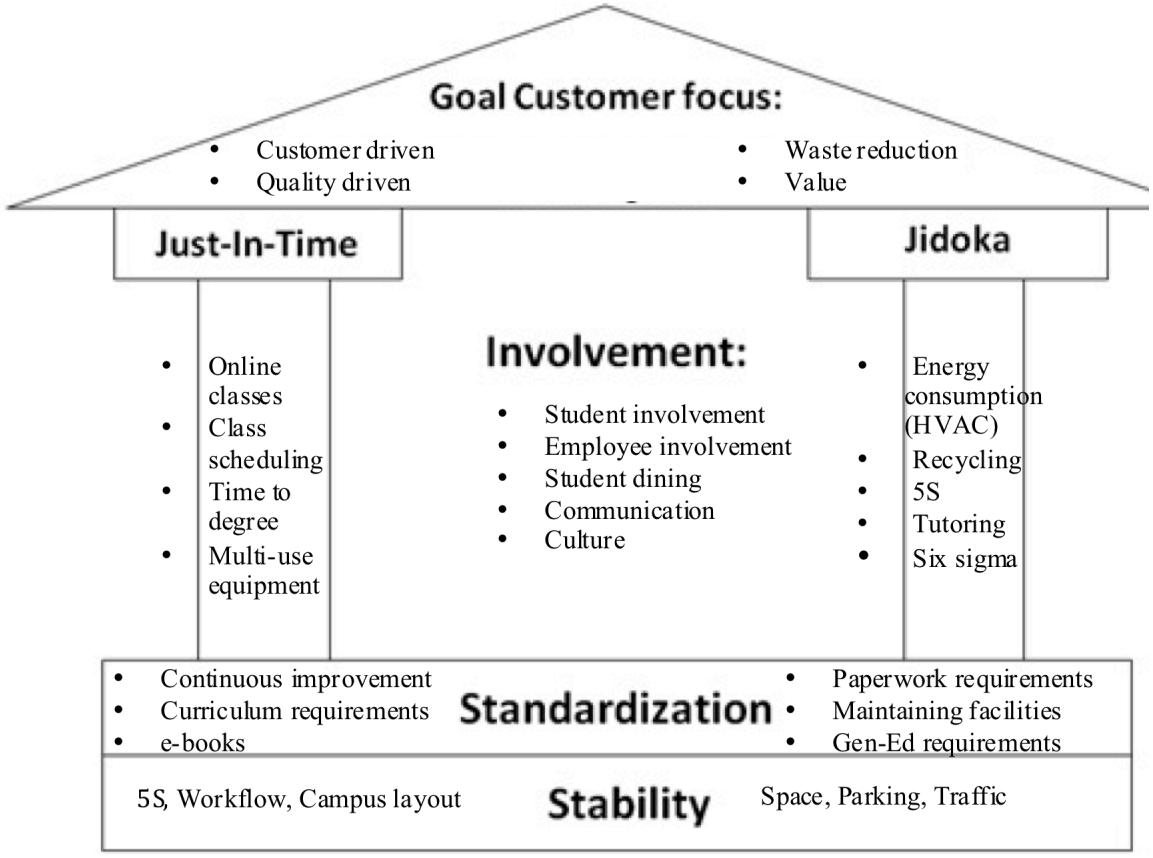

Figure 2. House of Lean Production model with lean activities applicable to universities [based on the model of "lean activities" suggested by Dennis[3]]

Counter logics on the applicability of lean at universities

Although majority of the students commented on the possibilities of implementing lean principles at the universities and perceived that lean can be applied to the university environment, few students argued about the applicability of lean at universities. The students argued that lean principles are mainly applied to a manufacturing or industry environment whose main goal is to make more profit. On the other hand, most of the universities are non-profit. One student commented:

"The goal of the university should be to provide a quality educational service, not to make a large profit."

In addition, students perceived that it would be difficult to remove all the *muda* from the university system. According to the students, the university should maintain a well-established athletics program, provide proper recreational facilities and focus on landscaping the campus to attract students. One student mentioned:

"It would be hard to eliminate all the muda and reduce cost at universities because there is a lot of necessary muda that goes with a university and its operations. Some of those include landscaping of the campus, recreational activities and athletics."

Conclusions

This paper presented undergraduate students' perceptions on the applicability of lean principles in the university environment. The perceptions of the students were collected as a part of the assignment and discussions in the Lean Manufacturing class. After analyzing the students' perceptions related to the popular House of Lean model, the following conclusions can be drawn from this study:

- Majority of the students perceived that lean manufacturing principles can be applied to the university environment. A limited number of students perceived that it would be very difficult to eliminate many necessary *muda* at the universities; hence, it would be difficult to implement lean at universities.
- The students perceived themselves as products and industrial employers as customers. The students stressed on being customer focused by revising the curriculum, adding contents that would provide the required skillsets, and eliminating non-value added coursework such as general education requirements.
- The students also stressed on implementing more online classes and providing e-book access. This would reduce many different types of *muda* associated with class scheduling and instruction modes.
- The students suggested various areas at universities where wastes could be eliminated and 5S or TPM applied to improve the stability. The students also suggested standardization of processes using posters or visual management in the classrooms and laboratories.
- The students urged on graduating at the right time. According to the students, this could be done by introducing online and competency based education, by helping them to choose appropriate major and by helping poor students with tutoring services outside the classroom.
- Finally, the students believed that lean can be applied more effectively through the involvement of customers, university administration, faculty, staff and the students. The students suggested involving themselves in the university system and to work together with the customer to continuously improve the quality of education.

The study took place in program accredited by the Association of Technology, Management, and Applied Engineering (ATMAE). However, the activity would also support the learning goals and outcomes of an ABET accredited program. Specifically, this type of activity would support demonstration of (c) an ability to design a system, component, or process to meet desired needs, (g) an ability to communicate effectively, (j) knowledge of contemporary issues, and perhaps (d) an ability to function on multi-disciplinary teams if the exercise was done in a group setting. Regardless, the ability to analyze and apply lean concepts across different contexts demonstrates higher levels of learning and would be desirable for many engineering and engineering-related programs in general.

Bibliography

1. Wilson, L. (2010), *How to implement lean manufacturing*, McGraw Hill, New York.

2. Tatikonda, L. (2007), Applying Lean Principles to Design, Teach, and Assess Courses, *Management Accounting Quarterly, 8*(3), 27-38

3. Dennis, P. 2002, *Lean production simplified: A plain language guide to the world's most powerful production system*, Productivity Press, New York.

4. Womack, J., Jones, D. and Roos, D. (1990). *The machine that changed the world*, Rawson Associates, New York.

5. Womack, J. and Jones, D. (2003). *Lean thinking: Banish waste and create wealth for your corporation,* 2nd ed. Simon & Schuster, New York

6. Aziz, R.F., Hafez, S.M. (2013), Applying lean thinking in construction and performance Improvement, *Alexandria Engineering Journal*, *52*, 679–695

7. Issa, U.H. (2013), Implementation of lean construction techniques for minimizing the risks effect on project construction time, *Alexandria Engineering Journal*, *52*, 697–704

8. Marhani, M.A., Jaapar, A., Bari, N.A.A. (2012), Lean construction: Towards enhancing sustainable construction in Malaysia, *Procedia - Social and Behavioral Sciences*, *68*, 87 – 98

9. Lindquist, K. (2013), *Synthesis of lean information and practice in government*, Retrieved from http://www.wsdot.wa.gov/NR/rdonlyres/3CEB019E-77EE-40D2-877D-3F75FED0C99D/0/LeanPracticesinGovernmentSynthesisUpdate112013.pdf (last accessed on January 29, 2015)

10. Bhatia, N. & Drew, J. (2006), *Applying lean production to the public sector*, Retrieved from http://www.mckinsey.com/insights/public_sector/applying_lean_production_to_the_public_sector (last accessed on January 29, 2015)

11. Joosten, T., Bongers, I., Janssen, R. (2009), Application of lean thinking to health care: Issues and observations, *International Journal for Quality in Health Care*, *21*(5), 341–347

12. Hagg, H., Suskovich, D., Workman-Germann, J., Scachitti, S., Hudson, B., Swartz, J., & Vanni, C. (2007), Adaptation of lean methodologies for healthcare applications, *Proceedings of the 2007 Society for Health Systems Conference*, New Orleans, LA, February 2007.

13. Mozammel, A., Mapa, L., Scachitti, S. (2011), Application of lean six sigma in healthcare: A graduate level directed project experience, *Proceedings of American Society for Engineering Education*, Paper no. AC 2011-604

14. Kanakana, M.G. (2013), Lean in service industry, *SAIIE25 Proceedings*, 9th – 11th of July 2013, Stellenbosch, South Africa, 574, 1-9

15. Alessandro Laureani (2012). *Lean six sigma in the service industry, advanced topics in applied operations management*, Mr. Yair Holtzman (Ed.), ISBN: 978-953-51-0345-5, InTech, Available from: http://www.intechopen.com/books/advanced-topics-in-applied-operations-management/lean-six-sigma-in-theservice-industry (last accessed on January 29, 2015)

16. Comm, C.L. & Mathaisel, D.F.X. (2005), A case study in applying lean sustainability concepts to universities, *International Journal of Sustainability in Higher Education*, *6*(2), 134-156.

17. Deem, R., Hillyard, S. & Reed, M. (2007), *Knowledge, higher education, and the new managerialism: The changing management of UK universities*, Oxford University Press, London.

18. Comm, C.L. & Mathaisel, D.F.X. 2005a, An exploratory study of best lean sustainability practices in higher education, *Quality Assurance in Education*, *13*(3), 227-240.

19. Cristina, D., Felicia, S. (2012), Implementing lean in a higher education university, *Constanta Maritime University's Annals*, Year XIII, 18, 279-282.

20. Barroso, I.P.M., Santos; S.M.F., Carravilla, M.A. (2010), Beyond classroom boundaries: How higher education institutions apply lean, 1st Brazilian Symposium on Services Science, Brasilia, 17-19 Nov, 2010

21. Isaksson, R., Kuttainen, C., Garvare, R. (2013), Lean higher education and lean research, *Proceedings of 16th Toulon – Verona Conference*; Faculty of Administration, University of Ljubljana, Slovenia; 29-30 August 2013.

22. Francis, D.E. (2014), Lean and the learning organization in higher education, *Canadian Journal of Educational Administration and Policy*, Issue #157, 1-23.

23. Maguad, B. A. (2007). Lean strategies for education: Overcoming the waste factor. *Education*, *128*(2), pp. 248-255.

24. Moore, M., Nash, M. & Henderson, K. (2007), *Becoming a lean university*, Retrieved from http://www.sacubo.org/docs/bestpractices/2007/UnivofCentralOkla-LeanUniversity.pdf (last accessed on January 29, 2015)

25. Kanakana, M.G., Pretorius, J.H.C. & van Wyk, B.J. (2012), Applying lean six sigma in engineering education at Tshwane University of Technology, *Proceedings of the 2012 International Conference on Industrial Engineering and Operations Management*, Istanbul, Turkey, July 3 – 6, 2012

26. Hines, P. & Lethbridge, S. (2008), New development: Creating a lean university, *Journal Compilation: Public Money & Management*, Issue: February 2008, 53-56.

27. Sreedharan, S. & Liou, F. (2007), Can lean manufacturing be applied to university laboratories? *Proceedings of American Society for Engineering Education*, Paper no. AC 2007-273

28. Rizvi, H.R. (2013), Application of lean-six sigma approach in a laboratory experimental case study, *International Journal of Lean Thinking,* 4(2), 1-13.

29. Ohno, T. (1988). *Toyota production system: Beyond large-scale production*. Cambridge: MA: Productivity Press

30. Japan Management Association. (1986). *Kanban—Just-in-Time at Toyota: Management begins at the workplace*. Cambridge: MA: Productivity Press.

31. Liker, J., K. (2004). *The Toyota Way - 14 Management Principles from the World's Greatest Manufacturer*, McGraw Hill.