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Lean Engineering Education: DNA for Change




Anabela Carvalho Alves
University of Minho
(Portugal)

Franz-Josef Kahlen
University of Cape Town
(South Africa)

Shannon Flumerfelt
Oakland University
(Michigan, US)

Anna Bella D. Siriban-Manalang
De La Salle University
(Philippines)

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The Lean Engineering Education (LEE) model is advocated by the authors of a book in press, *Lean Engineering Education: Driving Content and Competency Mastery* (Flumerfelt, et al., 2014) as a methodology to allow for students' parallel content and competency development, based on the double helix DNA image (Figure 1). This LEE methodology targets the shortcomings in the professional development of engineering students as evidenced in several data sets, such as the ASME's Vision2030 survey results (2010, 2011).

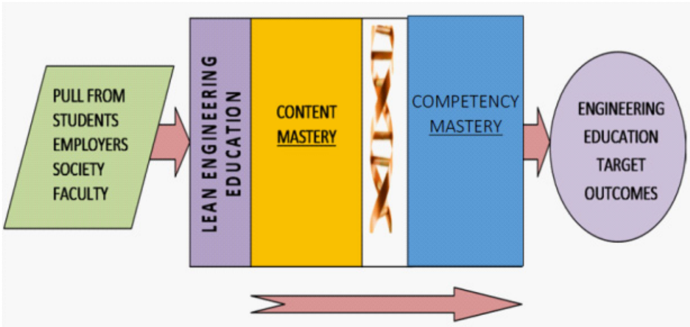

Figure 1: Content and Competency Mastery Combined in a Double Helix DNA

Lean Engineering Education (LEE) is intended to capture on the lessons learned and philosophies employed in continuously improving engineering, product development, and service delivery. The National Institute of Standards and Technology (NIST, 2010) defined Lean Production as:

> *"(…) a series of tools and techniques for managing your organization's processes. Specifically, Lean focuses on eliminating all non-value-added activities and waste from processes. Although Lean tools differ from application to application, the goal is always incremental and breakthrough improvement. Lean projects might focus on eliminating or reducing anything a final customer would not want to pay for: scrap, rework, inspection, inventory, queuing or wait time, transportation of materials or products, redundant motion and other non-value-added process steps."*

Lean Production, a generic term, was more succinctly named after the Toyota Production System (TPS) (Monden, 1983; Ohno, 1988) by Womack et al. (1990) based on the examination of world-class production practices. Developed over many decades, TPS has been supported by Toyota's Education Model. Much can be learned from the Toyota Education Model to inform academy about the scope, intent, design and delivery of engineering education for the workplace. Summarizing TPS, Toyota's Education Model, and the aforementioned definition of Lean Production, the term Lean Engineering Education explicitly pushes beyond the technical content of tradition Engineering Education design and pedagogy, and merges it with competencies development. Competencies are equally important to engineering professional practice as engineering content.

Based on this model, the authors defined Lean Engineering Education (LEE) (Flumerfelt et al., 2014) as:

> *A systematic, student-centered and value-enhanced approach to educational service delivery that enables students to holistically meet, lead and shape industrial, individual and societal needs by integrating comprehension, appreciation and application of tools and concepts of engineering fundamentals and professional practice through principles based on respect for people and the environment and continuous improvement.*

The authors subsequently encapsulated three key issues from the survey data to determine specifically (but not exclusively) the missing components in engineering education. These components were selected as systems competency, ethics competency and sustainability competency. The three competencies serve as a "starter list" for a holistic development approach, which will be taught along with essential engineering content, fulfilling the attributes of the double helix DNA mental model.

The LEE definition is the basis for understanding problems with the curriculum, designing to overcome those problems, improving teaching and learning, and assessing student progress in the engineering classroom for ongoing adjustment work. The continuous improvement should be applied

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(cont.)

by the academy to remedy shortfalls, while informing faculty and students about engineering professional practice. Additionally, Lean is a body of knowledge that provides a framework for Lean Thinking (Womack and Jones, 1996) to emerge within the academy and as a student outcome. Lean Thinking principles are translated to the educational services as described:

1) Value *– identify what is the value for the client*. Engineering students pay tuition to receive value in the form of a relevant education. The employer hires the engineering graduate to benefit from her/his value added work in product/service design, production and delivery. Faculty must provide engineering education services of quality based on the well-documented needs of society and employers.

2) Value Stream *– identify the activities that adds value to the products*. This means to organize educational degree programs in a way that only valued activities occur. Faculty must collaborate and engage in problem solving around the metrics that occur in our clients' value streams.

3) Continuous flow *– create continuous flow for a smooth and leveled workload without waste*. When employers find that graduates are not prepared, the flow from school to work is interrupted. Faculty must focus on minimizing that transition through a commitment to holistic engineering development outcomes.

4) Pull system *– triggers for processes of delivery and content are held by the client*. The list of needs from students, employers and society provide the academy with foci and the starting point for program redesign. For example, the "pull" of three competencies, systems, sustainability and ethics as desired engineering education outcomes is obvious. The workplace benefits from the "pull" of new hires who see the complexity of a whole process by using problem-solving tools and system thinking (Kahlen et al., 2013). Employers also experience value when employees provide the "pull" of the sustainability competency which demands knowledge of specific characteristics and principles the ability to analyze life cycle (Moreira et al., 2010). In addition, ethics competency is an expected "pull" behavior itself, by a standards, fundamental canons and behavior descriptions (Flumerfelt et al., 2012 & 2013). Faculty must abandon its traditional "push" system of educational design and delivery and allow these "pull" system demands to determine what is needed in engineering education.

5) Pursuit of perfection *– enacting the discipline of the continuous improvement cycle*. The confines of academic governance, its slow pace and complicated encumbrances are considered to be major constraints to rapid development and rapid deployment of change in engineering education. Individual faculty, departments and schools as micro-systems may be able to engage continuous improvement more readily. Faculty must scope out the parameters of continuous improvement and set their own paths for the pursuit of perfection.

It is believed from examples in the workplace regarding deployment of the Toyota Education Model, that LEE, when instigated by the academy, will provide three major benefits: 1) the improvement of course design/delivery, 2) the improvement of the quality of the learning experience for students, and 3) the improvement of student outcomes and workplace demands. The double helix DNA mental model of content and competency mastery is the proposed pedagogy for leveraging these benefits (Kahlen et al., 2011). Through LEE, it is possible to bridge the gaps between academy and industry, providing students with an effective and relevant preparation for the challenges of the profession.

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