Enhancing student learning experience in lean manufacturing with industry engagement

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Abstract
Engagement with industry professionals is important to meeting Engineering Technology curriculum goals. Bringing industry representatives (guest speakers) to engage in the classroom, involving students with professional chapters involved in Lean, student field trips and incorporation of a virtual plant tour is based upon a classroom model that incorporates industry advisory board feedback. The model for teaching an introduction to lean manufacturing course introduces students to lean thinking ideas in addition to introducing students to industry professionals as well. This provides students with an opportunity to bridge the gap between classroom education and real world experience. In this paper we are going to report various learning outcomes and address the objective of each activity by measuring student learning. Student learning will be measured by pre-visit survey, these questions prior to the industrial visit and guest speakers’ visits are aimed at priming the minds of the students and providing a mental framework to acquire the intended knowledge. After the completion of the visit, a set of questions related to the visit will be given to students. These survey results will help compare and contrast student learning through the industrial experience, and also will help in finding out how well our course assists students to align with industry. It will also provide the opportunity to address the gap between classroom studies and, student perception about the outside world (industry). This presentation will help in addressing the importance of involving students with the industrial environment. This also will address a) Curriculum innovation driven by industry input and b) ways to teach innovation, two key issues and strategic plan of CIEC.

I. Introduction
Scholarship and engagement are essential to the education delivery system. Original research is part of the binding mission of the public, land grant institution. However, the University system does not reach all audiences, engagement through extending the scholarship to
the public is an important to reach those individuals not involved in the original research sphere. While the internet has made information much more accessible to the general audience, it is not a medium that involves a model of research between individuals. Those parties involved in scientific research may create theoretical constructs to be applied in practice. In turn, practitioners applying theoretical principles may report on results as feedback to the scientific community for refinement (or abandon) for mutual understanding among all parties in developing new concepts. This model may described as a learning system described by (Senge, 1990) that results systems thinking when applied to an organizational context.

This paper will study the principles of agility, engagement, and transfer to better inform the development and continued refinement of an introductory Lean manufacturing course for improved student understanding of Lean techniques. The philosophical basis for this study requires an introduction to the principles that continue to be practiced within the higher education environment at the named institution. A philosophy of research and engagement is that there is a transfer of in depth knowledge between those in the University system and industry. However, the method to transform the role of engagement to incorporate the exponential rise of information access will require agility to ensure the quality of research reaching the general public continues to be informative.

We propose an agile approach to engagement for ensuring the partnership between academia and industry. Partnerships between academia and industry continue to be based upon the creation, refinement, and assessment of the inputs, processes, and outputs to create benchmarks for success (O’Sullivan and Stewart, 2010). Agility also helps academia stay within the range of industry accomplishments as well. Academic entities will continue to evaluate industry needs through accreditation standards, such as ABET. There is recognition that there is not a universal assessment for matching outcomes to objectives. The particular needs of industry will be assessed within the larger agency assessment (O’Sullivan & Stewart, 2010). To meet expectations of various stakeholders, accreditation to a nationally recognized body, in this case TAC-ABET is the overall accreditation body and standard(Policy and Manual, 2008) (ABET, 2009). The accreditation criteria of ABET places emphasis on learner-centered instruction and measured learning assessment (Fuehne, 2007; TAC-ABET, 2008). These characteristics are further described in this study. As noted by O’Sullivan and Stewart (2010), agile methods for content delivery will continue important component in successful learning outcomes.
The Technology faculty responded to industry needs and requirements through assessment to ensure that Technology graduates of the Industrial Technology Bachelor of Science degree program meet both the expectations and standards of the institution, and other stakeholders, such as private industry (Field, Freeman et al., 2004). For this study, the local industrial offerings include the content area of Lean manufacturing. Agile methods have been applied for the past four decades to organizational management, especially the ideals behind ‘Lean’ methods for manufacture of products and services first applied as the Toyota Production System and later applied as Lean Thinking worldwide. Lean Manufacturing is taught in the classroom and the focus of this study.

II. Literature

The course in which scholarship of teaching and learning is applied to is an Introduction to Lean Manufacturing. As a 200-level course, it is an initial offering within the Industrial Technology program noted above. As an introductory offering, students are exposed to Lean concepts applied to the manufacturing sector. The course is a three credit offering with a laboratory component. Laboratory activities are designed for students to explore and apply concepts offered in the course. Concepts taught in the class include basics theoretical concepts of Lean principles, Lean optimal work for production, and Lean management principles. This and other concepts are noted in Table 1.
**Enduring Understandings:** The instructional goals for this course are presented as enduring understandings of the ‘big ideas’ that are essential to the field of lean manufacturing:

| **Students will understand basic lean principles of waste, continuous improvement, and modern manufacturing system** |
| **Students will be able to complete a basic continuous improvement project utilizing lean thinking ideas and tools.** |
| **Students will understand principles to lead or support an organizational effort to implement lean enterprise strategies.** |

**Important to know and do:** Additional key topics and ideas considered important, but not essential, that contribute to one’s knowledge and skills in lean manufacturing in the next weeks:

| **Students will be able to identify the 7 basic principles of waste or muda in an evaluation of systems or process(s).** |
| **Students will be able to describe modern quality management systems in organization** |
| **Students will be able to apply techniques of process evaluation** |
| **Students will be able to apply lean techniques of production flow** |

**Worth being familiar with:** The following weeks encompass topics that should round out what a person familiar with lean manufacturing should understand:

| **Students will understand the history of lean manufacturing from a US and global perspective.** |
| **Students will understand implications of globalization and current industry trends.** |
| **Students will understand applications of lean manufacturing in other industries.** |

**Table 1. Student competencies for introducing lean manufacturing**

The instructional design and assessment was based upon student learning objectives first noted through industry interaction and faculty research in emerging topics in technology studies. The particular course curriculum was designed with student competencies first. This reverse curriculum design puts the student at the center of the curriculum design effort (Wiggins 2001). The student competencies were created based upon faculty expertise, faculty industry experience, and external industry identification of proficiency. Finally, student competencies’ were framed up as long lasting, enduring student understandings and reconciled with Society of Manufacturing Engineers (SME) competencies (appropriate to an introduction to Lean course) of SME Lean body of knowledge certification(SME, 2009). As the leading society for manufacturing professionals, SME reference is appropriate for external industry recognition.
With the ever changing business environment, the use of various inputs allows for constant recognition of changes in industry needs by being agile and lean (O’Sullivan and Stewart, 2010). Agility is a characteristic of keeping the curriculum accurate and of greater value for private benefits, the student, and the public value as well, starting with initial employers, and spreading beyond to wider audiences through wider dissemination of outcomes. Therefore, engagement between industry and academia may be based upon applying the concept of public value through the land grant model of extension (Kalambokidis, 2009). The transfer of knowledge between students and industry is based upon previous work to identify, create, and manage engagement (Klofsten and Jones-Evans, 1996; Pecas and Henriques, 2006).

Academic and industry has become more explicit over the last 30 years. Legislation such as the Bayh and Dole act seeks to utilize university resources in a more active manner for innovation purposes in the general economy. However, while transfer has become more explicit, the budgets for industry and academic partnership and research are still small in comparison to overall university budgets (Pecas and Henriques, 2006). While growing, the transfer mechanism is still largely an informal approach that is based on personnel and networks (Pecas and Henriques, 2006). In addition, to improve effectiveness between academia and industry depends upon the intrinsic characteristics of the organization (Pecas and Henriques, 2006). The size and composition of the industry to engage with is not the only variable. Geography also is a factor to be dealt with, especially with dealing with academic institutions that have specific land grant missions. While distance is becoming modified by technology, sustaining long term partnerships still has geographic roots.

III. Methods

The study of student outcomes was based upon content analysis of open ended survey questions. Student responses were gathered at the end of the semester and compared to initial discourse between students and faculty at the semester beginning. Understanding the initial frame of reference with regard to Lean manufacturing principles is done as an initial activity. The course is an introduction to Lean and occurs very early in the program of study for undergraduate students. Initial dialogue is based upon written reflections of student expectations of the course, before even syllabi are distributed. Students are asked to write about what skills and knowledge with regard to the class posed as competencies, as describe above: a) what do students expect to know at the end of the semester and b) what do students expect to do by the
end of the semester. Often done among practitioners’, Lean has traditionally been taught with classic, Taylorism manufacturing techniques serving as a foil. Lean is an iteration of the Toyota Production System (TPS) by Ohno (1987) and others Suzaki (1987). Lean manufacturing, or Lean thinking since the methods and practices have iterated to other areas of the global economy, Lean arose as a response to the competitive challenges Japan faced at the end of World War II with limited natural resources and in reaction to Taylorism (Suzaki, 1987). Since TPS, and later Lean was developed and practiced first among practitioners and refined by scholarship, adopting Lean for higher education requires a different approach. Lean taught for industry professionals is a different demographic than the traditional college age student. The industry person often has an existing frame of reference with regard to classic, manufacturing techniques, especially in traditional industry sectors that lend to Lean application. The traditional college student has limited, if any, frame of reference with regard to Lean, or even manufacturing. Since the course introduces Lean principally to manufacturing, the conventional techniques of comparing Lean to conventional manufacturing does not serve students without an existing manufacturing framework. From course expectations, student responses may be summarized by the lack of manufacturing knowledge. As a benefit, students learn what manufacturing experts deem advanced techniques. For the instructor, the challenge is teaching Lean without comparison and creating a context for students to construct a framework that is sensible, comprehensive, and compelling. A sensible construction of coursework for Lean represents systematic approach: teaching a process for learning lean, applying principles in a laboratory and practical setting, refining approaches based upon student feedback while creating a context that is compelling through a competency approach based on close industry exposure. Sprenger (1999) and Wolfe (1996) state that for learning to occur, the brain searches for patterns and meaning. The initial student starting point for this course is little or no exposure to Lean or manufacturing with the willingness to learn. Initial student expectations demonstrate the need to create these patterns and meaning for students.

The teaching and learning an introduction to lean is based upon coursework and labwork. The engagement between industry and classroom instructors is based upon an interpersonal approach and local. The geography of the state is based upon a manufacturing and agriculture basis. While emerging sectors are present, the economy of Indiana continues to iterate off of Indiana as a leading manufacturing, production, and logistics region. Classroom activities that
are engagement oriented include virtual plant tours using Web 2.0 technologies, in-class guest lectures, local plant tours, and roundtable events sponsored by chamber of commerce activities. There is a close arrangement of industry and student engagement based upon the principles described above. To understand student learning with engagement principles, the assessment of student competencies was done through the survey noted in Appendix A. The survey is based upon validated survey items from the University catalog (Purdue Center for Instructional Excellence, 2008). Based upon the course activities and schedule, questions were adapted for use of the survey noted below. For content analysis, students were asked to write reflectively and answer the open ended questions. For this study, the assessment of engagement with industry was through qualitative analysis. The themes of these results are noted below.

IV. Results

Overall, the results demonstrate student appreciation and understanding through interaction with industry. This study was based upon adapting student competencies noted in Table 1 to assessment through quantitative and qualitative approach through student writing (course expectations) and post survey results. Student learning was demonstrated through interaction with industry. The interaction was based upon industry in-class speakers, network meetings, and plant tours. The main question was if there were advantages of the collaboration between education and industry.

An initial theme was that students stated they had better comprehension of how a company operates. As noted above, this may be the initial introduction to plant operations for students at this stage in their academic career. As traditional age students, their exposure to industry may be limited. Students noted in particular that the processes involved in making the product was novel. They understand the big picture of the company and also learn about the process involved in making product. If students have limited a limited cognitive framework about manufacturing, then maybe the interaction might demonstrate to students that their preconceptions of manufacturing as a dangerous, dirty, dreary business is not the advanced manufacturing operation that exists today.

Secondly, students noted that interaction with industry professionals, in settings outside the classroom environment helped students connect the principles of lean with the operations students witnessed, guest lecturers they heard, and roundtable events they attended. Students learn a wide variety of ideas to reduce ‘waste’ associated with processes. Students noted that
they were able to relate the lean tools they were learning in class with the variety of process improvement tools they observed during their plant tours. Students were asked per laboratory activities to treat these tours as professionals might: as peers learning from each other. The students noted areas of waste that they could reduce or eliminate in their own coursework applications, whether through class projects or case study laboratory activities. Students noted increased confidence in utilizing their classroom knowledge to improve processes after finishing their coursework. While conventional, students also noted the increased variety of methods upon which to utilize to improve processes as well. This is a significant event; the application of expertise, especially in applying advanced manufacturing principles, is comprehensive. Problems come at practitioners whole, the ability to use many different tools is important for professionals.

Finally, the industry interaction was a unique classroom-based activity for the students. Students noted that the activities were fun for them. Students noted that the interaction was an opportunity for them to take a break from the monotonous schedule of attending classes day after day. The change in surroundings also helped students spark interaction between students. One final surprise was how important employee input was to the process improvements they were observing. The potential to utilize student interaction and employee input is worthy of further exploration.

V. Conclusions

The purpose of this paper was to study how agility, engagement, and transfer as curriculum development principles might better inform on student learning with regard to an introduction Lean manufacturing course. The students mentioned how the interaction offered them to stretch their thoughts and look more creatively at coursework applications. Sometimes, awareness produces its own teaching opportunity. This pilot study noted that the persistent conversation students had in part with industry personnel provided them a window on how to apply lean principles. Students have already been placed in internships through some of the industry contacts; a few have subsequently taken permanent positions. Regardless, utilizing industry in a model for development and refinement will lead to more innovative results as this study proceeds.
Appendix A

1. What is the most useful activity you did in this course? Please rank them in the scale of 1 to 5 with 1 being of little or no use and 5 being most useful:

1) Quiz  
2) Exam  
3) Project  
4) Lab  
5) Plant tour  
6) Wabash Valley Lean Network meeting  
7) Cheaper by the Dozen  
8) Lectures  
9) Virtual plant tour

2. Do you think going for a plant tour, meeting up with industry personnel is helpful or does not matter if presented as a course requirement?

3. Did you go for a plant tour with preconceived ideas? Can you define these ideas?

4. Was the plant tour interactive?

5. Were you able to understand lean in healthcare better after seeing our guest lecturer’s presentation?

6. Were the virtual plant tours helpful in understanding the course material?

7. Do you feel there should be more industry and student interaction involved in the class?

8. Were the books used for class provides the proper understanding of the course and topic?

9. Do your grades reflect fairly of your learning?

10. What was the most interesting part about visiting the Subaru plant?

11. How does interacting with companies/businesses during your project helped you understand the course material?

12. How do you feel doing a final project helped you gain more understanding of the course material?

13. Is there enough peer-to-peer interaction in the class and lab?

14. While working on your project, were you able to apply if the lean principles?

15. How difficult was it to apply classroom learning to the real world?

16. Did you receive an internship or fulltime position based on this course?

17. Do you think you would like to go into this field?

18. Any other comments?
References


Purdue Center for Instructional Excellence (2008). PICES Item Catalog.


