Development of an Associate Degree Level Course on Lean

Jeremy Espinoza
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DEVELOPMENT OF AN ASSOCIATE DEGREE LEVEL COURSE ON LEAN

Jeremy B. Espinoza

A Project

Submitted to the Bowling Green
State University in partial fulfillment of
the requirements for the degree of

MASTER OF TECHNOLOGY MANAGEMENT

July, 2016

Committee:

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ABSTRACT

Lean training and education has become a focal point in both industry and the realm of academics; however, the need within the industry remains, and oftentimes companies must take on the additional and high expense of training new graduates once they enter the workforce. Often, the classes that students study in the lean methodology, if any are studied at all, are taught within other disciplines, and the instruction is in a general sense as opposed to in depth and hands on. Within the past eight years it has been referenced in different academic articles that students are not coming into the workforce able to contribute to corporate lean initiatives. Although lean is making it into academics in greater measure, there is still opportunity to create an academic course that focuses specifically on lean and around the principles of lean which drive the techniques and tools required to build a lean culture.

The goal of this project was to develop an associate degree level course on lean, a stand-alone course that provided students with opportunity to conduct and contribute to lean projects and to understand the guiding principles that define lean and the lean culture. To achieve this, a review of literature was conducted on lean, lean history, and lean within the industry to determine where lean education is failing the marketplace. Next, a review of the different instructional paradigms within academics was performed to determine the best methods to administer a training such as lean and the many tools that can be associated with it. Then, a study of course construction and curriculum development was carried out to understand the accreditation requirements involved in creating a course that can be taught at state colleges and universities. Finally, research was conducted on course assessment and how to determine that a student has understood the tools and methodologies needed and set forth in the course objectives.
At the conclusion of the research, a course outline, schedule and assessment criteria were created that bring students through a progressing knowledge of the fourteen principles of lean and the tools and techniques that sustain a culture of continuous improvement. The course, administered in the paradigm set forth, carried out with hands on training in lean tools and exercises, and assessed by the measurement criteria provided, will enable students to be immediate contributors to lean initiatives upon entering the workforce.
Acknowledgements

I would like to thank Dr. Christopher Kluse, the chair of my project committee, for stepping in and guiding me through this process from a difficult beginning. I also appreciate the important feedback and input from my committee members, Dr. Sudershan Jetley and Dr. Mohamad Mayyas.

I am most grateful to my wife, Lisa Espinoza, who patiently endured and supported me even when the hours were long and the family had to do things without me. Without her, not only would this project not have been completed, but accomplishing my master’s degree would not have been possible either. She has been my enabler in so many ways, and I am deeply indebted to, and extremely grateful for her. I would also like to recognize the sacrifice my children have made, to be without their father for a season so that I might become a better provider, leader, and father to them as the years press on.

Finally, I give thanks and glory to God, and wish to magnify my Lord and savior Jesus Christ.

He lifted me out of the pit of despair, out of the mud and the mire. He set my feet on solid ground and steadied me as I walked along. Psalm 40:2

The path has seemed long but has been but a moment, and you have been faithful. May I live fully committed to the plan and purpose you have for my life.
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Section I: Introduction

Background

The investigated topic is lean, as it is known in the manufacturing and services industries. Lean involves maximizing value, minimizing waste, and simultaneously using the least amount of resources (“What is Lean,” n.d.). Lean is a philosophical approach with guiding principles aimed at achieving overarching corporate goals as well as a management system that is highly visible (Boyle, Scherrer-Rthe & Stuart, 2011, p. 588). Lean production is multi-dimensional in its management practices and applies tools such as just-in-time, work teams, 5S and supplier development all in an integrated system; this forms a streamlined quality system that provides goods to customers at the speed of the market with minimum waste (Shah & Ward, 2003, p. 129). Lean is more than just a set of tools; it is a fundamental way of thinking about a process and is inclusive of employees from all areas of the business, bringing changes in attitude and the very culture of an organization (Metha, Metha, & Metha, 2012, p. 119). Lean is comprised of fourteen principles as well as several tools that assist in supporting the fourteen principles. Lean is a way to think and do business— it is not a short-term cost reduction method but a culture in which a company operates (What is Lean, n.d.).

**History of lean.** Lean was birthed out of necessity to survive and compete in an automotive environment where much of Japanese industry had been destroyed during World War II, the country lacked natural resources, and the Japanese citizens had very little money (Liker, 2004, p. 20). This is the environment in which Toyota Motor Manufacturing lived. Furthermore, Japan was a country consisting of a small domestic auto market, high wages driven by unions, and an economy flooded with foreign producers establishing operations in the Japanese market (Womack, Jones, & Roos, 1990, p. 49). These obstacles made large scale mass production
virtually impossible, and craft production business models were not effective in establishing mass-market products (Womack, Jones, & Roos, 1990, p. 51). In spite of the potential problems, Toyota production manager Taiichi Ohno was instructed to match the productivity of Ford Motor Company by establishing continuous flow, standardized processes, and waste elimination (Liker, 2004, p. 22). This meant that productivity in Toyota would have to be increased eight to nine times compared to the then current pace and productivity of the work force, taking the work that was being done by 100 workers down to 10. Manager Taiichi Ohno knew Ford was not putting out ten times as much effort as the Japanese, so the problem had to lie in waste; thus, the lean journey began (Ohno, 1988, p. 3)

Lean, at its core, is waste elimination. Waste is considered:

Any human activity which absorbs resources but creates no value: mistakes which require rectification, production of items no one wants so that inventories and remaindered goods pile up, processing steps which aren’t actually needed, movement of employees and transport of goods from one place to another without any purpose, groups of people in a downstream activity standing around waiting because an upstream activity has not delivered on time, and goods and services which don’t meet the needs of the customer (Womack, & Jones, 1996, p. 15).

Toyota representatives attended many seminars on quality and productivity by W. Edwards Deming, who stressed to them that the customer included both internal and external customers (Womack, Jones, & Roos, 1990, p. 23), and this was a major contribution as to why lean organizations strive to create value as seen through the eyes of those customers, the customer who purchases or uses those products and services (A., D. F., & Juran, 2010, p. 333). If one is
going to eliminate non-value added activities, one must have an understanding of the various types of waste. There are essentially 8 wastes:

1. Over production – making or doing more than is required or earlier than needed
2. Waiting – for information, materials, people, and maintenance
3. Transport – moving people or goods around or between sites
4. Poor process design – too many / too few steps, non-standardization, and inspection rather than prevention
5. Inventory – raw materials, work in progress, finished goods, papers, and electronic files
6. Motion – inefficient layouts at workstations, in offices, poor ergonomics
7. Defects – errors, scrap rework, nonconformance
8. Underutilized personal resources and creativity – ideas that are not listened to, skills that are not used (A., D. F., & Juran, 2010, p. 334)

14 Principles of lean – philosophy, tools, & management. The fourteen principles of lean were derived from the renowned book entitled *The Toyota Way: 14 Management Principles from the World’s Greatest Manufacturer* by Jeffrey K. Liker. These principles have since been altered in some degree or another in order to make them fit more generally into all aspects of the workplace, but overall they have maintained the original integrity. The fourteen principles are now simply referred to as the fourteen principles of lean, but in fairness to their origin, the researcher will directly quote the principles as stated by Jeffry Liker: (Liker, 2004, p. 37-40)

- Principle 1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.
- Principle 2. Create continuous process flow to bring problems to the surface.
- Principle 3. Use "pull" systems to avoid overproduction.
• Principle 4. Level out the workload (heijunka). (Work like the tortoise, not the hare.)

• Principle 5. Build a culture of stopping to fix problems, to get quality right the first time.

• Principle 6. Standardized tasks are the foundation for continuous improvement and employee empowerment.

• Principle 7. Use visual control so no problems are hidden.

• Principle 8. Use only reliable, thoroughly tested technology that serves your people and processes.

• Principle 9. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.

• Principle 10. Develop exceptional people and teams who follow your company's philosophy.

• Principle 11. Respect your extended network of partners and suppliers by challenging them and helping them improve.

• Principle 12. Go and see for yourself to thoroughly understand the situation (genchi genbutsu).

• Principle 13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly.

• Principle 14. Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen).

It was upon these principles that the Toyota Production System was founded, and this system would come to be known as “lean production,” as coined by James Womack, Dan Jones, and Dan Roos (Womack, Jones, & Roos, 1990, p. 4). The principles within lean management are not a step by step instruction book— they are a roadmap of thought processes that should be tweaked
to line up with what a particular organization is doing, then diligently practice and apply them in order to achieve a high level of proficiency and buy-in, which in time continually shapes the organizational culture.

**Statement of the Problem**

The goal of this project was to develop an associate degree level course on lean, incorporating the 14 principles of lean with hands on application of the lean tools needed to be an immediate contributor on lean initiatives.

**Description of the Project**

The intent of the project will be to develop a standalone course at the associate degree level that educates students in lean. The course will instruct students in the foundational competencies of lean as well as provide cognitive development of lean tools. The course will consist of lessons for a 16-week duration and will include weekly lectures and studies in lean principles, along with other components such as workshops that apply lean tools, tests, homework problems and solutions, etc.

An outcome of the course will be to instill in students the principles of lean as a thought process that extends beyond the production floor, through all levels of management, and aligns the organization to common goals. The students will learn about culture, not just change. The course will be designed in such a way that lean skills are acquired with hands on learning that can be transitioned right into the workplace. According to Sink (2013), employers are looking for graduates who have an understanding of systems and process improvement, that are analytical and discipline in their approach to problem solving (Sink, 2013, p. 35). The project will be structured to ensure that this need is fulfilled upon course completion, and a final project
capstone consisting of demonstrative ability to conduct a lean assessment and event will be instituted.

**Significance of the Project**

Students entering the manufacturing world are not ready to implement or conduct lean exercises, the current courses being offered are not meeting the needs, and consequently, the majority of students leave higher education with little understanding of lean (Fliedner, & Mathieson, 2009, p. 194). Courses in lean are not widespread in higher education and lean-specific classes are almost nonexistent, and the segmented classes that do exist are generally found in operations management or engineering courses (Fliedner, & Mathieson, 2009, p. 194). This causes a need for training in lean principles and tools at the junior college level. Taninecz (2006) states, “On the campuses of many colleges and universities, lean hardly shows up in undergraduate or graduate curricula and faculty fail or are hesitant to teach principles that business is embracing” (p.1). There is a need for lean models within manufacturing that contribute to the continuous improvement of company processes, but there are difficulties in effectively implementing these models, and because of this, there is stimulated interest in finding new models and strategies to achieve the implementation of lean (Drohomereketki, Gouvea, Pinheiro, & Andrea, 2014, p. 804). The project will seek to create a new model for teaching lean, with a strategy to satisfy the stated need so that students can demonstrate the use of lean tools as well as display analytical decision making upon entering into the workforce.

**Definition of Terms**

**5S.** Sort, Straighten, Shine, Standardized, Sustain. These are the elements of keeping organization and cleanliness in a work center. It reduces waste by removing what is not needed and making sure that what is needed is located where it is used. It also ensures that only what is
needed is stored in that specific location, and the rest is stored elsewhere in a place designated for storage.

5Y. Designed to look more deeply into causes of a problem, asking ‘why’ several times until all symptoms have been found and the root of the problem has been identified.

**Associate Degree Level.** An undergraduate academic degree granted to a student who has completed a course of study lasting two years.

**Affinity Diagram.** Visual grouping of the needs, wants, and suggestions from highest level to lowest level; a way of organizing a large number of thought and ideas into their natural relationship of what is critical to satisfaction.

**Cost of Poor Quality (COPQ).** There are costs that would disappear if there were no errors, no re-work, no defect, no delay, etc.

**Flow Chart.** A picture style chart that separates process steps in sequential order: materials, actions, decisions, inputs/outputs, time, etc.

**Just-In-Time (JIT).** Ensuring that products get to the upstream process just when they are needed, reducing inventories, and not stock piling work-in-process to hide production inefficiencies.

**Kaizen.** In a lean process, as demonstrated by Toyota, there are two types of Kaizen, improvement kaizen and maintenance kaizen. Maintenance kaizen focuses on bringing problems to the surface and then bringing the process back to the standard. Improvement kaizen is continuously looking at existing processes making small incremental improvements daily. As kaizen began to be used in the west—it became a 3-5 day event where rapid improvements are made and where larger problems are identified and followed up on.
**Kanban.** A system/card which is a visual signal or sign that lets upstream processes know that more goods need to be delivered, or lets downstream processes know that goods can be picked up. Instrumental in a Flow System.

**Lean.** An operating philosophy that focuses on shortening lead time and eliminating waste from processes.

**Muda.** Is any human activity which absorbs resources but creates no value: mistakes which require rectification, production of items no one wants so that inventories and remaining goods pile up, processing steps which aren’t actually needed, movement of employees and transportation of goods from one place to another without any purpose, groups of people in a downstream activity standing around waiting because an upstream activity has not delivered on time, and goods and services which don’t meet the needs of the customer (Womack & Jones, 1996, p. 15).

**Non-value added** – Process step and necessary or unnecessary activities which a customer is not willing to pay for.

**Poka Yoke** – (Error proofing) Essentially modifying a device, machine, or process to ensure that an error cannot occur, or if something does break or go out of tolerance it is immediately noticeable and can be addressed so that it is not passed onto the next process.

**Project Charter** – A document that authorizes and brings definition to a project, includes project title, objectives, scope, estimated length, team members, etc.

**Process Map** – Graphic illustration of a process and its flow within a process, allows those not familiar with the process to see the key inputs and outputs.

**Root Cause Analysis** – Is getting to the main cause or "root" of a problem instead of fixing or focusing on symptoms.
Stakeholder – People or processes that are affected either favorably or unfavorably by a project or initiative.

Value added – Process steps and activity which the customer is willing to pay for, an activity that transforms or changes an input.

Value Stream Map – Illustrated map which follows the production/flow of a product or material, as well as its information as it makes its way through the value stream from the beginning (purchasing/order request) through to the customer.

Voice of the Customer (VOC) – Capturing the in-depth needs and expectations of the customer by being pro-active in understanding customer experience and focus.

Waste – Any activity which does not add value to process.

- Type 1 waste – activity that is needed for the process to function.
- Type 2 waste – does not add value and is not necessary.
Section II (Review of Literature)

Overview

The review of literature will first give a historical perspective of lean teaching as well as a theoretical look at various teaching methods and paradigms within academic instruction. The literature review will conclude with reviews of some of the current ways lean instruction is being delivered.

Historical Perspective

According to Peppers (2010), many companies are struggling to produce profits and are experiencing poor working conditions as well as low morale, all of which lead to poor efficiency and late delivery to customers. Often in these companies an entire culture change is required, and the resurgence of pride, commitment and success need to take place in order for the organization to begin pulling together as a team (Pepper, 2010, p. 11). To deal with this pressing issue, lean has become the dominant approach by manufacturing management and a catalyst in creating a competitive advantage. Lean is both a practical and philosophical perspective, guiding principles and goals as well as management practices and techniques (Boyle, Scherrer-Rathje, & Stuart, 2011, p. 587). Training in lean practices can be obtained through many consulting firms and lean organizations. The Lean Enterprise Institute, American Society of Quality, Lean.org, and the Gemba Academy are some examples of organizations offering lean training. Typically, lean consultants train in the 8 wastes mentioned previously and several other lean methods such as kaizen, 5S, just-in-time production (JIT), total productive maintenance (TPM), one-piece flow, and kanban. Additionally, workshops in principles include training in identifying waste, value stream mapping, creating flow, and establishing pull, and the concept of true north – the constant pursuit of the unattainable measure of perfection— is also taught (Rajesh, Mehta, & Mehta,
On-site training provided by these companies by way of workshops and seminars can cost between $800 - $3000 per class day of training, which is a large investment especially for businesses that are already in need of lean due to excessive waste that has resulted in high debt and low cash flow (Choomlucksana, 2012, p. 4). Organizational characteristics are different across industries, and there is no “cookie cutter” approach when it comes to implementing lean, and it should not be implemented the same way in every situation. Unionized environments often resist lean initiatives and fail to implement as quickly as their non-unionized counterparts, the main reasons being roadblocks in creating cross-functional work and teams that pull workers outside of their contracted job description, which is a key component in lean (Shah & Ward, 2003, p.130).

Theoretical Topics (Instructional – Methods & Paradigms)

**Horizontal/independent approach & vertical/dependent approach.** The teaching and instruction in lean began following the same structure as most teaching structures; the horizontal/independent approach, which fosters innovation and creativity by the instructor at the expense of integration and continuity across departments, or the vertical/dependent approach which fosters high continuity and uniformity throughout the organization but are highly regulated with little decision making or “change” authority at the lower management levels (Stratton, Rudy, Sauer, Perman, & Jennings, 2007, p. 333). This horizontal/independent structure allows for a high degree of autonomy and the low oversight by management provides strong buy-in to the model because the instructor is free to teach the curriculum however they feel, but best practices are rarely replicated in these scenarios because lack of oversight, which brings with it collaboration and accountability, decreases the chances of shared practices across the organization (Stratton et al., 2007, p. 333). The vertical/dependent structure brings accountability
back to the teaching environment because standards are set to ensure instructional quantity and quality. However, this structure also leads to added layers of bureaucracy which leaves oversight disconnected from the teaching environment, so when a change is needed it becomes difficult to come to a collective focus; this leads to lack of pride and ownership while at the same time stifling individual innovation and creativity (Stratton et al, 2007, p. 333).

**Interdependent approach.** The challenge for educators is to blend the best of both the horizontal/independent approach and the vertical/dependent approach. Both of these teaching practices, when joined together, create a teaching environment that is conducive to learning and the retention of knowledge. Stratton et al. (2007) note that combining these elements into an interdependent model strategically disassociates the decision-making function from the organizational accountability function, giving lean instructors the decision-making and change authority needed to be adaptive when conduct training, not held to a rigid syllabus, fostering a sense of ownership, innovation, and creativity (p. 333). Adopting the interdependent model provides the instructor freedom to make program changes as needed, without the approval of upper management; once these changes or decisions are made, they are evaluated and can be shared across organizational departments (Stratton et al., 2007, p. 333). Structure is very important when embarking on a lean transformation; it is a journey that can lead to remarkable improvement when embraced organizationally. While many of these lean concepts seem simple in nature, they require a radical mindset change and must be effectively taught to all levels of employees (Kuriger, Wan, Mirehei, Tamma, Chen, 2009, p. 487-488). This statement is key because potential job candidates should come to the interview already possessing a lean management mindset, but instead, once they are offered the job the new company has to reprogram them to this lean methodology which stands in contrast to what they just spent four
years learning. “What the students are learning in the classroom doesn’t address their needs or ours; therefore, we must bring them back into another classroom and instruct them some more” (Barr & Tag, 2016, p. 14).

**Instructional paradigm/learning paradigm.** There is good reason for structure in the learning environment, but it doesn’t need to be rigid to the point that instructors cannot be fluid in an ever changing teaching environment. Structure brings opportunity for efficiency and effectiveness and fluid standardization is at the heart of lean. Once a teaching model is aligned to an independent structure, a best method must be used to ensure that those receiving instruction are able to apply what they have learned through practical application, and this is determined or measured by the teaching approach taken by the instructor. In the traditional instructional paradigm, institutions of higher learning felt their purpose was to provide instruction mainly through a series of lectures on a chosen topic. Barr and Tagg (1995) state that instructors need to recognize that providing instruction is not their chief aim, but stimulating an environment that produces learning is the goal. Learning is the responsibility of the instructor, and in a learning paradigm that instructor must find a way to engage students and provoke understanding and comprehension through the way they teach their students; the purpose is not “knowledge transfer” but “environment creation,” which brings students to think for themselves, make discoveries and solve problems (Barr & Tagg, 1995, p. 15). Students of lean in an instructional paradigm often have difficulty applying course techniques to real-world situations, especially when they have had little or no manufacturing experience and are expected to transfer what they know to their new job immediately (Fliedner & Mathieson, 2009, p. 198). “The idea that colleges cannot be responsible for learning flows from a disempowering notion of responsibility. If we conceive of responsibility as a fixed quantity in a zero-sum game, then students must take
responsibility for their own learning” (Barr & Tagg, 1995, p. 15) The learning paradigm requires students to process new information based on what has transpired, navigating these thoughts to find answers that were not initially seen.

**Problem based learning.** The concept of problem-based learning embraces the concept of the learning paradigm and avoids the pitfalls of the instructional paradigm by providing applicable knowledge through attaching hands-on exercises with the lecture based portions of lean theory (Conger & Miller, 2014, p. 81). Many educators are in agreement in the logic that active learning, via hands-on exercises, expose students to practical issues in a manufacturing setting, where the gap between theory and practice are bridged and the students understanding goes beyond simply learning, to the point that they can apply facts and combine ideas to make critical judgements (Elbadawi et al., 2009, p. 537-538). In research conducted by Conger and Miller (2014), it is stated that “students are ill equipped to deal with complex, unquantifiable issues after they leave collage, and that their learning environments fail to provide students with the knowledge of how to be fact integrators rather than fact memorizers” (p.82). Problem based learning uses a variety of techniques including applied participation and interaction with their environment, which then leads to problem variability and structured discussions of what the student has learned through their experiences (Conger & Miller, 2014, p. 82).

Another important element in problem based learning is the critical role of the instructor as mentor. Instructors must be able to analyze a student’s thought process to imbue discussions that lead to constructive feedback and intellectual guidance. Knowledge gaps help the learning process because students must revisit problems using new information and ask follow up questions; this is the coaching opportunity that pushes students toward independent thought,
allowing them to begin understanding how to teach themselves and become avid self-developers (Conger & Miller, 2014, p. 82-83).

**Current Technology (Instructional Delivery)**

Lean has been a major business strategy for the last two decades and a major driver of corporate profit and earnings growth; yet lean is not widespread in higher education curriculum, so consequently the majority of college graduates leave higher education with little to no understanding of lean (Fliedner & Mathieson, 2009, p. 194). Some universities have created courses to introduce students to lean and are typically found in business and engineering majors; however, based on time constraints, instructors pick and choose which topics to cover based on personal preference or whichever best fits into the critical path they feel they must prepare their students for (Marley, Arnheiter & Venkateswaran, 2012, p. 332). The reason for this time constraint and ineffectiveness of the teaching is due to the text cramming multiple categories of lean such as total quality management, just-in-time, total productive maintenance, human resource management practices, as well lean supplier management and training all into the same textbook (Marley, Arnheiter & Venkateswaran, 2012, p. 333). When these practices are taught or written about in textbooks, they are pre-existing practices “rebuilt” in the context of lean principles, but they are not “the” lean principles; the philosophical origins have been skipped and application is pushed forth by passing the slow road of learning and moving straight to implementation. This is reiterated by Choomlucksana (2012) in a study which states: “[R]esearchers have found that although there are some lean courses available in higher education, learners remain unclear about the lean principles and methods” (Choomlucksana, 2012, p. 5). Employers seek out graduates that can demonstrate process improvement through analyzing manufacturing systems, preferably those that have had experience in real-world
settings where dealing with organizational issues and handling resource constraints are part of the experience (Sink, 2013, p. 35). Fliedner & Mathieson (2009) add: “[L]ean practitioners want university graduates to have a comprehensive or systems view of organizations,” and “organizations do not want the time or financial burden of a significant training program when hiring recent graduates” (p. 198). The lean initiative demands that people take a wholistic view of the organization, seeing all parts interrelated and critical to the organization’s success, and at the same time introducing the importance of relationship building in order to achieve goals and grow the company (Fliedner & Mathieson, 2009, p. 198-199). This type of wholistic thinking is learned when the fourteen principles are taught extensively.

In a current text book study by Marley, Stodnick, & Heyl (2013), on the total academic content on lean, it was found that 86% of the material had no mention of future state mapping which is a key component in understanding the goal for a process. Along with this data, only 7% of the material taught is about policy deployment, and even this small percentage was not in the specific chapters on lean. Sadly, this would indicate that the majority of students exposed to lean had virtually no training in how to conduct change or be a change agent. Another statistic found that in lean material only 14% of the material discussed the 5 Whys along with 7% in discussing Pareto charts, so root cause analysis was severely lacking (Marley, Stodnick, & Heyl, 2013, p. 335). On a final note, it should be mentioned that in all the lean material at the time of study, 0% had any discussion of the A3 process which lies at the heart of Toyota’s Plan Do Study Act (PDCA) methodology (Marley, Stodnick, & Heyl, 2013, p.). The A3 process heavily involves consensus building and laying a strong foundation for decision making, making sure the right things are being worked on and that the key stakeholders are involved in the decision making.
process; and through the A3 report the process owners gain a deep understanding of the problem and how it effects team members across departmental barriers (Liker, 2004, p. 244-248).

Chapter II Summary

The review of literature began with a historical perspective of how lean has been introduced to manufacturing facilities in the past, including some of the tools used, implementation in union vs. not union environments, and the high cost involved when consultants and lean institutions must be brought in to train workers. This perspective sheds light on the problem which speaks of the high cost companies must pay to train new employees in lean even though they have just come out of college and should’ve been trained in these latest business model philosophies. Next, a few theoretical topics were introduced as it pertains to effective curriculum building and teaching within the academic setting. The horizontal and vertical approaches to curriculum building contrast how horizontal approaches promote innovation and creativity while the vertical approach provides an atmosphere of continuity and uniformity within the course structure. This was further developed to show that a combination of the two, the interdependent approach, was a best method to creating a course, allowing instructors to be fluid in course delivery while at the same time being accountable to deliver on overall institutional directives. This interdependent approach promotes the cognitive development of students by allowing the instructor to adapt to the ever changing atmosphere within the college classroom dynamic, addressing another aspect of the problem statement.

Two paradigms were also researched, the instructional paradigm and the learning paradigm. The instructional paradigm was shown to hold students accountable for their learning through note taking, research and self-study; the learning paradigm inverted this methodology to hold the instructor accountable for providing an environment that was conducive to learning and
an atmosphere that allowed students to learn by doing, applying what they have learned in simulations, case studies and hands-on real world applications. The learning paradigm is a key component in addressing the problem of students not being able to participate and lead lean initiatives once they exit college.

The final theoretical topic involved problem based learning, a method of learning that teaches students to deal with complex issues by integrating the facts they’ve learned with the problems they face. Problem based learning is in the best position to generate lean thinkers that are coming out of college, having the thought process instilled in them that can translate into an immediate impact for a company that is embarking on a lean journey. Having the ability to step back and analyze a process, apply lean thinking and principles, and then lead an initiative to address issues is what companies seek today.

The last section in the lean review looked at the current technologies and delivery format as it pertains to academic instruction. There were two main issues that developed throughout the research. The first issues dealt with segmented teaching where different lean topics were thrown into other course material and text books ranging from courses in engineering to operational management. This yielded quick teaching done mainly through lecture and reading or the subject being skipped altogether by an instructor who did not see it important to the student career path. The other issue involved a fire hose approach that tried to teach the student everything about lean as well as its many counter parts all within a sixteen-week course. This provided a very shallow understanding of lean, minimal knowledge attainment and no ability to actively apply what was taught to a real world situation. Like other issues mentioned previously this too requires postgraduate education by the company if the student is to contribute in lean implementation.

The review of literature gave insight into the need for colleges to prepare lean thinkers with
applicable knowledge on both lean and the lean tools needed to rightly assess processes, and it also revealed the frustration within the industry of having to expend funds in training new employees who are not ready to make an immediate contribution once they join the organization. The reviews also pointed out that practical and applied knowledge is needed in any type of training or education where students are going to have to demonstrate skills upon leaving the educational institution. As the industry calls for problem solvers and independent thinkers, able to move in and make an immediate impact, it presents itself that problem based learning should be a part of the lean curriculum.
Section III: Procedure

Overview

The procedure section speaks to procedures to be carried out in solving the problem as stated in the “statement of the problem” above. The section will explain the intended methods to be used as well as describe sample curriculum structures used to benchmark a college course design. Each module in the curriculum will have a method for ensuring that learnings within the course are sustained and applicable in accordance with the learning methods discovered in the reviews of literature.

Development Procedures

Required text and instructional material. Building the course on the 14 principles of Lean was the predetermined objective for the project design; the 14 principles are already established and defined, and background on the development of the 14 principles shall be waived.

The course will be designed from the fourteen principles of lean presented in The Toyota Way, as the text lays out the 14 principles in a wholistic setting: part one gives a history of Toyota Production System (TPS) and the 14 principles in action, in part two the 14 principles are broken down and shown how they drive the management approach and tools used in TPS, and a third part which describes how a company can apply lean principles. The text was written by Jeffrey K. Liker who at the time of writing the book had over 20 years of studying the lean manufacturing practices of Toyota. He was also Director of the Japanese Technology Management Program at the University of Michigan which laid much of the foundation and research that went into the 14 principles of lean. Jeffrey Liker has authored eight other books on
the Toyota Way and has won eleven Shingo prizes for his research while co-authoring 85 articles and book chapters along with 5 other books in lean and lean manufacturing methods. The core objective in the course will be to give the student a solid understanding of lean that can be demonstrated through analytical thinking and case study. The course will incorporate a mix of case studies, tools, lectures, simulations, etc. and focus on one principle per week. Excerpts from *The Toyota Way to Lean Leadership*, *Toyota Kata*, and *Lean Thinking* will also be used as supplementary material to expand on the principles of lean.

**Tools.** The study of lean tools will be a key aspect of solving for the problem statement. Training in lean tools was shown as a problem within industry through the research and review of literature. The principles of lean drive particular tools and techniques needed to implement and sustain a lean environment; therefore, the study of, and training in, key tools will be necessary to satisfy the project objective of creating a course that allow a student to enter the workforce and be an immediate contributor on lean initiatives. Several tools found throughout the literature review were common in relation to lean: root cause analysis, standard work, vision & mission statements, JIT, flow chart, process mapping, value stream mapping, affinity diagrams, voice of the customer and 5S. The tools will be injected into the course curriculum, and the course will be designed in accordance with these principles and tools. The tools will be matched to workshop designs that will give students hands-on applicable knowledge. Lean websites will be reviewed to explore existing tool application workshops and to generate ideas that can assist in developing hands on labs for the tools found in the appendix.

**Course Design**

The course will be designed to delivered in a systematic format that is already accepted within state colleges and universities. In order to achieve this and reduce research outside the
scope of this project, Northwest State Community College and Bowling Green State University will be benchmarked for their course syllabi and course schedules. Several class syllabi and course schedules will be referenced from courses given during the 2011-2016 academic school years. Summer course syllabi will also be referenced for observation of shortened class schedules. The internet will also be searched for course development plans from universities, community colleges, and online learning centers, the Accreditation Body of Engineering Technology Programs (ABET) will also be used in understanding course development. The following measures will need to be looked into to ensure proper course development:

1) Planning and preparation
2) Course design (layout)
3) Course development Process (structure)
4) Developing the learning experience (flow)
5) Learning Assessment

Through review of lean teaching methods and practices, it was discovered that an interdependent teaching structure, combined with problem based learning taught in the learning paradigm would yield the best opportunity to create an environment that is conducive to learning, creates innovative thinkers, and produces practical problem solvers. Curriculum will be designed around these instructional paradigms.

**Course planning guide.**

Process Steps:

1. Research how to develop a course curriculum
   A. Internet search
   B. Northwest State Community College
      i. Interview Dean of Engineering Dept.
   C. Bowling Green State University
      i. Interview Associate Dean of College of Technology
   D. Material Review
i. Montana State University – How to plan curriculum
   1. http://www.montana.edu/facultyexcellence/Papers/HOW%20TO%20PLAN%20CURRICULUM.pdf

ii. Knox College – Guide to Academic Program Assessment

2. Build course according to research
   A. Define course objectives
   B. Build course backwards from objectives
      i. Design course to fill objectives
   C. Determine assessment to verify learning of objectives

**Modules and assignments.**

Process Steps:

1. Research how assignments and class learning are set forth
   A. Survey how existing universities break down course assignments
      i. Northwest State Community College
         a) Course syllabi and outlines
      ii. Bowling Green State University
         a) Course syllabi and outlines
      iii. Montana State University – How to plan curriculum
      iv. Knox College – Guide to Academic Program Assessment

2. Study how learning objectives are separated into modules or sections

3. Analyze 14 principles of lean and determine tools that align with given principle
   A. Verify assignments align with determined objectives

4. Separate 16-week course and weekly assignments into themes to construct modules

**Assessments.**

Process Steps:

1. Research course assessment methods online
   a. Accreditation Board for Engineering and Technology (ABET)
      i. http://www.abet.org/
b. Quality Matters (QM)
   i. [https://www.qualitymatters.org/](https://www.qualitymatters.org/)

c. Blooms Taxonomy
   i. Iowa State University
      a) [http://www.celt.iastate.edu/teaching/effective-teaching-practices/revised-blooms-taxonomy](http://www.celt.iastate.edu/teaching/effective-teaching-practices/revised-blooms-taxonomy)
   ii. Questions for the Revised Bloom’s Taxonomy

2. Determine criteria for assessment which is in line with both research and course objectives

3. Use Blooms Taxonomy to categorize educational goals and determine proper action words to display/describe the students’ learned knowledge

4. Use the above process to design an assessment for each module

**Syllabus.**

Process Steps:

1. Research existing syllabi for content and construction
   a. Northwest State Community College
      i. Various syllabi
   b. Bowling Green State University
      i. Various Syllabi
   c. Research online examples

2. Design course syllabus from knowledge gained from research
   a. Align with lean

**Chapter III Summary**

The course will be developed having the first priority to instill in students’ lean principles and lean philosophy as made public in *The Toyota Way*. Lean tools that were common in the review of literature will be researched and embedded into the class structure. Case studies, hands-on labs and projects will be researched and designed to bring out the lean principles and
tools. The course flow will be geared toward a progressive format that builds upon itself week to week. A course planning guide will be used and modules and assignments will be constructed based on methods used at existing colleges and universities as well as accredited organizations. The use of accredited college level examples for course layout, building, and structure will be key in following the current standard practices within state colleges, community colleges and universities.

Proper assessment will be a major portion of the curriculum as the goal of the project is to ready students to be immediate contributors to lean initiative upon entering the workforce. Accredited and respected organizations will be used to determine the best ways to assess gained knowledge. And lastly, a standard course syllabus will be constructed that is in line with current academic practice.
TIMELINE AND PLAN

Master Project Gantt Chart:

<table>
<thead>
<tr>
<th>Master Project Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronological Order of Typical Events</td>
</tr>
<tr>
<td>Section 1: Introduction</td>
</tr>
<tr>
<td>Section 2: Review of the Literature</td>
</tr>
<tr>
<td>Section 3: Procedures</td>
</tr>
<tr>
<td>Review and Presentation</td>
</tr>
<tr>
<td>Section 4: Results/Findings</td>
</tr>
<tr>
<td>Section 5: Summary, Discussion and Recommendations</td>
</tr>
<tr>
<td>Review and Presentation</td>
</tr>
</tbody>
</table>

*Figure 1: Project Gantt Chart*
Section IV Results & Findings – (Completed Course Blueprint)

Overview

The documents from undergraduate institutions were reviewed and a course blueprint has been assembled in referencing them. Course documents were created in accordance with materials referenced from Northwest State Community College, Bowling Green State University and online academic websites. Tools researched throughout the project were inserted into the learning curriculum blueprint. This chapter outlines the results and findings as modules and assessment were constructed throughout the course blueprint based on the materials referenced and researched in the literature review.

Instructional Strategies and Materials

The lean course functions best within an interdependent teaching atmosphere where instructors have the freedom to modify material as the class composition dictates. As the course is taught, it is intended that instructors share learning and develop plans and best methods on how to serve the wide variety of students they may encounter. The course requires that it be taught on the learning paradigm methodology, where the instructor is held accountable for the students learning. The instructor must find ways to reach each student, understand their learning style and adapt. As the instructor walks this out through demonstration and is successful, the student will gain an indirect understanding of change management and the different ways one must adapt when working in teams or leading change in a challenging environment. Change management as a concept is outside the scope of this project, but it serves the instructor well to demonstrate adaptiveness. The toughest aspect of going lean is knowing “how to create an aligned organization of individuals who … are continually learning together (Liker, 2004, p.290).
As stated in section two, the learning paradigm requires students to process new information based on what has transpired, navigating these thoughts to find answers that were not initially seen. Based on this concept, problem based learning is the chief teaching medium employed throughout the course to ensure students have the ability to contribute in the workplace. One avenue for hands on learning will be through offsite field trips to study lean environments and also to participate in a critical analysis of a local process. Lab activities directly involving the tools learned in classroom lectures will immediately follow the teaching, giving students the opportunity to apply the knowledge they have just learned. The tools and methodologies learned throughout the course will be demonstrated in a semester ending project that uses many of the tools in a real life kaizen event. Guest professionals will also be used to give instruction and conduct various learning simulations.

Introduction to lean principles will be given in lecture format to allow for a deep explanation of each of the fourteen principles. Prior to each lecture, a reading assignment will be given from the text *The Toyota Way*, the mandatory book for the class. Students will be asked to research various topics depending on the homework assignment; this is done to ensure that students understand where and how to find information on some of the topics and tools they will encounter in the workforce. Homework assignments will also include case studies that add value to the learning for the week. There will be two additional text books needed for the class: *The Quality Tool Box* by Nancy R. Tague and *Learning to See* by Mike Rother & John Shook.

**Course Planning Guide**

**Learning objectives/outcomes.** A course planning guide was created to take a systematic approach to developing the course. The development process began with determining what the students were expected to know and do upon completion of the course. The fourteen
principles of lean are key components to the lean curriculum and the course objectives are carefully aligned with the principles in *The Toyota Way*. Tools aligned with lean principles within the text are scheduled succinctly where possible, along with other appropriate tools discovered throughout the literature review. Overall course outcome objectives will be proven based on the students’ overall comprehension of the principles and tools as well as their function. The student will be able to restate the 14 Principles of Lean and provide a written explanation of each. The student will be able to restate and explain the 8 wastes, give a description of each waste, and identify waste within a process. The student will be able to restate and interpret the 5S categories, and define the process of a 5S event. The student will be able to plan and develop a Kaizen event, and demonstrate the ability to lead/contribute through a class capstone projects. In order to ensure the student has applied knowledge, a course capstone project will be conducted; therefore, the student must be able to develop a Project Charter and define project roles and project scope based on the Voice of the Customer selected from the surrounding communities.
**Course Planning Guide**

<table>
<thead>
<tr>
<th>Learning Objectives/Outcomes</th>
<th>Assessments (Measurable Results)</th>
<th>Instructional Strategies</th>
<th>Instructional Materials and Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>What will the students know/learn/be able to do when they have completed this course?</td>
<td>How will I know what the students know, learned, and are able to do as a result of this course?</td>
<td>What activities/experiences will lead students to achieve the objectives?</td>
<td>What will the student need and use to achieve the objectives?</td>
</tr>
</tbody>
</table>

**Course Objectives**

1. The student will be able to restate the 14 Principles of Lean and provide a written explanation of each.
   - Essays, Tests, Quizzes, and Assignments.
   - Activity/Lab evaluation
   - Lectures, Research, Text Reads, and Critical analysis of example process.
   - PP presentations, text book, online examples, site visits.

2. The student will be able to restate and explain the 8 wastes, give a description of each waste, and identify waste within a process.
   - Essays, Test, Quizzes, and Assignments.
   - Lectures, Research, Text Reads, and Critical analysis of example process.
   - PP presentations, text book, online examples, site visits.

3. The student will be able to restate and interpret the 5S categories, and define the process of a 5S event.
   - Essays, Test, Quizzes, and Assignments.
   - Activity/Lab evaluation
   - Lectures, Research, Text Reads, and Capstone project
   - PP presentations, text book, online examples, site visits.

4. The student will be able to plan and develop a Kaizen event, and demonstrate the ability to lead/contribute through a class capstone projects.
   - Essays, Test, Quizzes, and Assignments.
   - Activity/Lab evaluation
   - Lectures, Research, Text Reads, and Capstone project
   - PP presentations, text book, and site visits.
Lean Course Schedule (Modules and Assignment)

A module format is used to create the course schedule designed to fulfill the learning outcomes stated in the course planning guide. The course is designed as a 16 week - 5 credit hour course with a two hour lecture session and a 3 hour lab. The fourteen principles of lean are discussed weekly throughout the class and transcend all modules. In Module One the student will be able to give a history of lean, interpret COPQ, summarize root cause analysis and develop a vision/mission statement. Vision and mission statements are critical to the development of a long term strategy because they are what should align everyone corporately; they should also be measurable so that they can be evaluated over time. Labs include team building activities, 5Y activities/root cause analysis tools and developing a Vision and Mission statement. Duration 3 weeks. In Module Two the student will explain the 8 wastes and map a process; student will summarize Just-In-Time and explain Constraint Theory. Labs include conducting a waste walk and mapping a process, along with a Just-In-Time simulation that also incorporates Constraint Theory (Duration 4 weeks). In Module Three the student will be able to define standard work and visual management, student will be able to explain the Plan-Do-Check-Adjust cycle. Labs include standard work exercises, detailed process mapping and future state mapping (Duration 3 weeks). In Module Four the student will be able to charter and scope a project, and the student will be able to lead/contribute to a Capstone 5S Kaizen Event. Lab activities include project scoping and developing a project charter, gathering voice of the customer and affinitizing the VOC. The module will also initiate the 5S event that is the Capstone project (Duration 5 weeks). Two weeks are allotted for review and the taking of the final exam with the lab time being used for the final phases of the 5S event.
<table>
<thead>
<tr>
<th>Week</th>
<th>Module</th>
<th>Close Date</th>
<th>Work We Will Cover in Class on This Date</th>
<th>Reading Assignments to Be Completed by this Date</th>
<th>Work to be Completed by this Date</th>
</tr>
</thead>
</table>
| 1    | 1      | xx/xx/201x | Review:  
- Course Syllabus  
- Class Introduction  
- What do you know about Lean  
- Cost of Poor Quality (COPQ) | | Sign and turn in last page of syllabus to instructor, including Liability Waiver.  
Lab: Team Building Activities |
| 2    | 1      | xx/xx/201x | - PP & Lecture Chapters 1-4  
- PP & Lecture Root Cause Analysis | Having thoroughly read and reviewed chapters 1-4 in The Toyota Way | Quiz Chapters 1-4  
Essay Chapters 1-4  
Lab: 5 Why Activities/root cause tools |
| 3    | 1      | xx/xx/201x | - PP & Lecture Chapter 7 Principle 1  
- PP & Lecture Vision & Mission Statements | Having thoroughly read and reviewed chapters 7 in The Toyota Way & other assigned readings | Quiz Chapter 7  
Essay Chapter 7  
Lab: Vision & Mission Statements, & the purpose in making them measurable. |
| 4    | 2      | xx/xx/201x | - PP & Lecture Chapter 8 Principle 2  
- PP & Lecture 8 WastesFlow Charts, Process Mapping and Value Stream Mapping | Having thoroughly read and reviewed chapters 8 in The Toyota Way & other assigned readings | Quiz Chapter 8  
Essay Chapter 8  
Lab: Waste Walk & Mapping w/exercise  
Lab: Design Flow Charts from offline visit  
Construct Process Maps |
| 5    | 2      | xx/xx/201x | - PP & Lecture Chapter 9 Principle 3  
- PP & Lecture Just-In-Time/kanban/ Pull Systems | Having thoroughly read and reviewed chapters 9 in The Toyota Way & other assigned readings | Quiz Chapter 9  
Essay Chapter 9  
Lab: Just-In-Time –Simulation  
Guest Speaker & Activity |
| 6    | 2      | xx/xx/201x | - PP & Lecture Chapter 10 Principle 4  
- Constraint Theory | Having thoroughly read and reviewed chapters 10 in The Toyota Way & other assigned readings | Quiz Chapter 10  
Essay Chapter 10  
Lab: Offsite visit and observation of processes |
| 7    | 2      | xx/xx/201x | - PP & Lecture Chapter 11 Principle 5  
- PP & Lecture Mistake Proofing  
- Re- Visit Mapping | Having thoroughly read and reviewed chapters 11 in The Toyota Way & other assigned readings | Quiz Chapter 11  
Essay Chapter 11  
Lab: Map process from Week 6 |
| 8    | 3      | xx/xx/201x | - PP & Lecture Chapter 12 Principle 6  
- PP & Lecture Standard Work | Having thoroughly read and reviewed chapters 12 in The Toyota Way & other assigned readings | Mid-term over Chapters 1-4 & 7-12  
Essay included in Mid-term (2hrs)  
Lab: Standard Work Excercise  
Lab: Re-visit Offsite Company and bring definition to the Process Maps |
| 9    | 3      | xx/xx/201x | - PP & Lecture Chapter 13 Principle 7  
- PP & Lecture Visual Mangement | Having thoroughly read and reviewed chapters 13 in The Toyota Way & other assigned readings | Quiz Chapter 13  
Essay Chapter 13  
Develop future state Map from visit |
| 10   | 3      | xx/xx/201x | - PP & Lecture Chapter 14 Principle 8  
- PP & Lecture Brainstorming Techniques  
- PP & Lecture PDCA | Having thoroughly read and reviewed chapters 14 in The Toyota Way & other assigned readings | Quiz Chapter 14  
Essay Chapter 14  
Lab: Brainstorming Exercises  
Lab: Re-visit offsite Company and present future state Map and C.I. Ideas |
| 11   | 4      | xx/xx/201x | - PP & Lecture Chapter 15 Principle 9  
- PP & Lecture Project Scoping and Project Charter  
- PP & Lecture VOC & Affinity | Having thoroughly read and reviewed chapters 15 in The Toyota Way & other assigned readings | Quiz Chapter 15  
Essay Chapter 15  
Lab: Project Scoping and Project Charter based on Class Major Project |

Figure 3: Course Modules and Assignments
Assessments (Measurable Results)

Proper assessment is needed to ensure students are ready to make an immediate impact upon entering the workforce. To measure the level of knowledge attainment, quizzes are given weekly as well as weekly assignments over the reading material. Essays measure the students’ ability to express lean reasoning and thought and they are administered weekly. A Mid-term exam and a final exam are given in week 8 and week 17 (finals week). Labs are conducted weekly over lecture material and hands on simulations. Case studies are also used; students will travel off site to visit real world situations, and guest speaker/instructors from the lean workforce will be invited to assist in activities, simulations and lectures. Students are assessed during the labs by observing their participation and level of engagement.

Module assessment criteria.

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Educational Strategies</th>
<th>Methods of Assessment</th>
<th>Summative Assessment</th>
<th>Formative Assessment</th>
<th>Threshold for Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summarize the history of lean</td>
<td>Lectures, Research, and Text Readings</td>
<td>Essays, Test, Quizzes, and Assignments</td>
<td>Essays, Test, Quizzes, and Assignments</td>
<td>weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Interpret COPQ.</td>
<td>Lectures, Research, and Text Readings</td>
<td>In class group activity and role play</td>
<td>Essays, Test, Quizzes, and Assignments</td>
<td>weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Develop a vision/mission statement.</td>
<td>Lectures, Research, and Text Readings</td>
<td>Student will write a vision/mission statement for a mock business or organization.</td>
<td>Essays, Test, Quizzes, and Assignments</td>
<td>weekly essays and discussion posts</td>
<td>80%</td>
</tr>
</tbody>
</table>

Figure 4: Module 1 Assessment
### Figure 5: Module 2 Assessment

**Student Outcome Module 2:** Student will explain the 8 wastes and map a process; student will summarize Just-In-Time and explain Constraint Theory.

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Educational Strategies</th>
<th>Methods of Assessment</th>
<th>Summative Assessment</th>
<th>Formative Assessment</th>
<th>Threshold for Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>What concrete actions the student should be able to perform as a result of completing the module?</td>
<td>What activities/experiences will lead students to achieve the objectives?</td>
<td>How will I know what the students know, learned, and are able to do as a result of this course?</td>
<td>How will you evaluate student learning at the end of a module?</td>
<td>How will you monitor student learning and provide feedback throughout module?</td>
<td>What is the passing criteria to ensure competence</td>
</tr>
<tr>
<td>Explain the 8 wastes</td>
<td>Lectures, Research, and Text Readings</td>
<td>Student will conduct a critical analysis of a process.</td>
<td>Essays, Tests, Quizzes, Assignments, and visual observation</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Develop a process map</td>
<td>Lectures, Research, and Text Readings</td>
<td>Student will map a process through observation and interviews</td>
<td>Essays, Tests, Quizzes, Assignments, and visual observation</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Summarize JIT</td>
<td>Lectures, Research, Text Readings, guest speaker with activity</td>
<td>In class group activity and report out essay</td>
<td>Essays, Tests, Quizzes, Assignments, and visual observation</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Explain Constraint Theory</td>
<td>Lectures, Research, Text Readings, guest speaker with activity</td>
<td>In class group activity and report out essay</td>
<td>Essays, Tests, Quizzes, and Assignments.</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
</tbody>
</table>

### Figure 6: Module 3 Assessment

**Student Outcome Module 3:** Student will be able to define standard work and visual management; student will be able to explain the Plan-Do-Check-Adjust cycle.

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Educational Strategies</th>
<th>Methods of Assessment</th>
<th>Summative Assessment</th>
<th>Formative Assessment</th>
<th>Threshold for Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>What concrete actions the student should be able to perform as a result of completing the module?</td>
<td>What activities/experiences will lead students to achieve the objectives?</td>
<td>How will I know what the students know, learned, and are able to do as a result of this course?</td>
<td>How will you evaluate student learning at the end of a module?</td>
<td>How will you monitor student learning and provide feedback throughout module?</td>
<td>What is the passing criteria to ensure competence</td>
</tr>
<tr>
<td>Define standard work</td>
<td>Lectures, Research, Text Readings, and in class activity</td>
<td>Student will write a standard work instruction</td>
<td>Essays, Tests, Quizzes, and Assignments, Activity/Lab evaluation</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Define Visual Management</td>
<td>Lectures, Research, Text Readings, and in class activity</td>
<td>Student will perform a visual management activity</td>
<td>Essays, Tests, Quizzes, Assignments, Activity/Lab evaluation</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Explain the PDCA cycle</td>
<td>Lectures, Research, and Text Readings</td>
<td>Student will perform the PDCA cycle on the standard work and visual management activities for prior two weeks activities</td>
<td>Essays, Tests, Quizzes, and Assignments.</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
</tbody>
</table>

### Figure 7: Module 4 Assessment

**Student Outcome Module 4:** Student will be able to charter and scope a project; student will be able to lead/contribute to a Capstone SS Kaizen Event.

<table>
<thead>
<tr>
<th>Performance Indicators</th>
<th>Educational Strategies</th>
<th>Methods of Assessment</th>
<th>Summative Assessment</th>
<th>Formative Assessment</th>
<th>Threshold for Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>What concrete actions the student should be able to perform as a result of completing the module?</td>
<td>What activities/experiences will lead students to achieve the objectives?</td>
<td>How will I know what the students know, learned, and are able to do as a result of this course?</td>
<td>How will you evaluate student learning at the end of a module?</td>
<td>How will you monitor student learning and provide feedback throughout module?</td>
<td>What is the passing criteria to ensure competence</td>
</tr>
<tr>
<td>Charter and scope a project</td>
<td>Lectures, Research, Text Readings, and in class activity</td>
<td>Student will write a project charter and design and Inscope/outscope diagram</td>
<td>Essays, Tests, Quizzes, and Assignments, Activity/Lab evaluation</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Develop a Kaizen agenda for a SS event</td>
<td>Lectures, Research, Text Readings, and in class activity</td>
<td>Student will develop a Kaizen slide deck</td>
<td>Essays, Tests, Quizzes, and Assignments.</td>
<td>Weekly essays and discussion posts</td>
<td>80%</td>
</tr>
<tr>
<td>Lead/contribute in Capstone SS event</td>
<td>Conduct SS event at offsite location</td>
<td>Visual observation and questioning</td>
<td>Peer and Instructor evaluation</td>
<td>Weekly essays and discussion posts</td>
<td>85% positive team and instructor evaluation</td>
</tr>
</tbody>
</table>
Lean Course Syllabus

A course syllabus was created following the example observed in courses offered at Northwest State Community College and Bowling Green State University. The course syllabus presents what will be accomplished by the end of the semester, and these learning outcomes are aligned with the goals set forth by the project.

Course syllabus

Course Information Sheet

Course Title: Lean Essentials for Today’s Businesses
Semester: Current Semester
Instructor: Jeremy B. Espinoza
Office: 
Phone: 
E-Mail: 
Classroom: 
Office Hours: 

Required Text:
http://www.amazon.com/Toyota-Way-Management-Principles-Manufacturer/dp/0071392319/ref=sr_1_1?ie=UTF8&qid=1458408780&sr=8-1&keywords=the+toyota+way
http://www.amazon.com/Quality-Toolbox-Nancy-R-Tague/dp/0873896394/ref=sr_1_1?ie=UTF8&qid=1458408411&sr=8-1&keywords=the+quality+toolbox
http://www.amazon.com/Learning-See-Stream-Mapping-Eliminate/dp/0966784308/ref=sr_1_1?ie=UTF8&qid=1458408841&sr=8-1&keywords=Learning+to+see

Course Description:
A study to develop a basic understanding of lean principles and applicable knowledge of lean tools with emphasis on: The 14 Principles of Lean, Just-in-Time, Project Charter, VOC, Affinity

**Course Learning Objectives**

**By the end of the semester, you will be able to:**

- Describe in detail the 14 principles of lean.
- Give a learned description of COPQ and describes its effect on Corporate Sustainability.
- Develop a vision and mission statement.
- Explain the 8 wastes.
- Understand Just-In-Time and Constraint Theory.
- Define Standard work and Visual Management.
- Explain the PDCA Cycle.
- Properly develop a Project Charter.
- Define VOC and explain the process of turning VOC into a project.
- Apply a degree of root-cause analysis.
- Conduct a 5S Event/Kaizen.

**Evaluation:**

<table>
<thead>
<tr>
<th>Assignments and Quizzes</th>
<th>15%</th>
<th>Grading Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essays</td>
<td>20%</td>
<td>90-100</td>
</tr>
<tr>
<td>Lab Activities</td>
<td>20%</td>
<td>80-89</td>
</tr>
<tr>
<td>Final Project</td>
<td>25%</td>
<td>70-79</td>
</tr>
<tr>
<td>Final Exam</td>
<td>20%</td>
<td>60-69</td>
</tr>
<tr>
<td>Overall</td>
<td>100%</td>
<td>59-below</td>
</tr>
</tbody>
</table>

**Course Expectations**

**Participation:**

Students are expected to come to class and be in class on time, being late to meetings causes waste, and this class is about eliminating waste. Students will actively participate in class discussions and exercises to enhance their learning experience and to understand the concept of engaged involvement. I reserve the right to dismiss students who are not cooperative or unruly.
and to not allow students in class that are excessively late. Teamwork will be expected and required.

**Discussions:**
Discussions will be held using a “Discussion” forum. You will be expected to reflect on a question or topic, research it, and post your response to the topic or question. To earn points for each discussion you must respond personally and respond to at least two other student’s postings. Minimalist answers such as “I agree” or “Yes” will earn no points; you must tell why you responded the way you did and provide support for your answer. Due dates will also be posted in the discussion posting. NO abbreviations allowed within the class-related discussion threads…this is not text messaging!

**Respect for Each Other:**
The classroom will be a safe environment for you to challenge your assumptions and inspire new thought. A respectful learning environment will be maintained at all times and students will listen respectfully to each other and treat each other with respect. Disrespectful behavior will result in your dismissal from class and you must set up an appointment with me before the next class to discuss corrective measures for the behavior. Failure to make an office appointment with me may result in dismissal from course.

**Attendance:**
Attendance is required in Lean Essentials for Today’s Businesses, and I will take attendance at the beginning of each class. If you miss class, your grade will reflect your absence because participation on labs is graded, so make sure you’re here on a regular basis to earn full credit. The final project lab is mandatory for all students and only upon severe circumstances will students be given an excuse. With the second absence, I may drop you from the class.

**Food:**
You may bring a beverage to class.

**Cell Phone and other Technology:**
Cell phones are expected to be silenced during class. If your device is causing a distraction, you will be asked to leave the class. Neither audio nor video recordings of the instructor or the class can be made without the explicit prior written permission from the instructor.
Withdrawals:
Per institution policy

Academic Honesty:
Per Catalog and Student Handbook

Ability Concerns:
If you have reason to believe you have a disability, please see me so that I can direct you to appropriate resources.

Emergency Closings:
Per Institutional Guidelines

Class Cancellation:
Per Institutional Guidelines

Summary

The course development portion begins with the instructional strategies and material used in the designing of the course content. The main text is The Toyota Way by Jeffrey Liker which was the first English text that brought the 14 principles to the western manufacturing industry. The initial section also revealed both the teaching and learning styles to be used and the assessment criteria used throughout the course. This section also described the learning objectives required in the course and that a module format would be used. Several assessment types such as labs, tests and discussion boards are employed throughout the course. The course culminates in a 5S capstone project.

The course planning guide established a road map for ensuring the project would fulfill the learning objectives needed in an introductory lean course. The course planning guide listed four key learning outcomes that would be required to ensure that the student would be able to be an effective contributor upon entering the marketplace; these objectives were broken down into four learning modules over 15 weeks of the course, each with its own assessment criteria. The
fourteen principles of lean are at the forefront of the course objectives as they are critical to shifting culture, which is needed to sustain lean improvements. Understanding the eight wastes and 5S were key outcomes also stressed as they are needed to complete the capstone project.

The four modules were aligned with the learning objectives in the course planning guide and the concepts of hands on and problem based learning were incorporated into each module layout.

Assessments are key to knowing the student has learned the basic skills to be a contributor in the workplace. Each learning module has its own assessment and assessment criteria. Students will be held to a high standard of contribution and understanding. The course is not rigid and is open to adjustment based on the needs of the students. There will be a need to evaluate the learning accomplished in the course through a survey of the students which attend the course. Once the course has been surveyed, a gap analysis should be conducted to evaluate that the students’ needs are met and to ensure that the desired learning outcomes are accomplished. The section ends with an example syllabus for the course.
Section V Summary Discussion and Recommendations

Overview

The objective of this section is to analyze the results of the research and course completion, ensuring that in the course definition was brought to lean and the fourteen principles listed in The Toyota Way, as well as the various teaching methodologies and tools discovered in the literature review.

Observation One

The research has identified the foundational competencies of lean and given an overview of each principle to show the direction of the lean thought process and how it must be understood in order to gain a proper understanding of lean. The explanation provided in the research shows that the concepts of lean are more than ‘removing waste and trying to do more with less.’ Lean is shown as a philosophy, not just a set of tools that are applied and then automatically begin generating customer satisfaction. Lean is about the development of principles, and then applying these principles to every aspect of the way a company conducts its business, which in turn fosters a culture of high performance that adds value to customers, employees and the community in which it operates.

Observation Two

The study identified that an interdependent teaching approach along with the learning paradigm is needed to allow for accountability, creativity and flexibility by the instructor in administering the lean course. The freedom for adaptability allowed by the interdependent approach ensures that students achieve applicable knowledge in the ever-changing learning environments presented in today’s dynamic classrooms. This approach was designed into the course and stressed as the desired teaching atmosphere for the student taking the course to thrive.
The instructional paradigm for teaching was shown to be insufficient for lean instruction as it does not promote instructor responsibility for a student’s growth and development. Lean is about learning by doing and “going to the Gemba” to gain a deeper understanding of a problem and this requires applying what has been learned so that it becomes useful outside the classroom. A simple test that indicates you have memorized material will not suffice a lean curriculum. For this reason, the learning paradigm was determined to be the best approach to teaching lean because it pushes the responsibility for the students learning back on the instructor; the instructor is now burdened with creating an environment that engages the student in what is being taught and must provide him/her with the opportunity to demonstrate what was learned in order that he/she may apply the learnings in a real-world environment.

The curriculum was fixed together with problem based learning which forces students to apply what they have learned in case studies and lean activities. This active learning simulates real-world issues that lean practitioners will encounter in the workforce. Students are required to integrate what they have learned to solve real problems, and the curriculum will expose them to the types of variability they will encounter in a normal working environment. Another benefit in using this problem based approach and the learning paradigm approach is that the instructor is placed in the role of ‘mentor’ which fosters a deeper relationship with the student and provides opportunity for the instructor to convey his knowledge and wisdom.

**Observation Three**

The lean course was developed using the information obtained throughout the research and literary review. A course planning guide was constructed around 4 main learning objectives and then used to design course modules that enabled the instructor to meet the strategies therein. The course incorporated lecture based teaching by the instructor and guest professionals as well
as hands-on learning by way of simulations and class projects. The course followed a systematic approach in which each tool and learning dynamic built upon the previous week’s study and provided an opportunity for the student to demonstrate the material and tools week to week. Essays, assignments and tests were also used to evaluate student knowledge retainment. The class concludes with an overall project that allowed for the students to work in a team based environment to complete a lean assessment event.

**Discussion**

In the creation of a lean curriculum it was important to make sure students would leave the class with an applicable knowledge of lean that could be readily applied upon entry into the work force. A course in lean must contain the fourteen principles of lean if the student is to understand the philosophy behind why lean is so successful. To teach and apply lean tools without the philosophy of lean may lead to short term performance jumps but in the long term these gains are not sustainable (Liker, 2004, p. 41). The lean methodology, when based on the fourteen principles, enables individuals to “sense and understand a situation, and react to it in a way that moves the organization forward” (Rother, 2010, p. xv).

When designing the course, it was important not to make it one that was rigid and demanding, one that would not allow for needed changes to take place when class participation or enthusiasm required it; this meant that the course would need to follow institutional oversight and protocol, but the educational deliverance of the course would need to be left to the creative mind of the instructor: an interdependent approach. “This approach draws on industry experiences that strategically separate institutional accountability (management) for a quality curriculum from the decision-making process required to ensure it (production)” (Stratton et al., 2007, p. 331).
To accomplish the learning objectives in the course planning guide the learning paradigm was exercised. Students are going to be required to apply what they have learned in a real world situation and having the ability to use their new knowledge to solve problems and bring about critical analysis is a requirement. The learning paradigm embraces ‘education for understanding’ and requires that students grasp concepts and principles that they can apply to new problems and develop new solutions based on their current competencies; short-term retention based on text memorization cannot compete with this approach (Barr & Tagg, 1995, p. 22). When this paradigm is linked with problem based learning, “variability and uncertainty provides an effective means for students to test their mental models and understanding of techniques while also offering a way to extend them at the same time” (Conger & Miller, 2014, p. 82). The lectures and reading give a solid grounding in theory and is then coupled with hands on exercises, simulations and projects to allow students to critically think and apply what they have learned.

**Implications for Future Work & Summary**

The results of this study have provided a curriculum that is directional in its approach at giving students an understanding of the lean philosophy and providing them a learning environment that will allow them to learn and demonstrate their new knowledge in real life projects and simulations. The course is open to manipulation by the instructor to meet the needs of the students should an unforeseen dynamic arise. To gain real feedback on the effectiveness of the course, it must be taught, surveyed by students, and audited by external resources during its presentation and then modified if needed. Lean is a fluid methodology and it must be taught in a fluid environment. The underlying principles must be followed not only by the students but also
by the instructor if the course is to succeed. The author plans to submit the course to institutions of higher learning and have it evaluated in the hopes of generating interest in the proposal.

The recommendation for further work in this study would be twofold:

1. Create a secondary course that goes deeper into lean as a follow-up course to Lean 1; this course would look into A3 problem solving, Shu Ha Ri, Nemawashi, and many other tools that help facilitate the lean philosophy throughout the organization.

2. Students should be monitored for a period of time upon graduation and followed through their job search. If students enter a job in the continuous improvement sector or is a member of a team involved in lean, their superiors should be surveyed to see how effective the students were at contributing to lean initiatives when hired.

Lean takes time, lean is to be mentored not driven, lean needs to be taught, learned, and mastered. The philosophy that led Toyota to become one of the world’s best manufacturers can be deployed in virtually any American institutions, but it must be done *The Toyota Way.*
References


: affinity diagram


Lean Templates. (n.d.). Retrieved March 12, 2016, from  
http://www.sigmaxl.com/LEANtemplates.shtml


Sink, S., (2013). Fully Minted Industrial Engineers. *Industrial Engineer*, 34-39


Toyota Global Site


Appendix A

Tools to Be Used / Studied in Course Curriculum Design

**Lean tools and their function.** Lean is about waste reduction and effective utilization of resources to increase profitability and add value to the customer. There are several tools which are directly related to lean or derived from its methodology but there are also tools which assist in making sure things are carried out in a lean manner. According to Metha, Metha, & Metha (2012), there are several core lean tools and principles of lean manufacturing: 5S, JIT, Kaizen, value stream mapping, Kanban, flow, pull, and several others (p. 120) Some of these tools will be reviewed here and incorporated into the project as the research above has indicated that students are expected to apply lean once they exit college. The cost of poor quality (COPQ), while not considered a lean tool, is reviewed because it puts a dollar value to waste, assisting in validating lean implementation. Another tool not typically referenced in lean is the project charter. This is important because it helps to define what a problem or project is, why it’s being done, and who the stakeholders are in the process. It is important to understand the boundaries and context of a project so that it can be communicated exactly to everyone on the team.

The author would like to pause in the research to address the inclusion of the project charter. The project charter is often viewed as a six sigma or a project management professional (PMP) tool. In the Toyota culture, project managers practice an A3 problem solving methodology in regards to project management as well as use *nemawashi*, principle 13, in determining project stakeholders and stakeholder inclusion. A3 problem solving is an in depth tool that is outside the scope of an introduction to lean course and *nemawashi*, while relevant, grows to permeate all levels of management as well as horizontal and vertical lines of communication. For an introduction to lean principles and tools, a project charter is the best way to keep a project defined without digging deeper into a more mature lean environment or Project Management Professional methodologies. As stated in the previous research, when a lean curriculum tries to touch
every aspect of lean, instructors can be forced to pick and choose what to teach and what not to teach; this leaves some things being skipped over, and these issues may not ever be addressed again due to the narrow path of a degree roadmap. In keeping with the lean philosophy, a pointed approach to tools that will add value in an introductory setting will be used.

**Project charter.** A project charter states goal and objectives within a project and is crucial to a project because it transforms ideas and facts into an agreed upon project document (Hayes, 2000, p.3). The project charter should identify the project manager and their authority, the business purpose which is being addressed, the project description, the objectives as well as the constraints, the stakeholders, project scope, and risks (Kerzner, 2009, p. 468-469). Even within lean project initiatives, the scope of a project can grow outside of what was normally anticipated; this is why it is important to have a charter for project oriented process improvements. When an owner and a sponsor are identified, as well as the project manager, ownership is formed and the process improvement has a greater chance of success and sustainability.

**Cost of poor quality (COPQ).** The Cost of Poor Quality isn’t so much a lean tool as it is a measurement of waste in the system. The cost of poor quality is the total cost of repair, rework, scrap, service calls, warranty claims, etc., all of which add up to high opportunity costs (Prashar, 2014, p. 103). Opportunity costs exist when a producer is manufacturing poor quality products and the company cannot focus their attention on value added work, and these quality problems are very much quantifiable as this in turn causes the company to lose out on selling good products for profit (Freiesleben, 2005, p. 3). Cost of poor quality also impacts capacity planning, potential sales volumes, and cost per equivalent unit. An example of a COPQ illustration can be found at: [http://www.slideshare.net/anubhuti10/six-sigma-final-3605604](http://www.slideshare.net/anubhuti10/six-sigma-final-3605604)
**Voice of the customer (VOC).** The Voice of the Customer has become a key focus in many areas of both the manufacturing and services industry. Focusing on customer wants and needs provides a market sensing capability which helps an organization align its processes to meet the forthcoming desires of the market; interpreting the voice of the customer generates innovative products and services (Bharadwaj, Nevin, & Wallman, 2012, p. 1012). Understanding customer focus is not always as easy as asking the customer what they want because often they cannot articulate it properly but can only suggest their wants and desired features; this information must be analyzed to bring the underlying outcomes and needs to the surface and to develop a product that satisfies these customer expectations (Mazur, 2015, p. 25). An example of the VOC analysis can be seen at: [http://www.slideshare.net/Vijay_Bijaj/bringing-the-voice-of-the-customer-voc-into-dfss](http://www.slideshare.net/Vijay_Bijaj/bringing-the-voice-of-the-customer-voc-into-dfss)

**Affinity diagrams** – *(Affinitizing).* This is a quality tool that is sometimes mistakenly called or referred to as brainstorming; the tool is designed to stimulate creative thinking by allowing participants to consider a full range of ideas and concepts (brainstorming); once all discoveries are brought out, affinity helps organize these ideas (A., & Juran, 2010, p. 393). An instructional method for using the Affinity Diagram is presented in Juran’s Quality Handbook (2010):

1. Brainstorm ideas:
   a. Set a time limit.
   b. Record each idea on adhesive notes or 3 x 5 cards.
   c. Clarify ideas and eliminate duplicates.
2. Display the unsorted ideas on a table or stick them on a wall.
3. Sort the ideas into groups; do this without speaking, based on individual perception.
   a. Arrange ideas into meaningful categories of “like issues.”
   b. If one person does not like the placement of an idea, he or she can move it.
   c. If one idea seems to belong in more than one place, make a duplicate card.
   d. Continue sorting until a consensus is reached; aim for 5 to 10 groups
   e. Consider breaking large groups into smaller ones.
4. Create a title or heading for each category.
5. Transfer the groups into an organized affinity diagram.
6. Discuss groupings and understand how they relate to each other; if necessary, move items to complete a consensus affinity diagram.

An example of an affinity diagram can be viewed at:

**Just-in-time (JIT).** Just-In-Time systems operate with little or no inventory by supplying the upstream process or customer with what they need only when they need it. This creates a “pull system” in which each individual process requests resources from the process that precedes it, and this process is traced all the way back to the customer and takt time of the market (A., D. F., & Juran, 2010, p. 330). JIT is a system of flow management which involves level scheduling and decreased changeover times which allows for goods to be produce quickly, in smaller volumes, and give the ability to adjust to the needs of the customer, resulting in very efficient market response times (Womack & Jones, 1996, p. 58-59). An example of a Just-In-Time model can be viewed at: http://www.toyota-global.com/company/vision_philosophy/toyota_production_system/just-in-time.html
**Value stream mapping.** Lean production requires extensive knowledge of the value stream. A value stream consists of all the material and information flow as well as information on the process such as cycle times, downtime, capacity, wait times, yield, and inventory levels (A., & Juran, 2010, p. 339). The map itself is a graphical representation of this flow of material and information bringing a visual approach to understanding material and information movement. The value stream mapping process begins with identifying the current state of how the process actually operates and then a future state map is created to identify the root causes of waste the lead to inefficiencies and have a negative financial impact (Rahani, 2012, p. 1728). An example of a value stream map can be viewed at:

http://www.sigmaxl.com/LEANtemplates.shtml

**Process map (detailed flow chart).** The Process Map goes deeper into individual processes within a value stream and displays major and minor activities and decisions, as well as key inputs and output to show exactly how work is being performed and in what ways the process is performing (Tague, 2005, p. 259). This is an established tool to bring visualization to a process and contains considerably more detail, using flowchart symbols that identify customer critical features and the way the process inputs impact those critical features (Haefner, 2014, p. 255). An example of a Process Map can be viewed at:


**Root cause analysis.** Root cause analysis focuses on using a structured investigation approach to identify problems and eliminate the issues that lead to these problems, through using a wide range of tools and techniques that uncover the causes that occur beneath the surface.
(Anderson & Fagerhaug, 2000, p. 12-13). Root cause analysis is a very common tool used by lean practitioners around the globe, and they use this type of analysis to not only validate causes but to supply evidence to their theories as to why problems occur (Sarkar, Mukhopadhyay, & Ghosh, 2013, p. 171). The first step to root cause analysis is to identify the problem and then begin analyzing through extensive data collection from all sources that could be contributing to the issue, and from the data identifying the possible cause factors that led to the problem (typically shown in diagrams); the final step in the analysis includes recommendations and implementations of the root causes gained by the diagraming process to eliminate and prevent the same issues from occurring again (Cerniglia-Lowensen, 2015, p. 5). Another aspect of analyzing the root cause of an issue is determining if it is worth fixing or eliminating, it may be that eliminating the root cause is more expensive and costly than dealing with the symptoms (Flott, 2011, p. 41). An example of the Root Cause Analysis process can be referenced at: http://www.lifetime-reliability.com/cms/online-store/store-maintenance-management/rcfa-2day-training-course/
Appendix B

Exposition of Lean Principles

Principle 1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals. It is foundational that this is the first of the fourteen principles. Without this principle, whatever is built within a company will experience much difficulty in trying to sustain improvements. “Where there is no vision, the people perish” (Proverbs 29:18 King James Version), and without a long term philosophy of where an organization is going and how it plans to get there it wanders aimlessly, it has every intention of being in business for many years but has not established a long term plan on how to get there (Walter, 2012). For existing organizations that have operated in such an environment, living moment to moment, an entire culture shift will need to take place. Operating in the philosophy of Alex and Jonah where “the company exists to make money” can no longer be the status quo (Goldratt, Cox, 1984, p. 40). When the aim is simply to generate revenue many initiatives that are harmful to a company in the long term will seem like the right thing to do, at the moment. Relationships are second to profit, employees are second to profit, community and environment are second to profit. When the goal is to generate value for the customer as well as to contribute the overall wellbeing of the environment that the company operates in, profits are no longer the master of all but are a partner in achieving the company’s long term goals (Liker, J.2004, p. 37). A long term vision gives a company a target condition by which all decisions are subject to, depersonalizing decisions so that efforts are all aligned to a common purpose even if they don’t agree with short term financial goals (Rother, 2010, p. 102-103).
**Principle 2. Create continuous process flow to bring problems to the surface.** Flow focuses on value added vs. non value added steps, and the process of eliminating every one of the steps which do not add value to the product or system. In a flow system inventories are kept to a minimum so that problems and issues are easily identified, and so that the team is forced to fix problems rather than hide them. Inventories allow for problems and inefficiencies to be hidden, so that issues do not have to be confronted, but this does not allow you to improve your process because the problems are never addressed (Liker, 2004, p. 99). Flow means that everything is continuously moving from the initial order throughout every process and ending at the customer. Wait time between processes is sought to be zero, and although this may not be achievable, one must never stop striving towards that goal (Rother, 2010, p. 45-47).

**Principle 3. Use "pull" systems to avoid overproduction.** Flow may be the target condition that is desired but when that cannot be achieved a pull system is what should be implemented. “Pull in simplest terms means that no one upstream should produce a good or service until the customer downstream asks for it” (Womack, J. P., Jones, D. T., & Roos, D. 1990, p. 67). Still, even today, companies continue to run operations according to internal, convenient schedules that produce goods, or parts, according to those schedules and force, or push, the downstream customer to stockpile those goods until they are ready to use them (Liker, 2004, p. 105). There is also a dated culture that revolves around the need to run factories at max capacity in an attempt to justify capital investments (Arnheiter, Greenland, 2008, p.21). With pull the idea is to only produce enough to satisfy the need of the downstream customer at the pace of consumption of that customer. The production of many specific parts are produced much faster than the process or market demands them, even with internal customers, an example is a good that is needed every 60 seconds but which is produced in one second. Flow in this sense
would not be ideal, so pull systems will call for a certain number of these parts as needed, and once overall supply is depleted to set levels, the process calls for more of that product to be made but only in the proposition that is needed to satisfy the system as a whole (Liker, 2004, p. 108).

**Principle 4. Level out the workload (heijunka). (Work like the tortoise, not the hare.)** Leveling the workload looks at total volumes of production orders within a specific period of time and then adjusts production over the same time period so that there are not mass production spikes at particular points in the schedule resulting in the storing of excessive amounts of work in process; this leads to reducing the burden on the process in which products are made as well as the people that work in the process (Liker, 2004, p. 116). Companies need to be creative in this function of lean management, they must look at scaling processes up or down or by looking at areas in the process that can be done by combining job duties or reducing man power within a process in order that it will equal the needed takt time.

**Principle 5. Build a culture of stopping to fix problems, to get quality right the first time** Basing decisions on long term goals brings greater consequence to some of the most routine decisions that managers make every day. A simple oil leak must now be looked at in relation to the long term effects of the problem, not just a mess that shop towels can fix. What about low oil pressure, what does that do to the process? Does reduction in oil affect the wear of other parts? At what point does low oil pressure cause thermal and viscosity breakdown of internal parts? What type of variation will result as temperatures and frictions increase? How much will repair cost nine months from now? And what else will be needed to be repaired at the same time since the problem was not fixed immediately? Long term thinking goes against traditional evaluation based on quantity and direct costs, where cost and production quantities could be met as long as machines and other equipment do not go down (Buzacott, 1995, p. 118). Another aspect involves
the ability to identify problems, whether by statistical controls and baselines or by autonomination where the machine stops automatically when there is an error or defect in the process. For this to reach its full potential, support systems need to be aligned so issues are resolved quickly so that a culture of stopping to fix problems is advantageous to the operator through machine uptime and productivity and also to the company through equipment reliability (Liker, 2004, p. 38).

Principle 6. **Standardized tasks are the foundation for continuous improvement and employee empowerment.** The purpose and goal of standard methods is “to maintain predictability, regular timing, and regular output of your processes (Liker, 2004, p. 38). Standard work is more than simply having a specific way to do a job function, it is being able to achieve the target condition of a process while using the prescribed standard (Rother, 2010, p. 115). If there are not standards the process can’t be measured; processes need to be standardized whether they are good or bad and from that point they can be improved (Walters, 2012).

Principle 7. **Use visual control so no problems are hidden.** “No problems are hidden” encompasses everything from work place cleanliness to machine stoppages and abnormalities, when things are out of place this is considered an abnormality in lean. 5S has become one of the key building blocks within a lean system by supporting flow and takt time (Liker, J. K., 2004, p. 149-152). Visual controls make problems visible and challenges people to grow and become better problem solvers. This visual management has evolved into andon systems where equipment or people stop production and signal for help, often by way of lights or other systems that signal things are good, stopped, or need to be adjusted (Rother, 2010, p. 92). There are several other forms of visual management such as department metrics and company information boards that help an organization or department remain transparent.
Principle 8. Use only reliable, thoroughly tested technology that serves your people and processes. A lean organization takes the slow road when it comes to acquiring new technologies, putting a value on people and the technologies ability to help the people as the acid test for real value (Liker, J. K., 2004, p. 159-160). Historically many companies have held to the belief that technologies and various forms of automation will drastically reduce labor costs even though implementation cost could be much higher (Arnheiter, Greenland, 2008, p.24). Technology being able to support the existing production system is key in the lean environment, and if it hinders flow, decision making, or eliminating waste, it must be rejected (Liker, 2004, p. 160).

Principle 9. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others. Grow leaders from within, rather than buying them from outside the organization.

- Do not view the leader’s job as simply accomplishing tasks and having good people skills. Leaders must be role models of the company's philosophy and way of doing business.

- A good leader must understand the daily work in great detail so he or she can be the best teacher of your company's philosophy (Liker, 2004, p. 39).

When goals are aligned and teams are established that work towards those common goals, progress takes place at a much faster rate; when the philosophy of a company is understood by all levels of employees, and that philosophy is lived, the company is aligning itself with lean management (Walters, 2012).

Principle 10. Develop exceptional people and teams who follow your company's philosophy. Beliefs and values must be strong within a company’s culture, and the leaders in the
company must operate in that culture to form exceptional teams and achieve exceptional results. This gives opportunity for leaders to travel horizontally within organizations and remain effective because cross-functional team members are all living by the same corporate principles (Liker, 2004, p. 39). “A philosophy that is taught by leaders that believe in it and followed by people and teams has a stronger chance for success than a set of people and teams pulling in different directions than their leader” (Walters, 2012).

**Principle 11. Respect your extended network of partners and suppliers by challenging them and helping them improve.** In a lean organization suppliers are seen as partners, not cost reduction opportunities, it’s about relationships and working together towards a common goal; by working together and growing together the companies can find ways to mutually benefit each other in the long term (Liker, J. K., 2004, p. 202). When working with suppliers this is seen as an opportunity to reduce costs, not an opportunity to charge for your services. As the supplier removes cost from the process, the company benefits from lower prices and shorter lead time, while at the same time the supplier becomes more profitable in their business relationships with other clients (Womack & Jones, 1996, p. 266).

**Principle 12. Go and see for yourself to thoroughly understand the situation (genchi genbutsu).** The practice of visual verification should permeate the organization so that managers, team leaders, and executives alike can have a more thorough knowledge of any situation. Going to the source to solve problems rather than relying on theorized data and speculation will always yield better results, and brings more credibility to decision making (Liker, 2004, p. 40). It has become very common, even in industries that hail themselves as “lean,” to base big decisions on database reports that never bring them close to the problem;
focusing on “data only” just adds complexity to the problem and alienates managers and executives from the true issues within a process (Walters, 2012).

Principle 13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly. In a lean organization planning is everything; if planning is done thoroughly and consensus gained from all stakeholders, implementation is much easier and success is highly probable. In a lean organization nothing is left to chance, nothing is taken for granted, and everything is verified (Liker, 2004, p. 237-238). Failure to consider all options is a risk that is not worth taking within a lean organization and quick fixes can be the root cause of many lingering problems; more time is wasted fixing incorrect solutions than would have been needed to do things right the first time (Walters, 2012).

Principle 14. Become a learning organization through relentless reflection (hansei) and continuous improvement (kaizen). Principle fourteen is what makes the sustainment of the other thirteen possible; striving to continuously improve enables the process of continual progression (Walters, 2012). Reflection is the substance of principle fourteen and promotes sincerely looking at what has transpired in projects and ventures, looking at the good along with the bad, to develop future plans to both ensure growth as well as to be sure that mistakes are not repeated. Reflection encourages the organization to be honest about weaknesses, and this displays much more strength than only focusing on positives. Lean organization promotes this throughout the company and gives honest feedback to associates on even the most minor levels, not to bring shame but to encourage growth through honesty and a desire to see their employees succeed (Liker, J. K., 2004, p. 257-258).
Appendix C

An Example of a Lecture Slide Deck – Principle 3

Principle 3

Use “Pull” Systems to Avoid Overproduction

The more inventory a company has, ... the less likely they will have what they need
- Taiichi Ohno

Chapter 9

The Push System

Many companies and service organizations do what is convenient for them within their pre-determined schedule and push products to their customers.

- The push dairy system
- The pull dairy system

The Toyota Way

- Not about managing inventory but eliminating it
- Producing to customer demand
- Just-in-time manufacturing
  - Giving the customer what they want when they want
  - Producing for the downstream process - as needed
  - One piece flow
  - Schedule leveling

Schedule leveling

- Specific amount of inventory based on past purchase patterns and future demand
- Small, controlled amounts of inventory
- Replenishment system
- TPS uses “stores” of materials to replenish depleted inventories using pull systems

The Kanban System

- Kanban - sign, signboard, card
- Kanban System - used for managing and ensuring the flow of production of materials in a just-in-time production system
- Inventories go down, having the right parts goes up.
- Requires a very disciplined, stable set of work processes to function properly

The Kanban System

- Uses “stores of parts” as inventory buffers
- Production at the supplying process is regulated by the customer process’s withdrawals from the supplying process’s store, rather than by a schedule
- Supplying process only produces what the customer process has actually used - Customer/Supplier relationship

Pull Replenishment

- Pull systems correspond with actual usage or consumption.
- The gas tank in your car
  - Would you consider filling your car only on Monday morning?
- Signal Replenishment - based on usage rather than guessing and scheduling

Pull where you must

- The goal of Kanban is to eliminate the “store of parts” all together, creating One Piece Flow
- One piece flow means zero inventory
- Flow where you can pull where you must
- Inventory is waste, whether in a push system or a pull system.
An Example of a Quiz, Essay, and Link to a Simulation

Simulation Link from slide: The Dice Game

This is a link to The Dice Game Posted by Sanjiv at LitheSpeed.com and is free to use for the training your teams.