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P-PAC (PARTNERSHIP IN PEDAGOGY, ACCREDITATION, AND COLLABORATION): A FRAMEWORK TO SUPPORT STUDENT TRANSITION TO EMPLOYABILITY IN INDUSTRY. A LEAN SYSTEMS CASE STUDY

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Abstract
The global economic crisis of the past decade and the accruing shifts in labour market policy, coupled with the rapid advances in technology have resulted in a far less certain future employment horizon than ever before [1]. In response, Higher education institutions (HEIs) are best positioned to advance knowledge and produce work ready graduates with the requisite skills for the future economy [2]. In this paper, the current understanding regarding the role of HEIs, the academic-student partnership, graduate employability, industry collaboration and research led teaching are merged into a framework entitled P-PAC (Partnership in Pedagogy, Accreditation and Collaboration). This framework encourages and embeds a partnership approach between academia, students and industry with the goal of promoting collaboration, facilitating relevant curriculum and pedagogy practise and accrediting achievement in order to effect deeper and more engaged learning and teaching, so that students are better equipped with the necessary skills for both employability and global citizenship. The P-PAC framework is validated using a 5 ECTS Lean Systems module. The authors also define Threshold Concepts-major as those concepts (identified by the academic) which are inherent in a module and which need to be achieved by the student, in order to attain mastery of the subject matter. Threshold Concepts-minor are defined as those intermediate concepts identified by the student in their mastery of Threshold Concepts-major. Examples of both concept types are presented in this paper.

Keywords
lean systems, Threshold Concepts (major and minor), partnership, employability, graduate attributes.

Introduction

The purpose of the early higher education institutions (HEIs) was the cultivation of "knowledge for its own sake – and perhaps even of finding Truth" (p. 207) [3]. A more contemporaneous view is that the highest priority of HEIs "is to create, preserve, transmit and find new applications of knowledge so as to enhance and extend free choice throughout society" in as much as possible, acting in a dual role as defenders and supporters of society's values and as agents of change for society's benefit [4]. [5] contends that in the execution of their role, HEIs "bear a profound, moral responsibility" (p. 17) to effect change in people's lives through the creation of a more just future. However, this more altruistic perspective is impeded by increasing pressures on HEIs to contribute to economic growth as "knowledge businesses instead of social institutions" (p. 596) [6–8]. [9] regard HEIs as the prime drivers "in technological innovation in both the developed and the developing countries" (p. 12). Nedeva (2007) cited in [8] suggests that HEIs have "historically been seen as relevant and related to the economies and/or society in which

they are situated" (p. 39). With the massification of universities and the emphasis on a knowledge society, "governments, employers and other stakeholders have come to expect higher education to contribute to the development of a variety of complex 'skills', which – they argue – enhances the stock of human capital and makes for national economic well-being" (p. 2) [10]. This pressure from governments and other stakeholders is highly understandable given that within a competitive sector, HEIs are recognised as the institutions that can contribute to the knowledge that underpins a competitive economy whilst also producing the requisite knowledge workers to work in that economy [8]. This is increasingly critical given the rapid advances in technology; by 2030 "between 400 and 800 million people worldwide could be displaced and may need to ?nd new jobs" [58]. However, a dialectic tension exists between responding to the needs of the economy by producing employable work-ready graduates and contributing to the development of knowledge potential [11]. "Current conceptualisations of employability provide a strong incentive for universities to re-structure their curricula along more vocational lines, educating narrow specialists for specific jobs. Ironically and paradoxically, this might endanger the 'knowledge society', since this is characterised by a dynamic labour market demanding broad knowledge and core competencies rather than only narrow, specific and job-oriented skills" (p. 12) [8].

Regardless of the differing opinions on the role of HEIs and the resultant dialectic tensions, the undeniable fact remains that students choose to undergo a university education for diverse reasons, including interest in a subject and/or upskilling/reskilling towards better job opportunities [12–14]. Studies show that students typically view the purpose of HEIs as that of providing them with the credentials and competences necessary for rewarding employment [13]. Assuming that said students leave as graduates, it is legitimate to say that the majority will impact society in some manner in their post graduate lives. As a considerable component of that impact will derive from their work contributions, it is critical that these eventual "professionals who develop, lead, manage, teach, work in, and influence society's institutions" (p. 3) are prepared as 'best as possible' by their respective alma maters [5]. Indeed, it is crucial that decision makers more than ever are required to have improved quality of thought and enhanced knowledge [4].

In this paper, the authors propose a generic framework to support the student transition to employability. The Partnership in Pedagogy, Accreditation and Collaboration (P-PAC) framework encourages and embeds a tri-partite partnership approach between academia, students and industry to; promote collaboration, facilitate curriculum and pedagogy practise and accredit achievement for the purpose of developing graduates with the attributes for employability and global citizenship. The P-PAC framework is explained through the lens of a Lean Systems case study.

Graduates, HEIs and employability

The global economic crisis of the past decade and the accruing shifts in labour market policy, have resulted in a far less certain future employment horizon than ever before. It has also resulted in an increased governmental pressure on HEIs to prepare and produce employable graduates who are equipped with the practical skills required for their future employability [1, 8, 14–18]. [10] argue that a direct relationship exists between employability skills and good learning, as they contend that "good subject matter understanding is compatible with employability policies, and that employability and good learning are highly compatible" (p. 9). [19] contend that it is important that HEIs embed employability in curriculum and pedagogy practise. Furthermore, by fostering the use of "work based curriculum components" (p. 239) [19], effective teaching & assessment practices and the creation of supportive learning environments to reinforce student engagement and deep learning, the opportunities of and for developing graduate employability attributes are augmented. However, despite pressure from governments and other sources, HEIs cannot realistically guarantee employability. Nonetheless what can be legitimately expected of them, is the provision of a learning experience which supports the likelihood of their graduates becoming more employable through presented opportunities for the development of both hard and soft skills [18, 20]. Regarding graduate employability (Yorke 2004) cited in [18] defines it as "a set of achievements – skills, understandings and personal attributes – that makes graduates more likely to gain employment and be successful in their chosen occupations, which benefits themselves, the workforce, the community and the economy" (p. 6).

Studies by [21] and [2] regarding an employer's view of employability, highlight an emphasis on the need for graduates to be both prepared and capable of contributing to an industry and its mission, shortly after recruitment. [22] contend that the expectations of prospective employers are becoming increasingly long and complex; with desirable employability

attributes comprising; being able to function in the workplace; effective communicators, problem solvers and critical thinkers; capable of working effectively in teams and capable of adapting and responding to change etc. Meanwhile, research by (Archer and Davison 2008) cited in [12] suggests that the 'softer skills' such as team working and communication are regarded by industry as equal to, if not greater in importance than 'hard skills' (i.e. technical skills), to the point that employers view academic credentials as a 'tick box' activity [13]. Reiterating this focus on the more behavioural competences, the UK Commission for Employment and Skills has defined employability based on the demonstration of; a positive attitude, ability to take constructive criticism, numeracy, literacy and IT proficiency, adaptability to new technology, self-industry and self-management capabilities, critical, analytical, problem solving and creative thinking skills, being able to communicate and work effectively on a team and listening and innovation skills (UKCES 2009) (p. 17) cited in [12]. Indeed, this focus on soft skills is also recognised by the students themselves; "students increasingly viewed their employability as matter of 'what they are about' as individuals, as much as their technical know-how and cognitive skills" (p. 15) [13].

Employability metrics

Studies show that students increasingly use university rankings to aid their decision regarding their HEI of choice, a decision which is typically influenced by their concern for both their future employability and the selection of the 'right' type of university [23, 24]. Global university ranking schemes such as the *THE World University Rankings* and the *QS World University Rankings* include comparisons of the effectiveness of universities along multiple performance indicators such as teaching, research, interaction with industry etc. [18, 20, 21].

Meanwhile, the *QS Graduate Employability Rankings* use the following five indicators (weighted 30%, 25%, 25%, 10% and 10% respectively) to support students in comparing and contrasting the performance of international HEIs in the matter of employability [25]:

1. The Employer Reputation metric,
2. Alumni outcomes,
3. Partnership with employers,
4. Employer/student connections,
5. Graduate employment rate.

Understandably, HEIs are increasingly using employability metrics in student marketing and recruitment materials [19]. Whilst they legitimately cannot guarantee that their graduates will be in possession of all employability attributes necessary for securing employment; they need to be able to guarantee that there will be sufficient employability-development opportunities available to help their students develop generic skills [26]. Such employability-development opportunities can be embedded either implicitly or explicitly in course content and/or through add-on activities (e.g. work placement, internships etc.) [20, 27]. The efficacy by which these skills are developed is largely dependent on individual attitudes and the motivation of both the lecturers and the students. However, [20] cites a number of additional factors, which can play a significant role in graduate employability;

- *Type and ranking of HEI* – Graduate recruiters may have a preference for a specific HEI.
- *Economic environment* – An economic downturn can affect the number of employment opportunities.
- *Subject of study* – Dependent on the skills shortage and resultant demand, certain subject areas may experience high employability and others the inverse.
- *Prior work experience* – Recruiters can show preferences for previous work experience separate to the HEI. Studies show that part-time work can result in work-based benefits [28]. (Allen 2015) contends that "going out and finding a job and finding a way to successfully combine it with college work and life shows great initiative, true grit, and multitasking ability" cited in [29, 30]. The need to be disciplined, organised and efficient at time management, whilst developing social skills are some of the many benefits accruing to students who work part time during college [31].
- *Age* – Age discrimination is increasingly prevalent among recruiters and employers [32].
- *Ethnicity* – Ethnicity discrimination is still commonplace among recruiters and employers [33].
- *Gender* – Discrimination and inequalities based on gender are still significant issues, both in the workplace and from the viewpoint of recruitment [34].
- *Socio-demographics* – Despite the Free Fees Initiative (introduced in Ireland in 1996), Irish students pay an annual registration fee of € 3,000 [35]. In combination with rising accommodation and living costs, this results in families paying between € 4,340 to € 8,206 annually to cover the cost of college education [36, 37]. Whilst education may be advertised as being free to all, the reality is that those from a lower socio-economic background may not be able to afford to access third level educational opportunities.

Academia-Student Partnership

Studies carried out on student engagement in third level, confirm a direct relationship between positive student engagement and positive learning experiences and outcomes [38]. In order to foster student engagement and in turn deep learning, it is the responsibility of the academic to create an appropriate engagement framework which encourages each student to spend time mastering related Threshold Concepts [39]. A Threshold Concept is recognised as a discipline critical concept which must be achieved by the students [40]. If a Threshold Concept is not first mastered, then it may not be possible for the student to engage in advanced discipline learning [41]. Consequently, Threshold Concepts are by nature, inherently challenging as they demand that students accept a transformation of their own understanding [42]. In order to master Threshold Concepts, a student must enter into and then progress through what is known as the Liminal space. In effect, the Liminal space can be viewed as a "space of Transformation" (p. 5) [43], as it is the new state of Threshold Concept mastery. In the process of mastering a Threshold Concept, Liminality can be described as the learning journey. The academic, in their role as a 'guide'/facilitator can create and open a portal to encourage a student to enter this Liminal space. However the journey therein can be either a positive or a negative experience [43]. A strong partnership approach, which is key to overcoming lengthy journeys, creates a co-dependent relationship where the academic and the student must directly engage with and be self-motivated for the process to succeed. [38] contend that "engaging students and staff effectively as partners in learning and teaching is arguably one of the most important issues facing higher education in the 21st century" (p. 7). Partnership in this context is regarded as more of a process than a product; with the term relating to a "relationship in which all participants are actively engaged in and stand to gain from the process of learning and working together" (p. 7), [38]. Ideally, such a partnership supports and fosters; learning and teaching enhancement, curriculum for employability, practise led content and an increased awareness of the role and importance of research led teaching and learning (Dickerson and Stockwell 2014) cited in [44]. An additional benefit of an effective partnership is the support of communities of enquiry. A Community of Inquiry (CoI) framework draws upon ideas that computer-mediated teaching and learning require the existence of three interdependent presences (i.e. social, teaching and cognitive) in order to "collaboratively engage in purposeful critical discourse and reflection to construct personal meaning and confirm mutual understanding" [45]. However, the establishment of an effective student-academic partnership is increasingly challenged by rising enrolment figures, and the need to accommodate larger class sizes (Reidy 2014) cited in [46]. Further acerbating this challenge is the fact that "today's students are no longer the people our educational system was designed to teach" (p. 1) [47]. By nature, they are digital natives; familiar with receiving and processing information quickly; capable of multitasking; characterised by short attention spans and with a preference for games to serious work [47]. [48] contend that education must fundamentally change to meet the needs of these 'digital natives'. The authors assert that the incorporation of game based workshops, short experiential learning activities and laboratories into curriculum design and delivery, helps to accommodate this need for 'fun'. Meanwhile, by leveraging on the student academic partnership through active engagement activities, students can learn how to properly absorb knowledge and spend quality time in the Liminal space in their mastery of Threshold Concepts. Notwithstanding, an holistic university experience is not only about attending lectures, it is also about the co-curricular and extracurricular social participation/interaction that has a beneficial effect [49].

Global inter dependence demands that we act as responsible global citizens who identify "with being part of an emerging world community and whose actions contribute to building this community's values and practices" (p. 22) (Israel, 2013) cited in [50]. Moreover, the increasing interconnectedness of the world due to technological advancement and economic, political and social integration means that mankind faces "a common destiny" (p. 1) [51]. In this world of growing dynamic complexity, graduates need to understand the intricacies and dynamics of problems and have a deeper understanding of the social consciousness of human rights and the democratisation of decisions. They need to appreciate that solutions can have unanticipated side effects which may make the problem worse, or can create new problems. A global citizen is a person who "is aware of the wider world and has a sense of their own role as a world citizen, respects and values diversity, has an understanding of how the world works economically, politically, socially, culturally, technologically and environmentally" (p. 30) [52].

Academia-Industry Partnership

(Bruneel & Salter 2010) cited in [9] contend that not only is the role of HEIs to advance knowledge and equip graduates with relevant work ready skills, but to also engage in socio-economic activity, activity which is generally characterised by research and profit making through commercialisation. To fulfil the latter part of such a role, HEIs need to "proactively partner with the industry, thereby, accelerating the discovery, development and diffusion of knowledge and technology" (Bruneel, D'Este, and Salter 2010) cited in [7] (p. 1210). (Salter and Martin 2001) cited in [7] contend that the education of skilled graduates is one of the mechanisms by which "academic research can diffuse to industry" (p. 597). Meanwhile, (Armsby & Costley 2001) cited in [19] argue that strong collaborations with industry are seen as critical by HEIs in the development of industry led employability endeavours. Industry-academia collaborations generally align along a spectrum from "the involvement of individual academic scientists in collaborative research, contract research and consulting to more informal technology transfer" (p. 3) (Perkmann et al. 2013) cited in [7]. (Acworth 2008) and (Breznitz & Feldman 2012) cited in [9] argue that whilst mutually beneficial industry-academic collaborations have influenced the redesign of "the working space of academia and the industry" (p. 2), industrial benefits stemming from such collaboration can include; a positive impact on the industry's innovation capacity, greater accessibility to basic and applied research; greater availability to relevant technical and scientific knowledge and more defined linkages and recruitment pathways for highly qualified graduates [53]. By contrast, the benefits accruing to HEIs can include; augmented resources (financial, human and/or hardware/software), access to industrial knowledge and expertise, connections and linkages and "gains in image and visibility through the transfer of useful scientific knowledge coming from academic research to industry" (p. 4) (Godinho & Caracą, 1999; Martin, 2000; Jones-Evans et al., 1999, Schibany & Schartinger, 2001; Senker, 1998; OECD, 2001) cited in [53]. [14] assert that the participation of students in work experience and work-related learning as part of their course, influences them in being work ready on graduation. Furthermore, the involvement of employers in both course design and delivery facilitates the realisation of work-ready graduates [14].

P-PAC: Partnership in Pedagogy, Academia and Collaboration

Based on the above review, this paper presents the P-PAC (Partnership in Pedagogy, Academia and Collaboration) framework (Fig. 1). This framework encourages and embeds a partnership approach between academia, students and industry. Its goals include; promoting collaboration, facilitating relevant curriculum and pedagogy practise and accrediting achievement in order to effect deeper and more engaged learning and teaching, so that students are better equipped with the necessary skills for both employability and global citizenship.

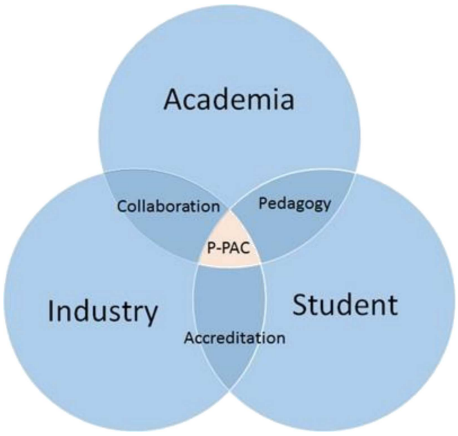

Fig. 1. P-PAC Framework.

The partnership-union between these the tripartite partners is:

- *Pedagogy through Partnership* – refers to the academic-student partnership approach using best practise approaches and tools, to create self directed and experiential learning within a supportive learning environment. It also accounts for module and learning environment design/re-design, with the aim of creating a vibrant community of learners where students are empowered to become partners in the validation of Threshold Concepts-major and the identification of Threshold Concepts-minor. The authors define Threshold Concepts-major as the academic's perception of crucial concepts inherent in a module which need to be achieved by the student, in order to attain mastery of the subject matter [54]. Meanwhile, the authors define Threshold Concepts-minor as the student's perceptions of those module concepts with which they struggle, in achieving the Threshold Concepts-major.

- *Collaboration through Partnership* – refers to the bi-directional collaboration between academia and industry; wherein industry is provided with a means to influence and contribute to curriculum and pedagogy practise, whilst also gaining greater access to relevant technical and scientific knowledge. HEI benefits include; access to industrial expertise and experience, increased linkages and augmented resources. (Van Dierdonck, Debackere, and Engelen 1990) cited in [9] contend that a positive experience in industry-academia collaboration can result in; the development of a positive mindset and bias in academia towards industry, the bi directional establishment of a larger network of industrial-academic contacts, the diffusion of scientific and technical knowledge [53] and the facilitation of mutual learning.
- *Accreditation through Partnership* – refers to the industry certification of student competency. This becomes a tangible demonstration of the relevancy of the content from an industry perspective and an assurance of competency and employability skills [19].

The authors contend that through the adoption of the P-PAC framework, a change in mindsets and practise from both an industry, academic and student perspective, can be effected, partnerships enriched and learning outcomes linked with employability attributes and global citizenship actualised.

P-PAC: Lean Systems Case Study

The presented case study focusses on a 5 ECTS Lean Systems module, which is an optional, transferrable skills module, offered to both final year undergraduate (UG) and postgraduate (PG) taught students in all engineering disciplines. Lean Systems teaches students how to approach problems or opportunities for improvement through a system wide approach. This module is offered in the final year of the Bachelor of Engineering Degree and to the taught Master of Engineering cohort as it is more impactful when the students have had prior work experience when dealing with process improvement projects. The critical thinking involved in the Lean Systems module is associated with the design of work systems and the pursuit of operational excellence through a socio-technical lens. During the semester, students are exposed to Lean Systems design and operational excellence concepts through a balanced socio-technical lens by exploring social and technical challenges facing industries in a global extended enterprise. These technically skilled students are also provided with additional opportunities to develop; their capacity in real world problem solving and organisational skills. This module introduces students to a number of process improvement tools and techniques which industry can use to retain a competitive advantage and maintain profitability. The Lean Systems module involves formal lectures peppered with discussions; primarily adopting an academia-student partnership approach by exposing lean systems failures and lessons learned. It also incorporates a number of practical exercises through Pair-Share experiential learning activities which are designed to entice students into the Liminal space. Real life experiences are provided through guest lecturers. A workshop, facilitated by a black belt practitioner is offered, where students present Lean solutions to operations problems. In total, the module comprises 2 hour weekly lectures across 12 weeks and an 8 hour Industry led Workshop with a total student effort of around 125 hours.

The application of the P-PAC framework to the Lean Systems module will be explained within the context of the resulting tri-partite partnership-unions and the manner in which these respective partnership unions were fostered.

Pedagogy through Partnership (Academia-Student partnership-union)

Underpinned by the P-PAC framework, the Lean Systems module employs "active, experiential, inquiry-based learning and real world problem solving" (p. 5) [5] to create a partnership between academia, students and industry in the support of student learning and the development of graduate attributes for employability and global citizenship. This partnership approach, based on a shared understanding, scaffolds curriculum design, development and delivery to provide opportunities for personal and professional skill development. Curriculum re-design is based on the following design principles associated with Threshold Concept mastery [55];

- *Jewels in the curriculum*: relate to those concepts which require mastery to advance student understanding of Lean Systems. (Land et al. 2006) cited in [55] contend that jewels in the curriculum allow for deeper insight into the material being studied. In the case study, Threshold Concepts-major and Threshold Concepts-minor were identified by the academic and the students respectively. Experiential learning activity based practices – where students solved complex real-life process problems and received feedback – were employed to advance the mastery of Threshold Concepts.
- *Listening for understanding*: refers to the academic's active listening for student misunderstanding

of content. Listening for understanding was implemented through a research-led activity which partnered students and the academic in researching areas of Lean Systems implementation failure resulting in human detriment.

- *A holding environment*: Mindful of student confusion, the academic made efforts to hold and support the students while they transitioned to an understanding of the Threshold Concepts. As engineers will be required to lead projects in a team-based environment, the pedagogy in the Lean Systems module develops leadership and team building skills through role play by building a safe space/holding environment in the classroom where students have the opportunity to increase their confidence through collaborative classroom based activities and experiential learning. "Good learning environments can improve the odds of groups of students becoming more employable but they do not guarantee that any individual will become articulate, emotionally-intelligent and self-motivating" (p. 7) [10]. An example of an activity which presented an opportunity for personal and professional development was the Research etivity, where students and the academic discussed and debated why Lean failed. During this activity, the academic was responsible for creating a safe and supportive environment (i.e. a holding environment) for presentations, discussions and online blogs.
- *Recursiveness and excursiveness:* In the journey to Threshold Concept mastery, students may need to revisit/revise previous concepts through alternative pedagogies. "Mastery of a threshold concept often involves messy journeys back, forth and across conceptual terrain" (p. 10) [55]. Recursiveness and excursiveness were supported through activity based practise in the classroom. As an example, in order to understand Value Stream Mapping (VSM), an activity took place comprising a number of improvement iterations which facilitated the repetitive nature of recursiveness and excursiveness for impactful learning.

The goals of curriculum re-design for the Lean Systems module were to: stimulate and deepen independent student learning; develop critical thinking skills and encourage student confidence through participation, active integration, interaction and teamwork. It is through the development of communities of enquiry and the use of group work on real life complex problems (initiated and validated by industry) that opportunities are presented for collaboration and the acquisition of skills requisite for future leaders and managers. The value of the Academia-Student partnership for teaching enhancement is central to the Lean Systems module.

Threshold Concepts-major: Case Study

As already outlined, Threshold Concepts (major and minor) (i.e. jewels in the curriculum) represent those key concepts which need to be understood by the student in order to attain mastery of the subject matter. As part of the Lean Systems module, Threshold Concepts were identified by both the academic and the students, and appropriate activities created to encourage students through the respective Liminal spaces to facilitate concept mastery. The nature of these activities also supported recursiveness and excursiveness. The visualization of a Value Stream Map (VSM) was identified as a Threshold Concept for the Lean Systems module [46]. Pivotal to the basic concepts of Lean Systems, the VSM is a Lean Six Sigma tool. VSM is used to document, analyse and improve the flow of information and/or material in the identification of waste, reduction of process cycle times, and the implementation of process improvement. To support mastery of this Threshold Concept, a specialised VSM role-playing workshop was designed into the curriculum. During this workshop, a case study embedded with challenges such as; complaints from customers, returned products, untidy workspaces, processes out of sync, and poor performance etc. is first presented to the students. The students are then encouraged to conduct a Kaizen activity on the case study using the basic principles of the Plan, Do, Check and Act methodology for continuous improvement. In the first step of case study analysis, value add and non-value add activities are identified using the customer lens, whilst performance efficiencies are identified and analysed using the industry lens. The TIM WOODS approach to visualising waste is next conducted, after which the VSM is created. The value add and non-value add activities are represented on Post-Its which are transferred to a notice board, after which a current state map/VSM of process flow is visualised (Fig. 2).

Once the VSM is structured, an analysis of improvement occurs i.e. value add and non-value is calculated Students then apply the Ishikawa diagram (Fig. 3) to screen cause and effect.

Other tools (e.g. House of Quality, Kanban, SMED, Cell Layout, Takt Time) are also used to identify root causes of waste. A future state map is next created to improve the flow and operational excellence. As part of this workshop, students are also tasked with benchmarking the old VSM with the new improved VSM, using predefined metrics.

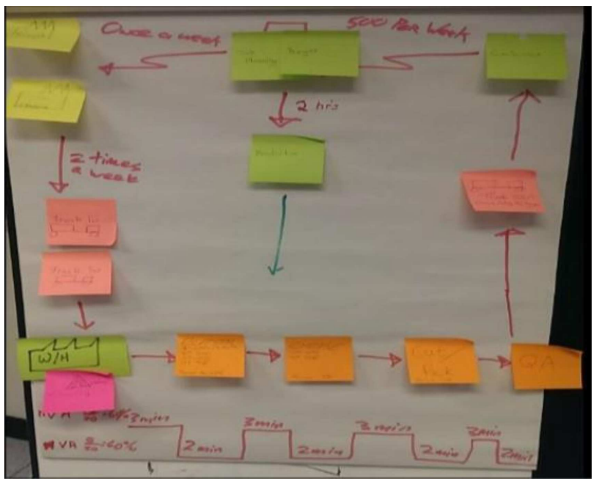

Fig. 2. Student Value Stream Map.

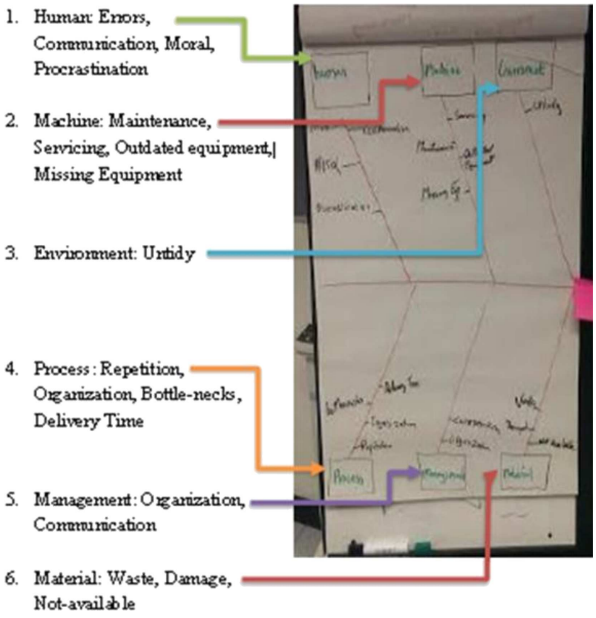

Fig. 3. Student Ishikawa Diagram.

Threshold Concepts-minor: Case Study

Whilst literature to date has typically focussed on the academic identification of Threshold Concepts, there is a paucity of literature on the student's own definition of those intermediate Threshold Concepts which they encounter on their journey to the mastery of the major Threshold Concepts. The authors categorise these concepts under Threshold Concepts-minor. In order to identify the students' perceptions of the intermediate Threshold Concepts (i.e. Threshold Concepts-minor), a student perception survey of PG and UG students was carried out. The purpose of this survey was to study the application of the P-PAC framework to the Lean Systems module. Having a response rate of 51% ($n = 109$), 65% ($n = 56$) of respondents were male and 35% female. The majority of the respondents were in the 18–24 (68.5%) age bracket with 28% aged between 25 and 30 years and 3.5% aged 31 years and older. The PG (Level 9) cohort represented 80.7% ($n = 56$) of the respondents. 100% of the UG respondents (Level 8) and 44% of the PG respondents had prior knowledge of Lean Systems. The Threshold Concepts-minor identified by the UG and PG respondents (in answer to open ended questions) are shown in Table 1, ranked in order of frequency.

Table 1
Summary of top Threshold Concepts-minor by course level and gender.

	Threshold Concepts-minor			
	UG (8M, 3F		PG (28M, 17F)	
	Threshold concepts	Frequency	Threshold concepts	Frequency
Male	DMAIC	3	VSM	16
	Six Sigma	2	Six Sigma	10
	Takt Time/rate	2	Takt Time	6
	Waste	2	Waste	6
	VSM	2	Lean Tools	5
	One piece flow/JIT	2	Standard	5
			Strategic planning	1
Female	VSM	2	VSM	11
	Standard	2	Six Sigma	12
	Six Sigma	1	DMAIC	5
			Waste	3
			OEE	2
			Kanban	2
			Strategic planning	3
			Kaizen	2
			Standard	2
			Takt time	2

Interestingly, the academic had identified the main Threshold Concepts as VSM and the Visualisation of Flow Principles and embedded activities in the curriculum to support same [54].

The top two Threshold Concepts-minor with which both UGs and PGs had difficulty understanding at first but which became clear during the module were VSM and Six Sigma. Both females (UGs and PGs combined) and males (UGs and PGs combined) expressly identified these two concepts as the top Threshold Concepts-minor, therein showing no significant gender specific difference between Threshold Concept identification. However, it is worth noting that none of the females (either PG or UG) identified Leadership as a Threshold Concept. Meanwhile, proportionately more PG female respondents (18%,

$n = 17$) identified Strategic Planning as difficult to understand compared to 3% ($n = 28$) of PG male respondents. This may indicate a specific gender issue.

Research e-tivity in the Lean Systems Module

Resulting from student feedback and collaborations with industry, the Lean Systems curriculum and pedagogy were revised to embed a Blog based Research e-tivity. The purpose of this e-tivity was to provide opportunities to students to develop critical thinking, personal and professional skills [56]. The nature of this Research e-tivity created both an effective holding environment for the students and a mechanism for the academic to listen for confusion and misunderstanding of content. In this e-tivity, students were asked to research Lean Systems publications and share their insights into the possible root causes of Lean Sytems failures, through a 60 second summary pitch to their peers. In order to capture the richness of this activity, students were encouraged to populate a Blog with a summary of the key messages from their research. The pedagogy underpinning this Research e-tivity (which was influenced by the CoI framework [57]) supported active online learning and encouraged students to spend enriched learning time in the Liminal Space. Results showed that the Research e-tivity resulted in a deeper student understanding of the module content. "*The research literature helped me understand each topic more clearly*" [Male, UG]. "*The presentation which we were asked to give made me go through a lot of papers. Reading similar topics repeatedly made me well understand about these topics*" [Female, PG]. "*The presentation of the research paper by students helped me in understanding Takt time*" [Male, PG].

Collaboration through Partnership (Academia-Industry partnership-union)

In partnership with industry contacts, real life case studies and problem scenarios were developed to support learning and teaching in real-life contexts and to assist students in integrating theory and practice, whilst also providing opportunities for the acquisition of a range of hard and soft skills. This shared understanding, whilst mutually beneficial to both parties also resulted in a common dialogue which was disseminated to the students. The Academia-Industry partnership collaboration was strengthened through;

- *Guest speakers:* Industry collaboration and engagement provided students with enriched experiences that allowed them to gain insights into their prospective career paths. Furthermore, invited guest speakers validated the teaching approach by linking industry practitioners with academia. Feedback from the students showed that the industry speakers had a very large impact on students' understanding of troublesome topics, with more male respondents (61%, $n = 36$) indicating impact than female respondents (45%, $n = 20$). However proportionately more PG male respondents (71%, $n = 28$) indicated significant impact on their learning (from the industry speakers) compared to their equivalent UG counterparts (25%, $n = 8$). 53% ($n = 17$) of female PG respondents indicated that the industry speakers were highly influential in their understanding of the content, compared to 0% of their UG counterparts. The results show that proportionately more PG respondents (64%, $n = 45$) found the industry speakers more relevant to their learning than their UG counterparts (9%, $n = 11$). Further study would have to be conducted to investigate this finding. "*Include more guest lecturers to aid students*" [Female, PG].
- *Real life case studies:* In consultation with leading industrial experts, real life case studies were embedded into the curriculum to ensure that aspects of said curriculum were practise-led. Further, these case studies partially bridged the gap between institutional curriculum and industry expectations.
- *Workshop:* Designed and delivered by a Master Black Belt certified specialist, the Lean Systems workshop immersed the students in a 'fun' in-class activity to encourage them to enter into the Liminal space. Through a supportive holding environment, students were supported in achieving Threshold Concepts. The workshop was based on a fictitious company which assembled food products. The students were told that in addition to the management team, the company employed a Sales-Planning manager, Procurement manager, Warehouse manager, Production manager, four Manufacturing operators/QA, a Shipping operator and a Customer Care operator (After Sales Support). The students were informed that management had become concerned about profitability and product returns and that customers had complained about late deliveries and quality defects. Additionally, the students were told that the customers had complained that the company did not offer sufficient product variety, whilst management, in a walk through the factory floor and warehouse areas, had observed that excessive inventory and incomplete orders were hindering flow, with the afore mentioned areas and office area appearing visibly untidy and disorganised.

Furthermore, the company relied on two suppliers. Students assumed roles in the fictitious company ranging from line operators to management and from customer to supplier roles. A number of metrics were used to measure the company performance including quality, delivery time, cycle time, space etc. Following a number of simulated disasters, a Lean Systems programme was initiated and the company re-organised. Students ran tests to simulate a customer order, whilst also monitoring and analysing key performance indicators for the Lean System. Through workshop participation, students expedited Threshold Concepts achievement. 61% ($n = 36$) of male respondents indicated that the Lean Systems workshop had a very large impact on their understanding of troublesome topics. Of those, 86% ($n = 22$) were PG. Proportionately more PG male respondents (68%, $n = 28$) found the Lean Systems workshop impactful on their learning compared to their UG counterparts (37.5%, $n = 8$). Meanwhile, 55% of the female respondents ($n = 20$) indicated that the Lean Systems workshop had a very large impact on their understanding of Lean Systems concepts. Proportionately more PG female respondents (59%, $n = 17$) found the workshop impactful compared to their UG counterpart (33%, $n = 3$). The results show that proportionately more PG respondents (64%, $n = 45$) found the workshop activity more relevant to their learning than their UG counterparts (36%, $n = 11$). Further study would have to be conducted to investigate this finding. "*The workshop helped a lot for understanding the purpose of VSM; and also gave clear explanations of how to use Kanban in the Lean System*" [Female, PG]. "*The day long workshop, with worked examples helped much more than being told conceptually what they are"* [Male, PG]. "*I had difficulty in understanding the idea of Takt time but got clear idea after attending workshop"* [Male, PG].

Other student-learning supports included; lectures and in class activities, the Dabbawala video and access to library resources. In general, students identified the Workshop, Lectures and in-class activities and the Industry speaker as the top three supports in their understanding of the Threshold Concepts. On completion of the Lean Systems module, 79% of respondents would now be able to teach/explain the topics they identified as initially difficult to understand to another student having difficulty understanding them. "*I feel like I could explain the concepts of value stream mapping that were introduced at the workshop. This would reinforce these concepts for myself"* [Female, UG].

Accreditation through Partnership (Industry: Student partnership-union)

The Green Belt Six Sigma Certification course is available to students of NUI Galway who have completed the Lean Systems module. Through this additional one day classroom based programme where content is reviewed and commercial case studies and practical workshops are presented, students are prepared for the Quality America Green Belt online certification examination. The Green Belt Six Sigma Certification course is delivered by a certified Six Sigma Black Belt tutor having extensive practitioner experience. Industry certification of student competency is a tangible demonstration of the relevancy of the Lean Systems module content from an industry perspective and an assurance of competency and employability skills [19].

P-PAC Outcomes: Student Employability Skills

Through the use of the P-PAC framework, students completing the Lean Systems module are provided with opportunities to develop competences in: applying VSM techniques on real life engineering management problems; critically analysing systems and generating solutions; creating current state maps and designing future state maps through deep analysis of data whilst taking cognisance of creating a socio-technical focused system to support Lean balancing, lean layouts and action plans; learning how they can contribute to decision making by advising management using Lean problem solving and generating and prioritising alternative solutions for real life operations problems. Essentially, students gain a deeper understanding of the connections between the curriculum, research and real world, thereby equipping them with the work-ready skills required for Lean Systems practitioners. Through the tri-partite partnership approach underpinning the P-PAC framework, students are presented with opportunities to develop and "deploy a range of personal, performative and organisational abilities" [13]. They are also exposed to competences which have a direct transferability to the marketplace.

The top two hard skills developed during the Lean Systems module (as reported by the respondents) were VSM and Takt Time calculations whilst Teamwork and Communication skills were the top two soft skills. There was no significant difference between UG and PG responses. Other soft skills which were developed as part of the module included; presentation, leadership, problem solving, critical analyses, public speaking, listening, organisational, research and risk management skills.

Conclusions

The Partnership in Pedagogy, Academia and Collaboration (P-PAC) framework is a tri-partite partnership among students, academia and industry, with the aim of presenting students with opportunities to develop and/or fine-tune work-ready hard and soft skills. Using a 5 ECTS Lean Systems module as the case study, 56 undergraduate and postgraduate students were surveyed regarding the effectiveness of the P-PAC framework. The results showed that the application of this framework positively impacted on HEI opportunities to develop graduate attributes for employability. Teamwork and communication skills were identified by the students as the top soft skills fostered by the application of this framework. Interestingly, the results also showed that proportionately more PG respondents found both the industry speakers and the Lean Systems workshop more relevant and impactful to their learning of Lean Systems content compared to their UG counterparts. This will be investigated further by the authors in a longitudinal study over the next five years.

The authors have also extended the theory of Threshold Concepts, to encompass Threshold Concepts-major and Threshold-Concepts-minor; with the latter being identified by the students as the intermediate concepts with which they struggle in order to achieve mastery of the Threshold Concepts-major, as identified by the academic.

In conclusion, whilst the "the advancing world of work is both more exciting and less secure" (p. 7) [1] than ever before, the authors contend that the success of education lies in the application of frameworks such as P-PAC to scaffold the student-academia-industry partnership in order to 'best' prepare and equip students with both the hard and soft skills for employability.

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