

NEWSLETTER SPEE
Nº 8
março 2015

spee

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Newsletter SPEE
Nº 8

março de 2015

Eventos

Notícias

Órgãos Sociais da SPEE

Direção

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ESPAÇO DA DIREÇÃO

Mensagem da Direção



Alberto Cardoso
Presidente SPEE

Na sequência da eleição da nova Direção da SPEE, em abril de 2014, um dos objetivos apresentados para o biénio 2014/2016 foi o relançamento da Newsletter, como espaço de reflexão e meio de divulgação de atividades no âmbito da Educação em Engenharia.

O processo de retoma não foi fácil mas esperamos que este número da Newsletter, agora editada pelo colega Jorge Barata, corresponda ao início duma sequência com maior frequência de publicação.

Queremos agradecer a todos os que, direta ou indiretamente, contribuíram com o seu esforço e trabalho para este número.

Apesar das dificuldades em levar por diante todas as ideias programáticas, a Direção está a procurar dar prioridade às seguintes linhas de ação:

- Dinamizar os Grupos de Trabalho, promovendo a sua atividade como estruturas fundamentais para o dinamismo e intervenção da SPEE;
- Estimular a realização de atividades e sessões especiais, associadas à SPEE e aos seus grupos de trabalho, em conferências nacionais e internacionais;
- Continuar a promover a internacionalização da SPEE através dos protocolos de colaboração já existentes e procurando estabelecer novos acordos de cooperação com outras instituições nacionais e internacionais;
- Colaborar em iniciativas que tenham em vista a formação contínua e certificada dos professores do ensino superior;
- Promover a organização da 2ª edição da Conferência CISPEE;
- Promover a realização de Workshops e de sessões de debate sobre temáticas relevantes para a Educação em Engenharia.

De realçar que está a ser organizada uma sessão intitulada "A Atractividade dos Cursos de Engenharia em Portugal: Análise e Soluções", que irá decorrer no Pólo II da Universidade de Coimbra, na manhã do próximo dia 30 de março. Dado que irá ser convocada a Assembleia Geral da SPEE para a tarde desse dia, esperamos poder contar com a presença dos associados neste evento.

Para que a Newsletter possa constituir um meio de intervenção sobre as temáticas da Educação em Engenharia, apelamos à colaboração de todos os associados, contribuindo, por exemplo, com informações e notícias.

EDITORIAL



Jorge M M Barata
UBI

A Newsletter da Sociedade Portuguesa para a Educação em Engenharia, cuja publicação agora se reinicia, é um dos meios com que a SPEE visa contribuir para a promoção da educação em engenharia.

Continuamos a beneficiar da colaboração de Susan Zvacek, que na sua coluna “Talking about teaching”, desta vez, aborda a utilização de critérios e padrões de avaliação ligados a objetivos de aprendizagem (“rubrics”), pretendendo indicar caminhos para uma avaliação formativa com sucesso.

Apresentam-se algumas notícias e anunciam-se conferências e eventos, nomeadamente a Assembleia Geral da SPEE, a realizar na Universidade de Coimbra, no dia 30 de março. Na parte da manhã, a partir das 10h, haverá uma sessão para troca de ideias e experiências intitulada “A Atractividade dos Cursos de Engenharia em Portugal: Análise e Soluções”, cujos detalhes serão divulgados brevemente.

Este número encerra com um artigo relativo ao trabalho de Anabela Alves (Universidade do Minho), Franz-Josef Kahlen (Universidade da Cidade do Cabo), Shannon Flumerfelt (Universidade de Oakland) e Anna Siriban-Manalang (Universidade De La Salle), que recebeu o prémio de “Best Poster” da 1ª CISPEE.

No futuro pretende-se reativar a “Voz dos Sócios” e a “Voz das Escolas”, apelando-se desde já à participação de todos os Sócios que assim o desejarem.

TALKING ABOUT TEACHING
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Using Rubrics for Clarity and Convenience



Susan M. Zvacek
*Associate Provost for the Advancement of Teaching & Learning
Anderson Academic Commons
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Do your students have a clear understanding of your expectations and how their progress in your courses will be measured? If you require students to complete subjective assignments (that is, tasks that may have more than one right answer and that require human judgment to score), a rubric can address those questions and improve the consistency of your grading. Rubrics can provide detailed descriptions of the criteria used to award points on assignments so that students know what you think is important and how you expect them to demonstrate mastery of the subject.

Creating a valid rubric that discriminates between unacceptable, satisfactory, and outstanding performance can be time-consuming, but once you've identified and described the key indicators the rubric can be used or adapted repeatedly. To begin, ask yourself how you would identify and categorize the components of outstanding work - such as completeness, organization, accuracy, creativity, and/or analysis, just as a few examples. Next, describe (in simple, straightforward terms) each level of mastery. It's typical to include three levels, but four or more can be used if you're able to provide clear distinctions between them. When developing the descriptions, I usually find it easier to define the "Outstanding" performance category first, and then describe the other levels.) Here's an example for the category, "Tool Use":

Unacceptable Did not identify/ apply the appropriate tools for the task	Satisfactory Chose tools appropriate for solving the problem	Outstanding Identified and learned to use new tools for solving the problem in a creative way
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It's especially important to explain what you're looking for in terms of student behavior and evidence of learning that is observable. Avoid vague terminology such as, "Demonstrates understanding of..." or "Knows the difference between..." Instead, ask yourself questions like, "How would I know if someone understands the important concepts?" or "How could someone prove that they know the difference between two similar ideas?" Here's an example for the category, "Problem Solving," that provides clear guidelines:

Unacceptable Only one solution is proposed (no alternatives) or solutions proposed are not realistic/ feasible	Satisfactory At least two solutions are suggested; solutions are realistic/feasible	Outstanding Three or more possible solutions are identified; solutions are creative and/or clearly analyzed for their feasibility
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Feel free to label the mastery levels with whatever terms are most appropriate/clear for the assignment, such as those I've used in the examples above, or "Needs Work - Acceptable - Excellent", for example. If you are assigning points for each category (for example, 10 points possible for Problem Solving, 5 points for Creativity, etc.), check to ensure that the point distributions within the mastery levels are aligned with your grading scale. That is, if you consider 65% the minimum passing score for an assignment, the points possible for each category's "Satisfactory" level should be at least 65% of the total for that category (i.e., if there are 10 points possible for Problem Solving, a rating of Satisfactory will be at least 6.5 points). For greater flexibility, consider offering a range of points for each mastery level, like this:

Unacceptable (0 – 6 pts) Only one solution is proposed (no alternatives) or solutions proposed are not realistic/ feasible	Satisfactory (6.5 – 8.5 pts) At least two solutions are suggested; solutions are realistic/feasible	Outstanding (8.6 – 10 pts) Three or more possible solutions are identified; solutions are creative and/or clearly analyzed for their feasibility
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Using rubrics for grading not only provides students with clear expectations, but has been shown to improve consistency/validity of scores and (even better) speed up the process. If you're not already a fan of rubric-based scoring, give it a try – it can be a winner for both you and your students.

ATIVIDADES DA SPEE

Assembleia Geral da SPEE

Teve lugar a 9 de abril, no anfiteatro do IEETA na Universidade de Aveiro, a Assembleia Geral ordinária da SPEE. Foi apresentado, apreciado e votado o Relatório e Contas de 2013, acompanhado do respetivo Parecer do Conselho Fiscal. De seguida, procedeu-se às eleições para os Órgãos Sociais para o biénio abril de 2014 – março de 2016. A única lista apresentada foi eleita. Assim, os novos elementos passaram a ser os seguintes.

Direção



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NOTÍCIAS
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1ª Conferência Internacional da Sociedade Portuguesa para a Educação em Engenharia



A 1ª Conferência Internacional da Sociedade Portuguesa para a Educação em Engenharia (CISPEE) decorreu de 31 de outubro a 1 de novembro de 2013, no Instituto Superior de Engenharia do Porto (ISEP). Organizada em conjunto com a Sociedade Portuguesa para a Educação em Engenharia (SPEE), o evento reuniu no ISEP peritos nacionais e estrangeiros para debater o futuro do ensino em engenharia, sobre o tema de "Educação em Engenharia: Desafios para a Inovação".

Com um total de 42 apresentações em inglês e 5 apresentações em português, a CISPEE contou com mais de 100 participantes oriundos de Portugal (principalmente), Alemanha, Brasil, Estados Unidos da América, Irlanda, Japão, Marrocos, Reino Unido, República Checa, e Suécia. No decorrer das sessões técnicas foi possível debater alguns dos desafios atuais para o ensino da engenharia, nomeadamente: uma maior preocupação com a formação pedagógica dos docentes de engenharia; a incorporação de contributos vindos das áreas das ciências de educação; a utilização de novos recursos educativos de acesso livre, on-line, e de dispositivos móveis, em benefício do ensino da engenharia; a formação ao longo da vida; o reconhecimento de competências adquiridas em contextos informais e não formais, e a preocupação com a aquisição de competências de carácter geral, como por exemplo a capacidade de trabalho em equipas multi-disciplinares, com elementos de diferentes nacionalidades, e ainda a capacidade de criar e inovar. Adicionalmente, foram também exploradas questões relacionadas com a ética e com o ensino da matemática, transversais a todos os cursos de engenharia.

Finalmente, todos os artigos apresentados em inglês na CISPEE2013 foram incluídos nas atas publicadas e indexadas pela IEEE Xplore® Digital Library. Um conjunto seleccionado de artigos foi ainda convidado para

publicação em revistas nacionais e internacionais de elevado prestígio, de sociedades e organizações que patrocinaram o evento, nomeadamente: a *Ingenium*, da Ordem dos Engenheiros; a revista *ABENGE*, da Associação Brasileira para o Ensino da Engenharia; a *IEEE-RITA* e o *IEEE-TICAL*; e o *International Journal of Engineering Pedagogy (i-JEP)*, do IGIP. Brevemente, deverá ainda ser publicado um n.º especial do *European Journal of Engineering Education (EJEE)*, dedicado à CISPEE, que recebeu um conjunto significativo de submissões, de todo o Mundo, sujeitas a um novo processo de *double blind review*.

Mais informações sobre a CISPEE2013, incluindo fotos e vídeos do evento, e ainda os trabalhos seleccionados como *Best Paper* e *Best Poster*, estão disponíveis em www.isep.ipp.pt/cispee.



Publicação de artigo do iJEP sobre o TAT'2013

O Volume 4, Número 2, de 2013 do iJEP (*International Journal of Engineering Pedagogy*) inclui um artigo sobre a sessão especial da SPEE, TAT'13, na conferência anual do IGIP de 2013, cujos autores foram Teresa Restivo (FEUP), José Couto Marques (FEUP) e Alberto Cardoso (FCTUC).

NOTÍCIAS

Special Session "IT's and Engineering Pedagogy" (ITEP'14)



The IGIP Special Track *ITEP'xx* is running within EDUCON conferences, since 2011, with the objective of offering an open discussion and a reflection forum on the use of Information Technologies in Engineering Education. It also intends to foster the involvement in continuing education, bridging the gap between higher education and industry by focusing the IT's use in lifelong learning and training. At K-12 level this ST intends to evaluate the impact of IT's in engaging younger people and in motivating them in the field of science and technology. The review process selected 11 works. Some of them have been reworked and submitted to [online journals](#).

Edição 2014 dos prémios "As Novas Fronteiras da Engenharia"

No dia 24 de setembro, pelas 17h30, realizou-se no auditório da sede da Ordem dos Engenheiros da Região Centro, em Coimbra, a cerimónia de entrega dos prémios "As Novas Fronteiras da Engenharia", aos vencedores da edição de 2014. Na categoria de "Docentes de Engenharia" o artigo vencedor foi "A Joint Academy-Industry Initiative for the Development of an Engineering Program", da autoria de João Carlos Costa Faria da Cunha, José Pedro Matos Nogueira Amaro e António Luís Ferreira Marques, do Instituto Superior de Engenharia de Coimbra.

O artigo premiado foi um dos que estiveram no 1º CISPEE, que se realizou no Porto de 31 de outubro a 1 de novembro de 2013.

GOLC and IAEO Annual Meetings

In the 11th International Conference on Remote Engineering and Virtual Instrumentation, REV 2014, the new leadership of the [Global Online Laboratory Consortium \(GOLC\)](#), was elected. GOLC is focused on promoting the development and sharing of, and research into, remotely accessible laboratories for educational use. The Faculty of Engineering of the University of Porto and School of Engineering - Polytechnic of Porto are among GOLC Voting Members.

The [International Association of Online Engineering \(IAOE\)](#), has the main objective of encouraging the wider development, distribution and application of Online Engineering (OE) technologies and its influence to the society. IAEOE aims to promote the Online Engineering practices in education, in research and in industry. The association also supports initiatives with impact in society, encouraging the exchange of knowledge, staff and students between cooperating institutions. IAEOE had its annual meeting during REV2014, during which its Executive Committee has also been elected.

IGIP Biannual Meeting

The Executive Committee and the International Monitoring Committee of the International Society for Engineering Education (IGIP) had their biannual meeting in February 25, 2014, at the Faculty of Engineering of University of Porto, the Portuguese Institution that is recognized as an International IGIP training Center in teaching development. In this meeting 6 new ING-PAED - International Engineering Educator - were granted to six engineering teachers. The IGIP president, Prof. Michael Auer, granted the ING-PAED Honoris Causa to the Rector of the University of Porto, Prof. José Marques dos Santos.



NOTÍCIAS

11th Remote Engineering and Virtual Instrumentation (REV) Conference

A 11ª Conferência de Engenharia Remota e Instrumentação Virtual (REV) decorreu de 26 a 28 de fevereiro de 2014, no Instituto Superior de Engenharia do Porto (ISEP). Este evento, que corresponde ainda ao encontro anual da International Association for Online Engineering (IAOE), contou com o patrocínio técnico-científico do Institute of Electrical and Electronics Engineers (IEEE), do Global Online Laboratory Consortium (GOLC), e da Sociedade Portuguesa para a Educação em Engenharia (SPEE).

A REV2014 foi a maior das várias edições já realizadas, tendo contado com 170 participantes de 38 países. Para além das sessões técnicas, de workshops ministrados por empresas do sector, e outros eventos, a REV incluiu uma mostra tecnológica organizada por membros da SPEE (Prof.ª Teresa Restivo e Prof. Alberto Cardoso), que contou com 30 demonstrações práticas, e um debate de abertura sobre resultados da aprendizagem em laboratórios remotos e virtuais, que contou com a presença de peritos reconhecidos mundialmente.

Mais informações sobre a REV2014, incluindo fotos e vídeos, estão disponíveis em www.rev-conference.org/REV2014/



Assembleia Geral da SPEE

A realizar no anfiteatro do Departamento de Engenharia Química, no Pólo II da Universidade de Coimbra, no dia 30 de março de 2015, a partir das 14h30.

Das 10h às 12h haverá uma sessão aberta a todos os interessados, intitulada "Os Cursos de Engenharia têm futuro?" com a participação de diversas individualidades.

WEEF and IGIP 2014

World Engineering Education Forum including IGIP Conference 2014

3rd - 6th December 2014, Dubai International Convention and Exhibition Centre, Dubai World Trade Center

weef2014.org and www.icl-conference.org/icl2014/

Following in the footsteps of WEEF 2010 in Singapore and WEEF 2012 in Buenos Aires, the 2014 World Engineering Education Forum brought together a whole array of activities. The Forum combined a number of international engineering education conferences, including the IGIP 2014 on the exchange of relevant trends and research results as well as the presentation of practical experiences in Engineering Pedagogy and Education.

CIEC 2015

2015 ASEE Conference for Industry and Education Collaboration (CIEC)

4th - 6th February 2015, Pam Springs, CA

www.asee.org/conferences-and-events/conferences/ciec/2015

This annual conference was celebrating its 40th anniversary and includes workshops, technical sessions, training and a plenary emphasizing the long and mutually beneficial partnerships between education, industry and government.

The 2015 conference theme was focused on Engineering Education: Past, Present and Future and will highlight the accomplishments of the four sponsoring divisions: Cooperative and Experiential Education Division (CEED), College-Industry Partnerships Division (CIPD), Continuing Professional Development Division (CPDD) and the Engineering Technology Division (ETD). The 2014 conference theme is "Educating for a Sustainable Future". The CIEC 2015 was held in Palm Springs, CA, February 4-6, 2015.

EVENTOS

REV 2015

25 – 27 February 2015, Bangkok (Thailand)
www.rev-conference.org/REV2015

The REV conference is the annual conference of the International Association of Online Engineering (IAOE) and the Global Online Laboratory Consortium (GOLC). REV 2015 will take place in Bangkok, Thailand and will be organized in cooperation with Burapha University – Informatics Faculty.

EDUCON2015

18-20 March 2015, Tallinn (Estonia)
www.educon-conference.org/educon2015

Engineering Education towards Excellence and Innovation

The IEEE Global Engineering Education Conference is the sixth of the series of conferences that rotates among central locations in IEEE Region 8, Europe, Middle East and North Africa.

exp.at'15

2nd – 4th June 2015, São Miguel (Azores)
paginas.fe.up.pt/~expat

3rd Experiment@ International Conference

The Experiment@International Conference 2015 (exp.at'15) is the 3rd event of a conference series which was started at Calouste Gulbenkian Foundation, Lisbon, Portugal, in November 2011, followed by the second one hosted by University of Coimbra in September 2013.

exp.at'15 will be held at University of Azores (Ponta Delgada, São Miguel Island, Azores, Portugal) and it is a joint organization of the University of Porto and the University of Coimbra with the collaboration of the University of Azores and with the technical support of IEEE.

CSEDU 2015

23-25 May 2015, Lisbon (Portugal)
www.csedu.org

The International Conference on Computer Supported Education (CSEDU 2015) aims at becoming a yearly meeting place for presenting and discussing new educational environments, best practices and case studies on innovative technology-based learning strategies, institutional policies on computer supported education including open and distance education, using computers. In particular, the Web is currently a preferred medium for distance learning and the learning practice in this context is usually referred to as e-learning. CSEDU 2015 is expected to give an overview of the state of the art as well as upcoming trends, and to promote discussion about the pedagogical potential of new learning and educational technologies in the academic and corporate world.

ASEE Annual Conference and Exhibition

14 - 17 June 2015, Seattle (USA)
www.asee.org/conferences-and-events/conferences/annual-conference/2015

The ASEE Annual Conference and Exposition is dedicated to all disciplines of engineering education. It is committed to fostering the exchange of ideas, enhancing teaching methods and curriculum, and providing prime networking opportunities for engineering and technology education stakeholders such as deans, faculty members and industry and government representatives.

WEEF 2015

20 - 24 September 2015, Florence (Italy)
www.weef2015.eu

World Engineering Education Forum 2015 focuses on and address the general theme of resilience to varying aspects and scales. There will be an opportunity to engage with the concept and explore its applicability and value in engineering education and in engineering overall. But, considering that it is also of importance to engage with a dialogue among disciplines in order to be capable to propose effective (that is holistic) solutions to future risks, the Forum will cede considerable space to interdisciplinary reflection on the notion of resilience, its utility and its limits. Besides, and in order to ensure a smooth passage in engineering education from the previous paradigms to that of resilience, a strand for 'teaching teachers', at university and pre-university level (elementary and high school) will be also of importance to the Forum.

Qualidade do Ensino de Engenharia – Certificação Pedagógica de Docentes de Engenharia

Durante o ano de 2015, o Instituto Superior de Engenharia do Porto (ISEP) organizará com o apoio da Faculdade de Engenharia da Universidade do Porto (FEUP) um curso de formação pedagógica dirigida a docentes de engenharia. A frequência e conclusão deste curso permitirá obter o Diploma Ing Paed da International Society for Engineering Pedagogy (IGIP), o que significa a certificação internacional das competências adquiridas para o ensino de engenharia. De acordo com o relatório da Comissão Europeia sobre como melhorar a qualidade do ensino e da aprendizagem nas instituições europeias de ensino superior, a formação pedagógica certificada dos docentes surge como uma das recomendações que deverá ser uma realidade até 2020. O programa do curso, lecionado por um centro de formação acreditado pelo IGIP, é constituído por um plano de estudos de 20 ECTS, composto por 13 módulos: 3 módulos basilares, 4 módulos teóricos e 6 módulos práticos.

	Plano de estudos		ECTS
Módulos Nucleares	M1	Pedagogia da Engenharia em Teoria	2
	M2	Pedagogia da Engenharia em Prática	3
	M3	Didática Laboratorial	2
Módulos Teóricos	M4	Psicologia	2
	M5	Sociologia	1
	M6	Ética	1
	M7	Pensamento Crítico & Criatividade	2
Competências de Comunicação Oral	M8	Competências de Comunicação Oral	2
	M9	Escrita Científica	1
	M10	Aprendizagem com Base em Projetos	1
	M11	Multimédia & Tecn. Assistidas por Computador	1
	M12	Ensino à Distância	1
	M13	Infoliteracia	1

A frequência desta formação implica um investimento de 50€ por ECTS, existindo condições especiais para membros da SPEE que se inscrevam em todos os módulos correspondendo a 10% sobre o valor total. Os módulos serão ajustados para permitir a todos os colegas frequentarem com o mínimo impacto nas suas atividades letivas. O número de vagas disponíveis é limitado. O período de candidaturas decorre até ao final do mês de Março e segue a política de "first come, first served". Para reservas ou perguntas por favor contactar Drª Alexandra Trincão, formacao@isep.ipp.pt.

ARTIGO

Lean Engineering Education: DNA for Change



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Best Poster na
 1º Conferência
 Internacional
 da Sociedade
 Portuguesa para
 a Educação em
 Engenharia

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).

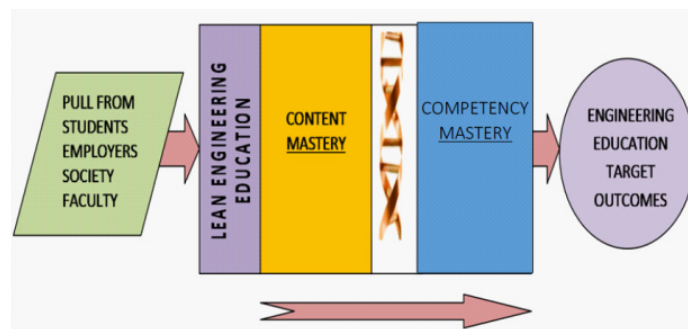


Figure 1: Content and Competency Mastery Combined in a Double Helix DNA

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

ARTIGO

Lean Engineering Education: DNA for Change

(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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