Developing employability in engineering education: a systematic review of the literature

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Developing employability in engineering education: a systematic review of the literature

In this systematic review of the research literature on engineering employability, curricular and pedagogical arrangements that prepare graduates for work in the 21st century were identified. The research question guiding the review was: Which curricular and pedagogical arrangements promote engineering students' employability? The particular focus of the study was on how authors prioritised engineering knowledge and professional skills. The review drew on a theoretical framework that differentiated between engineering knowledge and professional skills to explain how employability could be included in engineering programmes. Data was obtained from research studies over the period 2007-2017. We found an interdependent relationship between engineering knowledge and professional skills that enabled engineering graduates to attain employability. The complexity of engineering problems require students to master engineering knowledge, while the ability to work with others across contexts requires professional skills. Both are necessary for deep understanding of engineering principles and a focus on real world problems.

Keywords: engineering employability; professional skills; soft skills; professional competence

Introduction: engineers for the 21st century

Recent studies and reports provide compelling reasons why undergraduate engineering education is in need of change if graduates are to develop the capacities for responding to the complex challenges of the 21st century (e.g., Graham 2012). Of particular concern is the readiness of engineering graduates to do engineering work in times of global economic competitiveness (World Economic Forum (WEF) 2016). There is a recognised shortage of engineers worldwide, in both developing (WEF 2017) and in developed nations (WEF 2016), as well as concerns about the lack of gender and racial diversity in the engineering professions, and the high attrition rate in many engineering programmes. There are thus mounting pressures on engineering curricula and teaching practices to change, but there is confusion about what should change and how change should be implemented. Systematic reviews of the literature offer a useful way of basing practices for curricular and pedagogic change on evidenced successful practice. Synthesizing research findings can potentially lead 'to improved theoretical foundations, better inform[ed] practice, and identifying important new research directions' (Borrego, Foster, and Froyd 2014, 213).

A number of reviews of employability have been published, but many are generic and do not have a specific engineering focus. In 2006, however, a review of the literature on engineering graduates' employability was published in the *European Journal of Engineering Education.* The review recommended the identification of 'core graduate skills for employability' applicable to all graduates, irrespective of their discipline', but warned that 'enhancing employability requires a holistic approach integrating knowledge, work experience and technical and interactive skills development' (Markes 2006, 648). Markes' study concentrated on 'skill gaps in engineering and manufacturing in the UK and London/Thames Gateway … with the intention of determining whether and how these relate to the employability skills listed by various organisations' (2006, 638). Markes did not claim to have conducted a systematic review of the research literature, her review was limited to 23 UK studies and combined research studies with non-research texts, such as reports produced by universities, employer and other agencies (see Table 1, 639-642). Markes' study identified similarities and differences across the skills lists extracted from the studies and reports that she reviewed; she does not address the curricular or pedagogical arrangements that might facilitate the development of student employability. Markes concluded that 'there is an increased need for a common terminology used in employer-led/[Further Education] and [Higher Education]-led surveys to articulate engineering/ graduate/employability skills in detail' (2006, 647). Our paper extends the scope of this work globally through a systematic review of the international research literature over the period 2007 – 2017. Our focus is on how engineering educators addressed the reported gap between higher education provision and the levels of performance expected of graduate engineers by employers through curricular and pedagogical arrangements. The paper offers a theorised approach to Markes' identification of the need 'to articulate engineering/ graduate/employability skills in detail'. While many of Markes' findings remain valid, the time period that separates her study from the current study saw increasing pressures on graduate employability, a growth in the diversity of student populations in engineering disciplines globally, coupled with concerns about the high attrition of rates of engineering students (WEF 2016; WEF 2017).

The research question guiding the study is: Which curricular and pedagogical arrangements promote engineering students' employability? – with a particular focus on how these arrangements vary, based on authors' prioritisation of engineering knowledge and professional skills. Applying a theoretical framework based on the interrelationship between scientific knowledge and social practices (Maton 2014), the review extracts principled recommendations from the research literature on curricular and pedagogical change and their implications for practice. Ultimately, these recommendations speak to issues of what it means to be an engineer in the 21st century, and how engineering educators might better prepare engineers of the future.

Theoretical framework

Many of the studies reviewed confirm the importance of Mathematics, Physics and the engineering sciences as the basis of engineering practice, but equally, point out that key professional skills, such as communication, team-work, project management, and professional ethics – as well as broader environmental and societal issues – have been neglected in engineering programmes (e.g., Ramadi, Ramadi, and Nasr 2015). None of the studies surveyed dispute that the basic and engineering sciences form the epistemological core of the engineering curriculum, nor that professional skills are necessary; what is under dispute is how much engineering science is required, how it is taught and learned, and how professional skills, particularly non-technical skills, might be built onto, or integrated into, the engineering knowledge base.

The building of non-technical professional skills on a technical base, and the relationships between these different forms of knowledge are complex issues. In order to understand the ways in which employability can be founded on engineering disciplinary knowledge, we draw on a social realist framework that distinguishes between disciplines that have stronger or weaker epistemic relations to scientific knowledge and those that have strong or weaker social relations to knowledge in the arts, humanities and social sciences (Maton 2014). Many educational studies draw on social constructivist theory which explains the importance of students' active engagement in the learning process, and which has been very influential in university pedagogy. However, the strong emphasis that constructivist theories place on the student and the nature of the learning, means that the complexity of the concepts and topics to be learned in the engineering disciplines are underestimated (Shumba, Ndofirepi and Gwirayi. 2012). Social realism studies the 'organising principles of (or relations within) different forms of knowledge, their modes of change, and their implications for such issues as such social inclusion, student achievement and knowledge building' (Maton 2014, 10). For this reason social realism was selected as an appropriate approach for understanding employability in engineering. We draw on the dimension of 'Specialization', which is based on the premise that 'practices and beliefs are about or oriented towards something and by someone' (Maton 2014, 29). Specialised knowledge thus involves 'relations to subjects and relations to objects' (Maton 2014, 29). These relations can be represented on a Cartesian plane in which the x-axis represents the social relations, in this case, the professional skills, and the y-axis represents the objective (epistemic relations) to engineering knowledge, as in Figure 1.

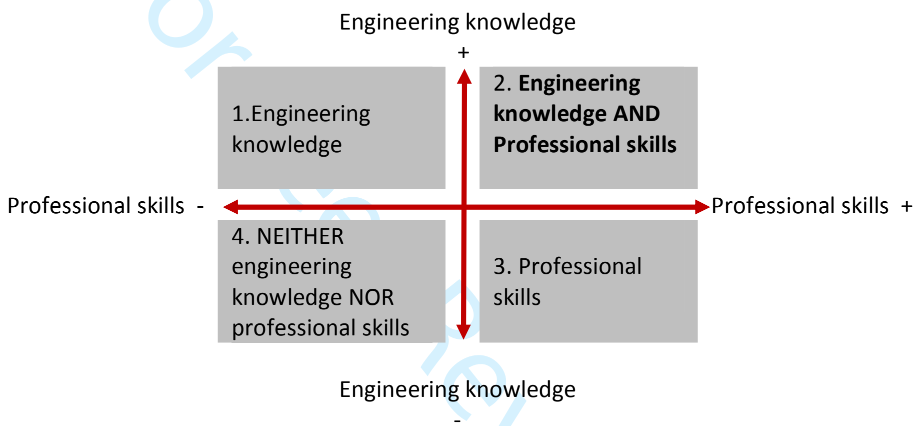

Figure 1: A theoretical framework for studying employability in engineering (adapted from Maton 2014)

Traditionally, engineering curricula have been dominated by a concern for scientific content (White and Davis 2009), but external pressures are driving engineering programmes towards greater societal relevance (Ramadi *et al*. 2015; WEF 2016). Engineering science and professional skills are not mutually exclusive; on the contrary, it is desirable for professional programmes to include both (Case and Marshall 2016; Graham 2012). The issue is how to appropriately integrate engineering concepts and professional skills across programmes, particularly those that have a strong scientific core.

The key issue is the relative transferability of non-technical skills into the specialised knowledge of engineering disciplines and fields. Understanding the nature of the disciplinary core of an engineering programme is essential when trying to extend engineering knowledge with elements taken from another field, such as Communication, Management, or Ethics (White and Irons 2009). Understanding the disciplinary base of employability (usually grounded in humanities or social sciences) is equally important (Clement and Murugavel 2015). When professional competence has to do with environmental impact, water security, or issues more aligned with engineering problem-solving or design, the transfer between engineering knowledge and professional skills is less challenging (Case and Marshall 2016). Difficulties are exacerbated when there are pronounced disciplinary differences between the 'hard applied' engineering core and the 'soft applied' new fields (Stevens and Norman 2016). Understanding these differences and similarities is key to integrating employability into engineering curricula.

Methodology of the systematic review

In this section we briefly explain the approach to the systematic review, the search strategy, the criteria applied, as well as how the studies retrieved were analysed. Systematic reviews are 'intended to critically appraise and synthesize research to inform policy and practice' (Borrego *et al*. 2013, 212). Systematic reviews generally include four methods: 1) systematic searching to retrieve relevant studies, 2) systematically applying criteria to code the studies for inclusion or exclusion, 3) an evaluation of the quality of the studies, and 4) an analysis of the results of the review (Borrego *et al*. 2013, 213).

The first step in a systematic review is to conduct a systematic search. This involved the identification of search terms. Studies and reports on education for employability in engineering use a variety of key words, such as 'employability skills' (Barte and Yeap 2011), 'professional skills' (Case and Marshall 2016), 'soft skills'

(Stevens and Norman 2016), ‘professional competence’ (Lappalainen 2013), and ‘professional capabilities’ (Boni, Sastre, and Calabuig 2015), as well as specific skills, such as ‘communication skills’ (Clement and Murugavel 2015), ‘team work’ (Liu 2015), or ‘project management’ (Clark 2008). Initial searches were done, and the search terms were refined to those shown in Table 1. The reason why specific skills such as ‘communication’ were not used as search terms was because they yielded studies on how to teach communication, rather than how to integrate employability issues into engineering communication courses. Searching for specific skills also biased the searches towards those skills, rather than enabling the search to harvest a wide variety of professional skills. Nine academic databases were searched and cross-checked by searching for the keywords within journals, academic books, and published conference proceedings. We also searched engineering education journals that were not linked to academic databases. Table 1 is a schematic representation of the search strategy. The application of the search strategy resulted in an initial database of 149 articles, book chapters, and conference proceedings.

The second part of the review involved systematically applying inclusion and exclusion criteria. All items in the database were read for their relevance to the research question, that is, whether they firstly addressed employability in engineering education, and secondly, whether they addressed curricular and/or pedagogical arrangements. Those articles that did not address these issues were deemed to be not relevant to the topic and excluded from the study. The research studies selected for inclusion in the database thus share a similar research focus, which is, broadly, the inclusion of skills related to employability in engineering education programmes in order to better prepare engineering graduates for engineering work.

Table 1. The search strategy

SEARCH TERMS	DATABASES SEARCHED	CROSS-CHECKED	Studies yielded in the initial search	Studies included following relevance exclusions	Studies included following relevance exclusions
"Engineering Education" AND ("industry needs" OR sustainability OR context) AND (Employability OR "Employability skills" OR "Soft skills" OR "Professional skills" OR "Professional competences" OR "Professional capabilities" needs" OR "work-readiness")	ACM Digital Library	*ACM Transactions on Computing Education*	11	8	5
	Elsevier	*Education for Chemical Engineers*	18	12	10
	Emerald	*Engineering, Construction and Architectural Management*	5	2	2
	IEEE Xplore	*IEEE Transactions on Education*	5	2	2
	SABINET	*South African Journal of Chemical Engineering*	0	0	0
	SCOPUS	*Journal of Engineering Education*	21	20	8
	Springer	*International Journal of Technology and Design Education*	13	11	9
	Taylor and Francis	*European journal of engineering education*	45	25	16
	Wiley	*Computer Applications in Engineering Education*	10	5	3
JOURNALS NOT LINKED TO DATABASES (ALSO SEARCHED)					
Search terms as above	-	*Australasian Journal of Engineering Education*	5	2	1
	-	*International Journal of Engineering Pedagogy*	5	4	1
	-	*Journal of Technology and Design Education*	11	5	3
		TOTALS	**149**	**96**	**60**

The third part of the review required an appraisal of the quality of the studies. All studies had been found through systematic searches using reputable academic data bases, which ensured the basic quality of the articles. However, additional articles were excluded because they were opinion pieces rather than research studies, or because they were work-in-progress conference papers, or very short papers (i.e., shorter than 2 pages). We excluded studies that did not have a clearly explained research methods section. We also excluded studies prior to 2007 because much of this literature had been addressed by Markes (2006), resulting in a final database of 60 studies. The data base for this systematic review can be viewed at: https://sites.google.com/site/stempedagogy/critical-review-1/home/systematic-review

The fourth step in conducting a systematic review, is an analysis of the results of the review. The research studies covered a wide variety of research sites: eleven studies were UK- and US-based, Australia had ten studies, five studies were from India, and China and Malaysia had three studies each. There were two studies from each of the following countries: Chile, Fiji, Germany and Spain, and one each from: Botswana, Finland, Ireland, Lebanon, Norway, Portugal, Romania, Sweden and South Africa. A variety of research designs and methods were used across the studies. Most of the studies (26) were evaluation studies in which a curricular or pedagogical intervention intended to promote employability was assessed (e.g., Akpan 2016). There were five case studies (e.g., Boni et al. 2015) that were similar to the evaluation studies but had a broader scope. There were four interview-based studies (e.g., Case and Marshall 2016), 14 surveys (e.g., Stevens and Norman 2016), and five mixed method studies combining surveys and interviews (e.g., Jollands, Jolly, and Molyneaux 2012). Two studies were observation-based (e.g., Bingham, Southee, and Page 2015). Three of the research articles studied curricular documents with a view to understanding programme affordances for the inclusion of professional skills (e.g., Toral, Martínez-Torres, Barrero, Gallardo, and Durán 2007), and there was one action research project. Data collection methods included questionnaires (Stevens and Norman 2016), individual interviews (Case and Marshall 2016), focus group interviews (Boni et al. 2015), analyses of student assignments (Guzzomi, Male, and Miller 2017), gap analyses

(Ramadi et al. 2015), analyses of job advertisements (Stevens and Norman 2016), and concept mapping (Toral et al. 2007).

All articles selected had a focus on curricular and pedagogical arrangements in support of students' employability. The research studies were analysed in Step 4 with a view to identifying different categories of curricular and pedagogical arrangements, such as whether the study reported predominantly on the importance of engineering knowledge as a basis for introducing professional skills into an engineering programme, whether the study focussed predominately on specifying the professional skills themselves (without overdue concern about how to integrate these with the disciplinary content of the programme), or whether the study tended towards achieving a balance between both specifying the professional skills and explaining how to integrate these professional skills with engineering knowledge. Two external consultants were appointed to check the data-base for accuracy in assigning the studies to categories that foregrounded engineering knowledge, professional skills, or both. The results of this analysis are presented in the next section.

Results of the systematic review: towards employability in engineering education

The findings of the systematic review are clustered into three categories: 1) findings that foreground the disciplinary core of engineering sciences, 2) findings that foreground professional skills, and 3) findings that integrate the disciplinary core of engineering sciences with professional skills. Several of the studies contain recommendations and implications for supporting curricular and pedagogical change in order to promote employability, and these suggestion are included at the end of each category.

'Knowledge matters': foregrounding the disciplinary core (n =14/60)

The first category of articles (~25%) argues that engineering knowledge matters and that 'a strong technical knowledge base' (Bingham *et al.* 2015, 410) is key to employability and necessary for the development of professional skills. These studies explain that the disciplinary core is highly relevant to employability and should not be neglected because engineering students who lack confidence in the core engineering disciplines would be unlikely to develop competence in engineering communication, management or professional ethics. None of the studies in this category implied that employability was unimportant, or that professional skills should not be included in an engineering curriculum; on the contrary, employability was seen as a critical part of an engineering education.

The studies that foregrounded the engineering sciences in employability attempted to address the challenges of integrating professional skills, especially those that have their basis in social science disciplines, into engineering curricula. Several authors pointed out that not all 'employability skills' are of the same order (e.g., Bruegge, Krusche and Alperowitz 2015). Where professional skills involved industry simulation (D'Souza and Rodrigues 2015) or using new engineering tools (Sedelmaier and Landes 2015) these were understood as central to engineering work, and were easier to integrate into engineering programmes. When employability concerns were not seen as obviously relevant to engineering work, and predominantly derived from the humanities or social sciences, such as Communication or Ethics, this posed a challenge to engineering educators (White and Irons 2009). Some authors therefore proposed that concepts derived from engineering research and professional practice were better suited for introducing employability into engineering education. For example, most engineering disciplines have their own ways of describing relevant professional skills, such as 'process planning' in software engineering (Sedelmaier and Landes 2015).

Similarly, the 'project' has become the way in which engineering organisations do their work; skills in engineering project management are increasingly sought after and developing such skills are generally accepted as relevant across engineering disciplines (Clark 2008). The discourse of 'entrepreneurial skills' is also compatible with engineering concepts, particularly if these are designed and implemented within a 'Conceive Design Implement Operate' (CDIO) or similar framework (de Magalhães, Estima, and Almada-Lobo 2007).

Some of the studies that foregrounded engineering knowledge focussed on curricular issues. While several studies found that problem-based learning (PBL) supported students' employability, a comparative study of traditional and PBL courses across programmes, found that although the PBL cohorts developed more team work skills, both cohorts needed to draw on core engineering concepts and processes to solve problems (Jollands *et al*. 2012). Thus, a comprehensive understanding of engineering principles is fundamental to tackling problems and successfully completing projects. A difficulty for curriculum developers has been how and when to include professional skills. To address the integration of professional skills into an engineering curriculum, Toral and colleagues (2007) proposed concept-mapping techniques that extracted and organised relevant information from engineering and career experts. This process, they argued, was helpful in determining compatibility between the engineering core and related employability issues. Professional skills can then be organised 'according to their affinity' with topics or areas in an engineering curriculum. One study highlighted the importance of the disciplinary base of professional skills, with a particular focus on English for Specific Purposes, and the importance of employing specialists to teach engineering communication in order to address the gap between classroom teaching practices and industry expectations (Clement and Murugavel 2015).

Several studies that foregrounded engineering knowledge addressed issues of pedagogy. Bingham and colleagues (2015) explained that there were often pedagogical discontinuities across engineering programmes. For example, design pedagogy in engineering is supervision-based and is offered 'almost exclusively through applied learning using PBL activities', while traditional engineering science pedagogy is typified by a 'more traditional lecture-based approach' (Bingham *et al.* 2015, 430). There is thus a disjuncture between how academics and students tackle design projects and how the engineering sciences are usually taught. The researchers found that pedagogy (rather than curriculum content) was key to constructing professional skills on an engineering disciplinary base, and suggest that problem-solving and design pedagogies should be used in teaching the basic and engineering sciences due to the potential of these approaches both for the transference of scientific concepts to the design process and wider employability issues (Bingham *et al*. 2015). Sedelmaier and Landes (2015) similarly showed that professional skills could be developed through teaching and assessment tasks that encouraged professional skills development alongside engineering content. Taking this idea even further, Guzzomi and colleagues found that including industry standards in the assessment rubric for technical project reports improved their disciplinary content, as a '50% good enough' pass mark would not be acceptable in industry (Guzzomi *et al.* 2017, 219).

The assumption underpinning the studies that foreground the engineering sciences for employability is that students need to accumulate scientific engineering knowledge in the first place, for without this they could not be expected to develop the professional skills needed to work effectively in complex engineering contexts (Bruegge *et al*. 2015). This group of studies thus recommended that the building of expertise, and the learning processes that supported engineering knowledge, required that engineering curricula and pedagogies encompass a wide set of learning experiences to allow students to both construct conceptual knowledge in the scientific engineering disciplines, and to develop key technical and professional skills through their engagement in a number of authentic engineering projects. Engineering curricula and teaching methods are often not well aligned with these goals. Curriculum and pedagogical change should therefore focus on improving the alignment across theoretical and practical course components (Litzinger, Lattuca, Hadgraft, and Newstetter 2011). Additional recommendations arising from this group of studies centre on the need for professional development for engineering educators (Bingham *et al.* 2015), post-training follow-up and the establishment of support networks (e.g. De Magalhães *et al.* 2007) and well as the building of sustainable collaborations with industry and other partners (Brugge *et al.* 2015). Preparing students for curricular and pedagogical change should not be neglected (D'Souza and Rodrigues 2015).

'Engineering in a social context': Foregrounding professional skills (n=31/60)

Approximately 50% of the studies foregrounded generic professional skills. In other words, these studies, although identified as being in the field of engineering education, did not particularly take into account the disciplinary base of engineering. Engineering thus tended to be circumstantial as the focus was on the acquisition of general professional skills. The findings emerging from these studies broadly addressed issues around: 1) the identification of relevant professional skills; 2) best practices for 'stand-alone' skills development courses, 3) experiential learning, 4) community engagement, and 5) the practicum.

Key professional skills have been identified in a number of government agency and professional council reports internationally. The UK Quality Assurance Agency (QAA), for example, requires that engineering graduates should be professional in their outlook, be capable of team-work, be effective communicators and be able to exercise responsibility and sound management approaches (QAA 2015). The Engineering UK report highlights 'technical and transferable skills, at the right levels, to satisfy the demands of current employers' (Graham 2012). The US Accreditation Board for Engineering and Technology (ABET) lists six professional skills: multidisciplinary teamwork, professional and ethical responsibility, effective communication, understanding the impact of engineering solutions in global economic, environmental, and societal contexts, a knowledge of contemporary issues and an ability to use modern engineering tools (ABET 2016). Engineers Australia defines six professional skills: ethical conduct and accountability, effective oral and written communication in professional and lay domains, creative, innovative and pro-active demeanour, information management, professional conduct and effective team membership and team leadership (Engineers Australia 2013). Of its eleven required outcomes, the Engineering Council of South Africa (ECSA) lists six professional skills: effective communication, understanding social and environmental impact, management skills, life-long learning, professional ethics and work experience (ECSA 2015).

The research studies included in the data-base went into considerable depth with regard to defining 'engineering graduate attributes' (Nair, Patil, and Mertova 2009) and 'engineering employability skills' (Saad and Majid 2014). Some studies clustered groups of 'soft skills' (e.g., Stevens and Norman 2016), while others developed frameworks for understanding relationships between different kinds of professional skills, such as Lappalainen's (2013) 'Social competence model' that linked 'assertion, emotive availability, inspiration and emotional regulation'. Some studies focussed more narrowly on a particular skill, such as collaborative team work (Chan and Sher 2014). In one case study, the development of professional skills was proposed as a measure to address difficult student behaviours, such as ‘bad social etiquette, demand[ing] too much pay, …[being] too choosy’ (Barte and Yeap 2011, 771). Psychological barriers, including negative perceptions of professional skills, were difficult to address and required time, dialogue and measurable outcomes. Researchers pointed out the ‘unrealistically high expectations’ (e.g., Perera, Babatunde, Zhou, Pearson, and Ekundayo 2017, 2319) of some skills development programmes and proposed re-focussing on more realistic employability attributes, such as ‘management of time, possessing a high level of technical skills, meeting deadlines and creating viable solutions for solving a problem’ (Ssegawa and Kasule 2017, 529). Such skills were more likely to be acquired in integrated approaches to skills development, such as problem-based approaches in mainstream subjects, than in stand-alone courses or workshops. Through problem-orientation, students acquired the additional skills, often social or political skills, necessary to implement solutions. Students gained general knowledge and skills from work on their specific projects that would be transferable to other areas, and found out about the value of learning from others. One fairly radical solution to meeting the needs of industry was proposed in the form of ‘experience-led’ engineering education that handed over much of the training of students to industry, via industry input into the curriculum, lectures by industry experts, student placements in industry and assessment by industry-panels (Arlett, Lamb, Dales, Willis, and Hurdle 2010).

A variety of academic subjects, short courses and workshops covering a range of professional skills were described, and some were evaluated. Many courses involved training on new technologies. Stevens and Norman (2016) claimed that academics typically responded to employability challenges ‘as calls to teach currently fashionable technologies’ (Stevens and Norman 2016, 210). Their study found that employers were generally satisfied that graduates' technical skills were adequate for further development through in-house technical training. Professional skills, however, contributed significantly to individual dispositions, team performance, client relations and awareness of the business context. Some studies considered interpersonal skills to be untrainable in work contexts, making students' acquisition of these skills prior to seeking work a critical factor for employability (e.g., Baytiyeh and Naja 2012). Consequently, industry tended to recruit graduates with existing professional skills, particularly in team-work, rapid learning of new technical skills, and customer empathy. Classroom-based activities that simulated workplace activities, such as group discussion, seminars, presentations, and role-play helped students acquire the kind of professional skills that would enable them to find placements in the corporate world (e.g., Bass, McDermott, and Lalchandani 2015; Goggins 2012). Portfolios, reflective logs and blogs were similarly found to be helpful in the development of skills in communication, action-planning and self-awareness (Marques 2016). Studies found that courses that developed entrepreneurial skills for engineers were more effective close to graduation (King and Newman 2009) or post-graduation (Hazelton, Malone, and Gardner 2009). When such courses were offered online, students needed to develop skills in creating rapport with remote work colleagues, managing delays caused by working across sites, and cultural awareness in international collaborations (King and Newman 2009). Such skills interventions helped students to recognise the role of technology in facilitating group cohesion beyond engineering applications (Bass *et al.* 2015).

A number of studies focussed on the role of experiential learning both in the classroom (e.g., Banky and Blicblau 2015) and in workplaces (e.g., Hazelton *et al.* 2009). These studies emphasised practical, hands-on experience, and the integration of 'analytical and design skills acquired in companion senior-level core courses' (Shet, Iyer, Nissimgoudar, and Ajit 2015, 479). A number of studies pointed to the strong links between students participating in service-learning activities and acquiring the abilities to navigate the complexities of workplaces (Huff, Zoltowski, and Oakes 2016; Goggins 2012). One study recommended the efficacy of a 'consulting practicum' as a pedagogical strategy for developing work-ready graduates (Akpan 2016).

Although similar themes on the importance of professional skills for engineering graduates appeared in the studies, there was considerable variety across types of professional skills – thus the need for careful selection and prioritization. Many studies that foregrounded professional skills did not acknowledge the role that engineering knowledge played in the transferability of skills. Clearly a narrow focus on the skills and values related to employability would not be adequate to prepare students for the challenge of delivering sustainable and appropriate engineering solutions.

Several studies pointed out that students also needed to be prepared for curricular or pedagogical change in undergraduate engineering, particularly with regard to team-work, peer assessment, and the management of industry-based projects, including the technical skills for virtual projects (Bass *et al.* 2015; Ssegawa and Kasule 2017). Student portfolios were seen as an effective way for students to keep track of their own knowledge and skills development (Singh, Sharma, Jokhan, and Lindley 2013).

Any change in curricula or pedagogy will require staff development and support; this is particularly the case when introducing or integrating professional skills into existing programmes. The studies point out the importance of ensuring that the professional skills developed are up-to-date and needed by industry. One study, for example, reported that many engineering academics had no professional contacts outside academia (Magnell, Geschwind, and Kolmos 2016); this posed considerable challenges as the engineering educators were expected to be role-models when facilitating classroom activities towards the development of employability skills. Not surprisingly, the more radical the change, the more difficult to bring staff along with it (Arlett *et al.* 2010).

'Hard skills in a soft context': negotiating engineering knowledge and professional skills (n = 16/60)

The third category of studies in the database (~25%) tried to find balance between engineering knowledge and professional skills in engineering curricula and pedagogies. 'the "content" constitutes individuals' inputs, which originate from disciplinary knowledge, skills and expertise, whereas managing the relationship requires a set of "soft" people management skills' (Soetanto, Childs, Poh, and Glass 2017, 101). Topics in this group included: 1) the interdisciplinary nature of professional engineering skills, 2) frameworks for achieving both engineering knowledge and professional skills across programmes, and 3) evaluating the results of programmes that embedded professional skills in mainstream engineering subjects.

A number of studies showed that there were both disciplinary and dispositional barriers to understanding engineering as a socio-technical field (Zareba, Schuh, and Camelio 2013). Studies found disciplinary difficulties in connecting concepts in the social sciences to specialised fields of technical expertise (Liu 2015); but studies also found that many engineering academics undervalued the contributions of multiple fields to complex problem-solving (Richter and Paretti 2009). The challenge was thus to bridge the gap between the needs of students and requirements of potential employers, whilst maintaining disciplinary integrity.

Acknowledging that the linkages between employability enhancement and disciplinary learning is problematic for many academics, several studies address this issue through the development of frameworks that integrate engineering science with professional skills development. One example is a framework that had the intention to develop 'interdisciplinary, industry-relevant professionals who utilise intuitive creativity with sound engineering design methods; responsible and reflective engineering designers with a strong understanding of social context, user and environment' (De Vere, Melles, and Kapoor 2010, 41). In another example, industry-sponsored projects became a central course component, from which engineering students' problem-solving and employability could be developed (Coll 2015). Industry is central to engineering employability and therefore a key driver in engineering education was seen to be the opportunities provided by industry and the range of activities that this includes (Hawse 2017).

Several programme evaluations reported on the successful graduation of highly employable students who had participated in community engagement projects (Huff *et al.* 2016), but also commented on the improved learning experiences that programmes that balanced engineering knowledge with professional skills offered to students, addressing, for example, their feelings of academic alienation and helping students 'to perceive the university not solely as a professionalising space, but rather as a space for integral growth, as a whole person' (Boni *et al.* 2015). Being able to use their engineering knowledge to help communities increased students' sense of ownership of their own learning (Coll 2017), while engaging in a business simulation assignment was motivating to students (De Vere *et al.* 2015).

The studies in this category confirmed that engineering education in all its forms should take a 'perspective on graduateness that recognises the significance of disciplinary knowledge but that also holds a space for the development of student agency in higher education' (Case and Marshall 2016, 832). Thus, a defining characteristic of an engineering degree is that it teaches the student to apply a range of engineering sciences to the solution of technical problems. However, these problems are embedded in a 'soft context'. The underlying assumption is that students had to use the engineering knowledge learned and professional skills acquired throughout their studies to solve problems and design solutions; students could not be expected to achieve this without such accumulated knowledge (Case and Marshall 2016). These studies thus emphasise the 'continuity of learning experiences' (Hawse 2017, 246) where there is clearly thought through integration of engineering knowledge and professional skills.

Several studies highlight issues around managing change in engineering departments needed to balance engineering knowledge and professional skills, in particular the adequate preparation and support of students, academics and industry partners. The main points made by these scholars include: 1) the need for faculty development and on-going support, 2) the need to prepare students for change, and 3) the logistic demands that change makes on engineering departments.

Some studies reported on the tensions between 'the pro-public-good oriented perspectives' of engineering and the 'more instrumental vision' of employability programmes (Boni *et al.* 2015). The purpose of and vision for integrating professional skills into programmes thus needs to be negotiated by the engineering department or faculty. The studies recommend ongoing consulting, mentoring, partnerships, and the building of learning communities that support one another (Coll 2015; Hawse 2017; Richter and Paretti 2009). These networks were intended to develop and discuss learning and teaching within an engineering integrated curriculum. Close cooperation between academia and industry for the production of courseware naturally requires significant time, effort and resources (De Vere *et al.* 2010.). Several studies highlighted the logistics of coordinating timetables for interdisciplinary work (Richter and Paretti 2009), the difficulties of managing international collaborations (Boni *et al.* 2015), and the need for better collaboration between engineering schools and engineering firms (De Vere *et al.* 2010).

Summary of the findings

Key curricular and pedagogical arrangements for employability development in engineering education are summarised in Table 2. These provisions could be understood as a comprising many overlapping areas, rather than as strictly separate educational areas or a linear sequence. The literature suggests that variety in educational provision is useful for employability development, and that employability starts with the basic and engineering sciences and the pedagogies used to support student learning, rather than 'add on' components to a curriculum. The table is framed with the key concepts of engineering scientific knowledge and engineering professional skills, and their various combinations, explaining firstly the purpose intended for introducing different professional skills at different levels of an engineering programme, and then expanding on the curricular and pedagogical arrangements that are appropriate for both subject content and skills development. Ways of assessing students' knowledge and skills are also suggested. The priority areas for faculty development are indicated and an example text is included.

Table 2: Curricular and pedagogical arrangements that promote employability

	Foregrounding engineering scientific knowledge		**Balancing engineering knowledge and professional skills**		**Foregrounding professional skills**
Purpose	To learn disciplinary content in more applied ways (that prepare for employability)	To solve contextually simplified engineering problems and design engineering solutions	To solve real-world engineering problems and design engineering solutions in a professional context	To develop basic professional skills	To develop complex professional skills
Main curricular arrangements	Problem-based learning	Design supervision	Integrated across the engineering curriculum	Short courses, workshops, Skills lab	Practicum (actual or simulated)
Signature pedagogy (teaching)	Facilitation of concept development	Project-based learning	Interdisciplinary co-teaching	Training (hands-on)	Work supervision
Signature pedagogy (learning)	Peer-learning	Team-work	Inter-professional learning	Practice	Work-based learning
Main assessment focus	Assignments, case studies (problem-based tests)	Demonstration (critique and feedback)	Assignments (clear assessment criteria for professional skills)	Practical skills tests (formative feedback)	Logbook, portfolio, blog (review/ debriefing)
Managing and supporting the change	Theory and facilitation of problem-oriented learning; concept mapping for curricular alignment.	Supervision training, facilitating team-work	Interdisciplinary collaboration. Advanced employability involves complex practices acquired over time) and are best taught/co-taught in an integrated way (i.e., integrated with a mainstream engineering subject or project).	External provision (whether for generic such as developing a CV or specific training on a new technology); basic personal, inter-personal and technical skills are appropriate as a short 'stand-alone' course. Some courses might be appropriate post-qualification.	Transdisciplinary collaboration; building industry networks and co-supervision or co-assessment with industry partners.
Example (from the reviewed literature)	Bingham, Darren, and Page 2015.	Jollands, Jolly, and Molyneaux 2012.	Hawse 2017.	Hazelton, Malone, and Gardner 2009.	Kulkari and Chachadi 2014.

Conclusion

The findings from this systematic review of the literature can be understood as occupying positions along two continua of engineering knowledge and professional skills: interventions with stronger or weaker forms of engineering knowledge, and interventions with stronger or weaker forms of professional skills. The first category of findings focussed on the strategy of ensuring a strong disciplinary foundation, while using appropriate pedagogies (such as problem-oriented learning) to build a range of different professional skills across the engineering curriculum. In order to achieve the goal of learning disciplinary content in ways that prepare students for employability, the alignment of disciplinary content and professional skills was found to be of crucial importance. Although foregrounding engineering knowledge, there was a tendency in these studies towards more integrated approaches (shown by the dashed arrow, indicating movement from quadrant 1 to quadrant 3).

The second category of findings focussed on defining and implementing basic as well as more complex professional skills in engineering programmes. Although some stand-alone skills development courses (particularly post-graduation) were found to be effective, stand-alone courses might be misaligned with disciplinary content. The studies indicated a shift towards more integrated skills development (shown by the dashed arrow moving from quadrant 2 towards quadrant 3), for example, developing interpersonal and communication skills through collaborative learning activities and problem-solving approaches across an engineering curriculum.

This leads to the third category of findings in which there was both stronger engineering knowledge and stronger professional skills that were achieved through embedding professional skills in mainstream engineering subjects, such as including problem-solving tasks and projects across the engineering curriculum. What was found to be critical for the successful integration of professional skills in engineering subjects was the use of a variety of approaches in curriculum design, teaching and assessment. Each approach potentially engages students in different ways, enabling them to develop additional skills while learning disciplinary content. If a programme of study has sets of learning outcomes including both technical and professional skills, appropriate curricular, pedagogical and assessment choices should made in alignment with the learning outcomes.

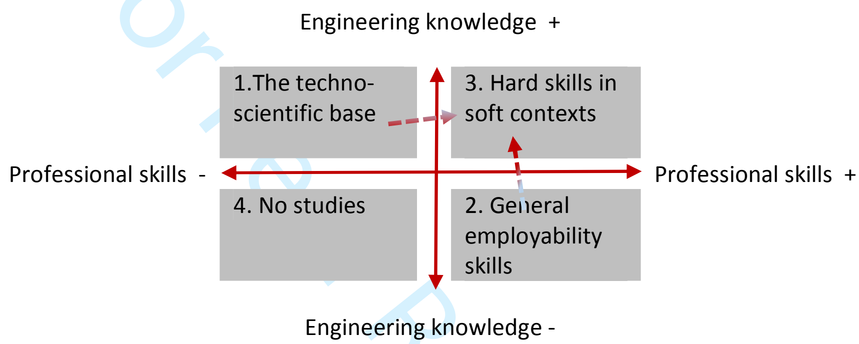

Figure 2: Strategies for developing employability in engineering programmes

The literature supports the need for both engineering knowledge and professional skills across engineering curricula and the use of problem-oriented pedagogies towards improved employability and professional skills. The social realist theoretical framework that was drawn on to frame and critique the literature shows that, in the same way that we do not understand engineering science as generic, we should also not understand professionals skills, such as engineering communication, engineering management or engineering professional ethics, as generic. If employability outcomes are more clearly specified, the professional skills can be more appropriately (and more successfully) integrated with disciplinary content. Graham (2011) notes that one of the key conditions for curriculum reform to be sustainable is a coherent, interconnected curriculum, where a wide pool of academic staff deliver the reformed courses, often through team-teaching. These understandings indicate a preference for problem-based, and related, approaches in attaining graduate employability in engineering.

Engineering programmes need to ensure a strong, competent, growing, sustainable and representative engineering profession, able to provide the expertise necessary for local and global work, and to exert a positive influence in the world. There is still some way to go to achieve this vision. Efforts should therefore be redoubled to improve engineering education, to attract young people into engineering, and to retain, motivate and, most importantly, to improve the employability of those already enrolled in engineering programmes.

Acknowledgement

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References

Akpan, Ikpe Justice. 2016. "The Efficacy of Consulting Practicum in Enhancing Students' Readiness for Professional Career in Management Information Systems: An Empirical Analysis." *Decision Sciences Journal of Innovative Education* 14(4): 412–40.

Arlett, Carol, Fiona Lamb, Richard Dales, Liz Willis, and Emma Hurdle. 2010. "Meeting the Needs of Industry: The Drivers for Change in Engineering Education." *Engineering Education* 5(2): 18–25.

Banky, George Peter, and Aaron Simon Blicblau. 2015. “Apples and Oranges: A Framework to Explore the Practiced Pedagogy in Experiential Learning.” *International Journal of Engineering Pedagogy* 5(3): 67–70.

Barakat, Nael, and Chris Plouff. 2014. “A Model for On-Line Education of ABET-Required Professional Aspects of Engineering.” *Proceedings of the IEEE Global Engineering Education Conference (EDUCON) 2014*: pp. 507–14.

Barte, Gil B., and Gik Hong Yeap. 2011. “Problem-Based Learning Approach in Enhancing Engineering Graduates’ Employability.” *Proceedings of the IEEE Colloquium on Humanities, Science and Engineering (CHUSER) 2011*, pp. 771–75.

Bass, J.M., R. McDermott, and J.T. Lalchandani. 2015. “Virtual Teams and Employability in Global Software Engineering Education.” *Proceedings of the 10th IEEE International Conference on Global Software Engineering (ICGSE) 2015*, pp. 115–24.

Baytiyeh, Hoda, and Mohamad Naja. 2012. “Identifying the Challenging Factors in the Transition from Colleges of Engineering to Employment.” *European Journal of Engineering Education* 37(1): 3–14.

Bingham, Guy A., Darren J. Southee, and Tom Page. 2015. “Meeting the Expectation of Industry: An Integrated Approach for the Teaching of Mechanics and Electronics to Design Students.” *European Journal of Engineering Education* 40(4): 410–31.

Boni, Alejandra, José Javier Sastre, and Carola Calabuig. 2015. “Educating Engineers for the Public Good through International Internships: Evidence from a Case Study at Universitat Politècnica de València.” *Science and Engineering Ethics*, 21: [online] https://link.springer.com/article/10.1007/s11948-015-9728-z

Borrego, Maura, Margaret J. Foster, and Jeffrey E. Froyd. 2014. “Systematic Literature Reviews in Engineering Education and Other Developing Interdisciplinary Fields.” *Journal of Engineering Education* 103(1): 45–76.

Bruegge, Bernd, Stephan Krusche, and Lukas Alperowitz. 2015. “Software Engineering Project Courses with Industrial Clients.” *ACM Transactions on Computing Education* 15(4): 1–31.

Case, Jennifer M., and Delia Marshall. 2016. “Bringing Together Knowledge and Capabilities: A Case Study of Engineering Graduates.” *Higher Education* 71(6): 819–33.

Chan, Caroline T.W. and William Sher. 2014. "Exploring AEC Education through Collaborative Learning." *Engineering, Construction and Architectural Management* 21(5): 532–50.

Clark, R. 2008. "Project Management: The Key to Engineering Employability." In Proceedings of the European Society for Engineering Education (SEFI) *36th Annual Conference, Aalborg, Denmark*, pp. 2–5.

Clement, A., and T. Murugavel. 2015. "English for Employability: A Case Study of the English Language Training Needs Analysis for Engineering Students in India." *English Language Teaching* 8(2): 116 – 125.

Coll, Richard K. 2015. "The Role of Cooperative and Work-Integrated Education in Chemistry Career Clarification." In I. Eilks, I. and A. Hofstein, A. (Eds). *Relevant chemistry education: From theory to practice.* Springer. Rotterdam: Sense Publishers, pp. 301-315.

de Magalhães, Barbedo, António, M. Estima, and B. Almada-Lobo. 2007. "PUKHA: a new pedagogical experience." *European Journal of Engineering Education* 32(6): 711-719.

D'Souza, Manoj Joseph, and Paul Rodrigues. 2015 "Extreme pedagogy: An agile teaching-learning methodology for engineering education." *Indian Journal of Science and Technology* 8 (9): 828 - 833.

De Vere, Ian, Gavin Melles, and Ajay Kapoor. 2010. "Product design engineering–a global education trend in multidisciplinary training for creative product design." *European Journal of Engineering Education,* 35(1): 33-43.

Engineers Australia. 2013. Stage 1 Competency Standard for Professional Engineer. Online [https://www.engineersaustralia.org.au/sites/default/files/resource-files/2017-03/Stage%201%20Competency%20Standards.pdf]

Engineering Council of South Africa (ECSA) 2015. Competency Standard for Registration in a Specified Category. Online [https://www.ecsa.co.za/register/Professional%20Engineers/R_02_SC-Spec_Cat_Stage2Standards.pdf]

Goggins, J. 2012. "Engineering in Communities: Learning by Doing." *Campus-Wide Information Systems* 29(4): 238–50.

Graham, R. 2012. *Achieving Excellence in Engineering Education: The Ingredients of Successful Change*. *The Royal Academy of Engineering*. Vol. 101. http://epc.ac.uk/wp-content/uploads/2012/08/Ruth-Graham.pdf.

Guzzomi, Andrew L., Sally A. Male, and Karol Miller. 2017. “Students’ Responses to Authentic Assessment Designed to Develop Commitment to Performing at Their Best.” *European Journal of Engineering Education* 42(3): 219–40.

Hawse, Sally. 2017. “Transitioning to Professional Work: A View from the Field.” In Leigh N. Wood and Yvonne A. Breyer (Eds.) *Success in Higher Education: Transitions to, within and from University*, Singapore: Springer, pp. 229-253.

Hazelton, Pam, Molly Malone, and Anne Gardner. 2009. “A Multicultural, Multidisciplinary Short Course to Introduce Recently Graduated Engineers to the Global Nature of Professional Practice.” *European Journal of Engineering Education*, 34(3): 281–90.

Huff, James L., Carla B. Zoltowski, and William C. Oakes. “Preparing engineers for the workplace through service learning: Perceptions of EPICS alumni.” *Journal of Engineering Education* 105(1): 43-69.

Jollands, Margaret, Lesley Jolly, and Tom Molyneaux. 2012. “Project-Based Learning as a Contributing Factor to Graduates’ Work Readiness.” *European Journal of Engineering Education* 37(2): 143–54.

King, Melanie, and Richard Newman. 2009. “Evaluating business simulation software: approach, tools and pedagogy.” *On the horizon* 17(4): 368-377.

Lappalainen, Pia. 2013. “Pedagogy Enhancing Engineering Graduates’ Employability” Proceedings of the European Society for Engineering Education (SEFI) 41st Annual Conference, 16-20 September 2013, Leuven, Belgium. https://www.sefi.be/conference/2013

Litzinger, Thomas A, Lisa R Lattuca, Roger G Hadgraft, and Wendy C Newstetter. 2011. “Engineering Education and the Development of Expertise.” *Journal of Engineering Education* 100(1): 123–50.

Liu, Yucheng. 2017. “Renovation of a mechanical engineering senior design class to an industry-tied and team-oriented course.” *European Journal of Engineering Education* 42(6): 800-811.

Magnell, Marie, Lars Geschwind, and Anette Kolmos. 2016. “Faculty Perspectives on the Inclusion of Work-Related Learning in Engineering Curricula.” *European Journal of Engineering Education* 42(6): 1038-1047.

Markes, Imren. 2006. “A Review of Literature on Employability Skill Needs in Engineering.” *European Journal of Engineering Education* 31(6): 637–50.

Marques, Maira Rejane. 2016. “Monitoring: An Intervention to Improve Team Results in Software Engineering Education.” *Proceedings of the 47th ACM Technical Symposium on Computing Science Education* (SIGCSE 16), Memphis, TN. 2–5 March 2016, pp. 724-724.

Maton, Karl. 2014. *Knowledge and Knowers: Towards a realist sociology of education*. Abingdon: Routledge.

Nair, Chenicheri Sid, Arun Patil, and Patricie Mertova. 2009. “Re-engineering graduate skills: a case study.” *European journal of engineering education* 34(2): 131-139.

Perera, Srinath, Solomon Olusola Babatunde, Lei Zhou, John Pearson, and Damilola Ekundayo. 2017 “Competency mapping framework for regulating professionally oriented degree programmes in higher education.” *Studies in Higher Education* 42(12): 2316-2342.

Ramadi, Eric, Serge Ramadi, and Karim Nasr. 2015. “Engineering Graduates’ Skill Sets in the MENA Region: A Gap Analysis of Industry Expectations and Satisfaction.” *European Journal of Engineering Education* 41(1): 34-52.

Richter, David M., and Marie C. Paretti. 2009. "Identifying barriers to and outcomes of interdisciplinarity in the engineering classroom." *European Journal of Engineering Education* 34(1): 29-45.

Saad, Mohd Shamsuri Md, and Izaidin Ab Majid. 2014. “Employers’ perceptions of important employability skills required from Malaysian engineering and information and communication technology (ICT) graduates.” *Global Journal of Engineering Education* 163(3): 110-115.

Sedelmaier, Yvonne, and Dieter Landes. 2015. “A Competence-Oriented Approach to Subject-Matter Didactics for Software Engineering.” *International Journal of Engineering Pedagogy* 5(3): 34–44.

Shet, R. M., Nalini C. Iyer, P. C. Nissimgoudar, and S. Ajit. 2015. “Integrated Experience: Through Project-Based Learning.” In *Proceedings of the International Conference on Transformations in Engineering Education*, New Delhi: Springer, pp. 479-486.

Shumba, Almon, Amasa Philip Ndofirepi, and Pesanayi Gwirayi. 2012. “A Critique of Constructivist Theory in Science Teaching and Learning.” *Journal of Social Sciences* 31(1): 11-18.

Singh, Shaveen, Bibhya Nand Sharma, Anjeela Jokhan, and David Lindley. 2013. “Supporting Sustainable Student Learning at USP through the Use of ePortfolios." *Proceedings of the IEEE Conference on E-Learning, E-Management and E-Services (IC3e)* Kuching, Malaysia 2-4 December 2013, 68–72.

Soetanto, Robby, Mark Childs, Paul SH Poh, and Jacqueline Glass. 2017. "Designed to be employed? Measuring the impact of a multidisciplinary collaborative design project on learner perceptions of employability attributes." In Mark Childs and Robby Soetanto (eds.) *Online Learning for STEM Subjects,* pp. 90-112. London: Routledge.

Ssegawa, Joseph K., and Daniel Kasule. 2017. "A Self-Assessment of the Propensity to Obtain Future Employment: A Case of Final-Year Engineering Students at the University of Botswana." *European Journal of Engineering Education* 42 (5): 513–32.

Stevens, Matt, and Richard Norman. 2016. "Industry Expectations of Soft Skills in IT Graduates: A Regional Survey." In *Proceedings of the Australasian Computer Science Week Multiconference* (ACSW16). Canberra, Australia 2 – 5 February, pp. 13–22.

Toral, S. L., M. R. Martínez-Torres, F. Barrero, S. Gallardo, and M. J. Durán. 2007. "An Electronic Engineering Curriculum Design Based on Concept-Mapping Techniques." *International Journal of Technology and Design Education* 17(3): 341–56.

UK Quality Assurance Agency 2015. Subject Benchmark Statement Engineering. Online [http://www.qaa.ac.uk/en/Publications/Documents/SBS-engineering-15.pdf]

US Accreditation Board for Engineering and Technology 2016. Criteria for Accrediting Engineering Programs, 2016 – 2017 Online [http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2016-2017/]

White, Su, and Hugh C. Davis. 2013. "Motivating Computer Scientists to Engage with Professional Issues: A Technology-Led Approach." In Proceedings of the IEEE Learning and Teaching in Computing and Engineering (LaTiCE) Conference 2013, 21-24 March 2013, Macau, China: 199-203.

White, Su, and Alastair Irons. 2009. "Relating Research and Teaching: Learning From Experiences and Beliefs." *ACM SIGCSE Bulletin*, 41(3): 75-79.

World Economic Forum. 2017. *The Africa Competitiveness Report 2017: Addressing Africa's Demographic Dividend. Geneva: World Economic Forum.* http://www3.weforum.org/docs/WEF_ACR_2017.pdf.

World Economic Forum. 2016. *The Global Competitiveness Report 2016–2017*. https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1

Zareba, Marek, Anna Schuh, and Jaime A. Camelio. 2013 "Accelerated problem solving sessions in university laboratory settings." *Journal of Intelligent Manufacturing* 24(3): 517-526.

SEARCH FIELD	Search Terms		Exclusions Relevance	
Developing employability	Engineering education AND		Elementary school, junior	
Engineering education	Industry Needs OR		Postgraduate education	
	Sustainability OR		Research collaboration	
	Context AND			
	Employability OR			
	Professional skills OR			
	Soft skills		**Exclusions: Quality**	
	Professional competence		Manuals and non-	
			Position papers	
			Policy documents	
			Workshops	
			Very short papers	
			No research methods	

TAGS		
THEME	***TOPICS***	**TAG**
ENGINEERING KNOWLEDGE	CURRICULUM	**EK**
	ASSESSMENT	
	PEDAGOGY	
PROFESSIONAL SKILLS	SKILLS IDENTIFICATION	**PS**
	STAND ALONE' COURSES	
	EXPERIENTIAL LEARNING	
	COMMUNITY ENGAGEMENT	
	PRACTICUM	
INTEGRATING KNOWLEDE	INTERDISCIPLINARITY	**K&S**
AND SKILLS	FRAMEWORKS	
	EVALUATIONS	

Databases/ Search engines	**Cross-checked**		**INITIAL RESULTS**	**RELEVANCE EXCLUSION**		**QUALITY EXCLUSION**
ACM Digital Library	*ACM Transactions on*		11	8		5
IEEE Explore	*IEEE Transactions on*		18	12		10
Elsevier	*Education for Chemical*		5	2		2
Emerald			5	2		2
SABINET	*South African Journal of Higher Education, South*		0	0		0
SCOPUS	*Higher Education*		21	20		8
SPRINGER	*Canadian Journal of*		13	11		9
Taylor & Francis	*Engineering Education: a*		45	25		16
WILEY	*Journal of Engineering*		10	5		3
	Journals not in databases					
	Journal of Technology and		5	2		1
	Australasian Journal of		5	4		1
	International Journal of		11	5		3
TOTALS			149	96		60

Source Types
J= Journal article
B=Book
BC=Book
ConPU= Conference
ConPP= Conference
Rep=Report

ENGINEERING FIELD	THEME	AUTHOR	DATE	TITLE	Categories			ABSTRACT
					K	S	I	
INFORMATION	SKILLS	Akpan	2016	The Efficacy of Consulting Practicum in Enhancing Students' Readinessfor		1		Consulting practicum (CP) is a form of experiential learning technique to preparestudents for professional careers. While CP has become a popular way to help studentsacquire the essential
GENERAL	SKILLS	Arlett et al	2010	Meeting the needs of industry: the drivers for change in engineering education		1		This paper examines the drivers for change behind the development of 'experience-led degrees' that aim to equip students with the employability skills needed by industry. The term 'experience-
INDUSTRIAL	INTEGRATED	Arthur & Marsh	2016	Stop playing it safe: The importance of taking risks in design education			1	The education and training of designers to meet; graduate employability and career opportunities are ever-present characteristics and central drivers in higher education today. The authors
GENERAL	SKILLS	Banky & Blicblau	2015	Apples and Oranges: A Framework to Explore the Practiced Pedagogy in		1		Experimental learning, traditionally conducted in on-campus laboratory venues, is the cornerstone of science and engineering education. To satisfy online student and accreditation requirements,
GENERAL	KNOWLEDGE	Barakat & Plouff	2014	A Model for On-Line Education of ABET-required Professional Aspects of		1		Employability and professional skills formulate a critical part of engineering education. These skills are strongly emphasized through ABET accreditation requirements for engineering
GENERAL	SKILLS	Barte & Yeap	2011	Problem-based learning approach in enhancing engineering graduates'		1		This paper looks at the experience of a Malaysian private college in implementing Problem-based Learning (PBL) in selected subjects in its Diploma programs in relation to improving future
SOFTWARE	SKILLS	Bass et al	2015	Virtual teams and employability in global software engineering education		1		Universities face many challenges when creating opportunities for student experiences of global software engineering. We provide a model for introducing global software engineering
GENERAL	SKILLS	Baytiyeh & Naja	2012	Identifying the challenging factors in the transition from colleges of engineering to		1		The transition from university to a career in engineering is a challenging process. This study examined the perceptions of engineering graduates regarding the difficulties they encountered in
INDUSTRIAL	KNOWLEDGE	Bingham et al.	2015	Meeting the expectation of industry: an integrated approach for the teaching of	1			This paper examines the traditional engineering-based provision delivered to Product Design and Technology (B.Sc.) undergraduates at the Loughborough Design School and questions its
INFORMATION	SKILLS	Blom & Saeki	2012	Employability and skill set of newly graduated engineers in India.		1		Skill shortage remains one of the major constraints to continued growth of the Indian economy. This employer survey seeks to address this knowledge-gap by answering
GENERAL	INTEGRATED	Boni et al.	2015	Educating Engineers for the Public Good Through International Internships:			1	At Universitat Polite`cnica de Vale`ncia, Meridies, an internship programme that places engineering students in countries of Latin America, is one of the few opportunities the students
SOFTWARE	KNOWLEDGE	Brugge et al.	2015	Software Engineering Project Courses with Industrial Clients	1			There is an acknowledged need for teaching realistic software development in project courses. The design space for such courses is wide, ranging from single semester to two semesters
INDUSTRIAL	SKILLS	Buyurgan and Kiassat	2017	Developing a new industrial engineering curriculum using a systems engineering		1		This paper reports on the development of an engineering curriculum for a new industrial engineering programme at a medium-sized private university in the northeast United States. A
GENERAL	INTEGRATED	Case & Marshall	2016	Bringing together knowledge and capabilities: a case study of engineering			1	In contemporary times there is a renewed focus on the purposes of university education in science or engineering ,especially in emerging economy contexts like South Africa where the
CONSTRUCTION	SKILS	Chan & Sher	2014	Exploring AEC education through collaborative learning		1		There is concern that traditional teaching methods (including lectures and tutorials) do not prepare graduates with the generic employability skills required by the construction industry. This has
GENERAL	KNOWLEDGE	Clark	2008	Project management: the key to engineering employability	1			In the modern engineering work environment, much of what takes place is in the form of projects. The 'project' has become for many companies the most common currency, yet how projects are
GENERAL	KNOWLEDGE	Clement & Murugavel	2015	English for employability: A case study of the english language training need	1			This article examines the effectiveness of English language courses offered in the engineering colleges in India. Many engineering graduates in India are found to be unemployable due to their
CHEMICAL	INTEGRATED	Coll	2015	The Role of Cooperative and Work-Integrated Education in Chemistry Career			1	Cooperative and work-integrated education is a strategy of education that combines academic learning in the classroom with real-world practice in a relevant workplace. Here it is argued that
GENERAL	KNOWLEDGE	De Magalhães et al.	2007	PUKHA: a new pedagogical experience	1			PUKHA: a new pedagogical experienceSociety needs responsible leaders and entrepreneurs. CDIO (conceive, design, implement and operate) is a framework for engineering education based
INDUSTRIAL	INTEGRATED	de Vere et al	2010	Product design engineering – a global education trend in multidisciplinary			1	Product design is the convergence point for engineering and design thinking and practices. Until recently, product design has been taught either as a component of mechanical engineering or as
COMPUTER SCIENCE	KNOWLEDGE	D'Souza & Rodrigues	2015	Extreme pedagogy: An agile teaching-learning methodology for engineering	1			Traditional instructor-centered, lecture-based teaching methods in engineering education have been criticized for being too linear, dogmatic, systematic and constraining. This paper proposes
CIVIL	INTEGRATED	Elgueta	2016	Methods agile and methodology A+S in the teaching of software engineering			1	Traditional engineering education is usually very theoretical and in a closed environment. By using the Learning Methodology + Service (L+S) and various techniques and Agile methods,
COMPUTER SCIENCE	KNOWLEDGE	Forshaw et al	2016	Meeting graduate employability needs through open-source collaboration with	1			This paper describes the development and delivery of a course, in close collaboration with industry, over a ten-year period. We describe the details of this collaboration, which aims to

CIVIL	SKILLS	Goggins	2012	Engineering in communities: learning by doing		1		Purpose – The purpose of this paper is to focus on a number of initiatives in civil engineering undergraduate programmes at the National University of Ireland, Galway (NUIG) that allow
MECHANICAL	KNOWLEDGE	Guzzomi et al.	2017	Students' responses to authentic assessment designed to develop	1			Engineering educators should motivate and support students in developing not only technical competence but also professional competence including commitment to excellence. We
GENERAL	INTEGRATED	Hassan et al.	2016	Employability proficiency in workplace: A study on skills affecting prospective			1	The objective of this study is to reveal the degree to which prerequisite of foundation knowledge and skill obtainable through institution of higher education might influence prospective graduates'
GENERAL	INTEGRATED	Hawse	2017	Transitioning to Professional Work: A View from the Field			1	This chapter explores the question: "what is a successful transition to professional work for an engineering graduate"? To answer this question, it considers the viewpoint of both recent
GENERAL	SKILLS	Hazelton et al.	2009	A multicultural, multidisciplinary short course to introduce recently graduated		1		Since 2001, the International Institute of Women in Engineering (IIWE) at EPF, Ecole d'ingenieurs generaliste, Sceaux, France, has conducted a 3 week short course for culturally and
GENERAL	SKILLS	Huff et al.	2016	Preparing Engineers for the Workplace through Service Learning: Perceptions of		1		Service-learning programs that emphasize engineering design have been posited to bolster the professional preparedness of engineering alumni. However, we know littleabout how such
MECHATRONIC S	SKILLS	Ibrahim et al.	2017	Industry-led mechatronics degree development in regional Australia		1		This paper presents a technique that was used in the recent development of a new Mechatronics degree in Australia. This technique addressed the local industry needs and the available
SOFTWARE	SKILLS	Johns-Boast and Flint	2013	Simulating industry: An innovative software engineering capstone design		1		Universities are required to produce graduates with good technical knowledge and 'employability skills' such as communication, team work, problem-solving, initiative and enterprise, planning,
GENERAL	KNOWLEDGE	Jollands et al	2012	Project-based learning as a contributing factor to graduates' work readiness	1			This paper explores what work readiness means for two cohorts of graduate engineers, one from a traditional curriculum, the second from a largely project-based curriculum. Professional bodies
MECHANICAL	SKILLS	King & Newman	2009	Evaluating business simulation software: approach, tools and pedagogy		1		Purpose - To identify a business simulation appropriate for MEng Engineering students. The selection was based on the following factors; exploring methods for evaluating potential software
GENERAL	SKILLS	Kulkarni & Chachadi	2014	Skills for Employability: Employers' Perspective.		1		Considerable studies have come out attempting to highlight the issue of non-employability of fresh engineering graduates in India. A few have tried to measure the employers' perspective in a
GENERAL	SKILLS	Lappalainen	2013	Pedagogy enhancing graduates' employability		1		The traditional focus in higher engineering education on technical abilities has been well substantiated by the types of abilities required in industrial processes. However,
GENERAL	KNOWLEDGE	Lin-Stephens et al.	2016	The career information literacy learning framework: A case study of information			1	Universities worldwide are under increasing pressure to ensure graduate work-readiness upon degree completion. However, the linkage between employability enhancement and disciplinary
GENERAL	KNOWLEDGE	Litzinger et al.	2011	Engineering Education and the Development of Expertise	1			Although engineering education has evolved in ways that improve the readiness of graduates to meet the challenges of the twenty-first century, national and international organizations continue
MECHANICAL	INTEGRATED	Liu	2015	Renovation of a mechanical engineering senior design class to an industry-tied			1	In this work, an industry-based and team-oriented education model was established based on a traditional mechanical engineering (ME) senior design class in order to better prepare future
GENERAL	SKILLS	Magnell et al.	2016	Faculty Perspectives on the Inclusion of Work-Related Learning in Engineering		1		The purpose of this paper is to identify faculty perspectives on the integration of work-related issues in engineering education. A mixed methods approach was used to explore faculty
SOFTWARE	SKILLS	Marques	2016	Monitoring: An Intervention to Improve Team Results in Software Engineering		1		Software engineering education is currently being taught in many universities with a hands-on approach, where students have to learn to develop software in teams, intending to simulate
GENERAL	INTEGRATED	Michelson et al	2017	Higher Education Learning Outcomes and theirAmbiguous Relationship to	1			This artic le highlight s the significance of professional and disciplinaryspaces in the shaping of Learning Outcomes (Los) in higher educat ion. It isbased on empirical studie s of three pro
GENERAL	SKILLS	Nair et al.	2009	Re-engineering graduate skills – a case study		1		Research on student learning outcomes indicates that university graduates frequently do not possess important skills required by employers, such as: communication, decision-making,
QS	SKILLS	Perera et al	2017	Professional competency-based analysis of continuing tensions between education		1		The education and training of construction graduates are highly influenced by the higher education institutions which produced them and the relevant professional bodies, which set the
COMPUTER	SKILLS	Rani and Babu	2017	Impact of learning environment and organizational variables on the		1		Employability becomes a bench mark for the quality of engineering education throughout the country. The ratio between a number of engineering graduates coming out from the colleges and
GENERAL	SKILLS	Richter & Paretti	2009	Identifying barriers to and outcomes of interdisciplinarity in the engineering			1	In addition to developing deep knowledge of a single discipline, engineers must also be able to collaborate across disciplinary boundaries and develop interdisciplinary expertise to successfully
GENERAL	SKILLS	Saad & Majid	2014	Employers' perceptions of important employability skills required from		1		This article presents the findings of a survey of 299 Malaysian employers from diverse types of agencies and organisations, which employ engineering and ICT graduates. The objective of the
SOFTWARE	KNOWLEDGE	Sedelmaier & Landes	2015	A Competence-Oriented Approach to Subject-Matter Didactics for Software	1			Instructors not only in higher education are regularly faced with the problem that they need to develop a new course or adapt an existing one to changed requirements. This is especially true
GENERAL	SKILLS	Shet et al.	2015	Integrated Experience: Through Project-Based Learning		1		Project-based learning (PBL) is an instructional method in which students learn a range of skills and subject matter in the process of creating their own projects. Sometimes, these projects are

SOFTWARE	SKILLS	Singh et al.	2013	Supporting sustainable student learning at USP through the use of ePortfolios		1		Universities have a responsibility to provide students with the means to support themselves in their learning processes in the contemporary workplace, particularly in light of the emphasis on
CIVIL	INTEGRATED	Soetanto et al.	2017	Designed to be employed? Measuring the impact of a multidisciplinary			1	A collaborative building design project undertaken within an internationally distributed team involves a dynamic process characterised by generation and sharing of information and synthesis
GENERAL	SKILLS	Ssegawa & Kasule	2017	A self-assessment of the propensity to obtain future employment: a case of final-		1		The article provides a self-assessment by final-year engineering studentsat the University of Botswana regarding the propensity to get employment. Students rated which employability
INFORMATION	SKILLS	Stevens & Norman	2016	Industry Expectations of Soft Skills in IT Graduates		1		Representatives of the Information Technology (IT) industry periodically question the work-readiness of university educated IT graduates. Academics typically interpret such challenges as
GENERAL	INTEGRATED	Tilly & Roach	2017	Ipsative Learning: A Personal Approach to a Student's PBL Experience Within an		1		University College London (UCL) has recently implemented a distinctive programme that connects curricula across seven engineering disciplines. The Integrated Engineering Programme
ELECTRONIC	KNOWLEDGE	Toral et al.	2007	An electronic engineering curriculum design based on concept-mapping	1			Curriculum design is a concern in European Universities as they face the forthcoming European Higher Education Area (EHEA). This process can be eased by the use of scientific tools such as
ELECTRONIC	INTEGRATED	Tudor	2016	The role of non-formal and informal education in competences training —			1	In every field of activity, including the education, the competence/skill represents the foundation to ensure the process performance and efficiency, enabling the transition from knowing and know
GENERAL	SKILLS	Walther et al.	2011	Engineering Competence? An InterpretiveInvestigation of Engineering		1		There is growing evidence that engineering students' professional formation is shaped by the interplay of explicit learning activities and various influences from the wider educational context.
SOFTWARE	INTEGRATED	Wang et al	2011	Institute–industry interoperation model: an industry-oriented engineering			1	Engineering education has been well implemented in the majority of developed countries such as the USA, Germany, and the United Kingdom so that the gap between engineering science and
COMPUTER SCIENCE	KNOWLEDGE	White & Davis	2013	Practice sharing paper: Motivating computer scientists to engage with		1		Modules in professional issues sometimes sit a little awkwardly in the computer science curriculum. They can be seen as an island of discursive teaching coming from what Biglan might
COMPUTER SCIENCE	KNOWLEDGE	White & Irons	2009	Relating research and teaching: learning from experiences and beliefs	1			The relationship between research and teaching has possible benefits and inherent tensions. Exploring the potentially beneficial relationship is of interest and possible value to faculty,
GENERAL	INTEGRATED	Zareba et al	2013	Accelerated Problem Solving Sessions in University Laboratory Settings			1	Current engineering students receive an extensive education in the technical principles associated with the design and manufacturing of products and services. However, collaboration,
					14	31	15	
				TOTAL	**60**			

COUNTRY	METHOD	CITATION	LINK TO TEXT
US	Evaluation	Akpan, Ikpe Justice. 2016. "The Efficacy of Consulting Practicum in Enhancing Students' Readiness for Professional	https://onlinelibrary.wiley.com/doi/full/10.1
UK	Interviews + documents	Arlett, Carol, Fiona Lamb, Richard Dales, Liz Willis, and Emma Hurdle. 2010. "Meeting the Needs of Industry: The Drivers	https://www.tandfonline.com/doi/abs/10.1
UK	Evaluation	Arthur, Leslie, and Phillipa Marsh. "STOP PLAYING IT SAFE: THE IMPORTANCE OF TAKING RISKS IN DESIGN EDUCATION."	https://www.designsociety.org/publication/
Australia	Observation/ video kikan-	Banky, George Peter, and Aaron Simon Blicblau. 2015. "Apples and Oranges: A Framework to Explore the Practiced	http://www.online-journals.org/index.ph
US	Evaluation	Barakat, Nael, and Chris Plouff. 2014. "A Model for on-Line Education of ABET-Required Professional Aspects of	https://ieeexplore.ieee.org/abstract/docum
Malaysia	Survey	Barte, Gil B., and Gik Hong Yeap. 2011. "Problem-Based Learning Approach in Enhancing Engineering Graduates'	https://ieeexplore.ieee.org/abstract/docum
UK	Action research +	Bass, J.M., R. McDermott, and J.T. Lalchandani. 2015. "Virtual Teams and Employability in Global Software Engineering	https://ieeexplore.ieee.org/abstract/docum
Lebanon	Survey + interviews	Baytiyeh, Hoda, and Mohamad Naja. 2012. "Identifying the Challenging Factors in the Transition from Colleges of	https://www.tandfonline.com/doi/abs/10.1
UK	Observtion + survey +	Bingham, Guy A., Darren J. Southee, and Tom Page. 2015. "Meeting the Expectation of Industry: An Integrated	https://www.tandfonline.com/doi/abs/10.1
India	Survey	Blom, Andreas, and Hiroshi Saeki. 2012. "Employability and skill sets of newly graduated engineers in India: a study." *IUP*	https://search.proquest.com/openview/a3e
Spain	Interviews	Boni, Alejandra, José Javier Sastre, and Carola Calabuig. 2015. "Educating engineers for the public good through	https://link.springer.com/article/10.1007/s
Germany	Evaluation	Bruegge, Bernd, Stephan Krusche, and Lukas Alperowitz. 2015. "Software Engineering Project Courses with Industrial	https://www1.informatik.tu-
US	Evaluation	Buyurgan, Nebil, and Corey Kiassat 2017. "Developing a new industrial engineering curriculum using a systems	https/doi10.1080/03043797.2017.1287665
South Africa	Interviews	Case, Jennifer M., and Delia Marshall. 2016. "Bringing Together Knowledge and Capabilities: A Case Study of	https://link.springer.com/article/10.1007/s
China	Survey	Chan, Caroline T.W. and William Sher. 2014. "Exploring AEC Education through Collaborative Learning." Engineering,	https://www.emeraldinsight.com/doi/full/10
UK	Case study	Clark, R. 2008. "Project Management: The Key to Engineering Employability." In Proceedings of the European Society for	https://www.researchgate.net/profile/Robi
India	Survey + interviews	Clement, A., and T. Murugavel. 2015. "English for Employability: A Case Study of the English Language Training	https://eric.ed.gov/?id=EJ1075200
Fiji	Evaluation	Coll, Richard K. "The Role of Cooperative and Work-Integrated Education in Chemistry Career Clarification." In	https://link.springer.com/chapter/10.1007/
Portugal	Evaluation	de Magalhães, Barbedo, António, M. Estima, and B. Almada-Lobo. 2007. "PUKHA: a new pedagogical experience."	https://www.tandfonline.com/doi/abs/10.1
Australia	Evaluation	De Vere, Ian, Gavin Melles, and Ajay Kapoor. 2010. "Product design engineering–a global education trend in	https://www.tandfonline.com/doi/abs/10.1
India	Evaluation	D'Souza, Manoj Joseph, and Paul Rodrigues. 2015 "Extreme pedagogy: An agile teaching-learning methodology for	http://www.indjst.org/index.php/indjst/articl
Chile	Evaluation	Elgueta, Jorge Cornejo. "Methods agile and methodology A+S in the teaching of software engineering." In Automatica	https://ieeexplore.ieee.org/abstract/docum
UK	Evaluation	Forshaw, Matthew, Ellis Solaiman, Oonagh McGee, Hugo Firth, Paul Robinson, and Ryan Emerson. 2016. "Meeting	https://dl.acm.org/citation.cfm?id=284464

Ireland	Evaluation	Goggins, J. 2012. "Engineering in Communities: Learning by Doing." Campus-Wide Information Systems 29(4): 238–50.	https://www.emeraldinsight.com/doi/abs/1
Australia	Evaluation	Guzzomi, Andrew L., Sally A. Male, and Karol Miller. 2017. "Students' Responses to Authentic Assessment Designed to	https://www.tandfonline.com/doi/abs/10.1
Malaysia	Survey	Hasan, Hazmilah, Zanariah Jano, Noraida Abdullah, Hanipah Hussin, and Lennora Putit. "Employability proficiency in	10.3923/sscience.2016.2965.2970
Australia	Survey	Hawse, Sally. 2017. "Transitioning to Professional Work: A View from the Field." In Leigh N. Wood and Yvonne A. Breyer	https://link.springer.com/chapter/10.1007/
Australia	Evaluation	Hazelton, Pam, Molly Malone, and Anne Gardner. 2009. "A Multicultural, Multidisciplinary Short Course to Introduce	https://www.tandfonline.com/doi/abs/10.1
US	Survey + interviews	Huff, James L., Carla B. Zoltowski, and William C. Oakes. "Preparing engineers for the workplace through service	https://onlinelibrary.wiley.com/doi/full/10.1
Australia	Survey	Ibrahim, M. Yousef, Gayan Kahandawa, T. A. Choudhury, and Abdul Md Mazid. 2017 "Industry-led mechatronics degree	https://ieeexplore-ieee-
Australia	Evaluation	Johns-Boast, Lynette, and Shayne Flint. 2013. "Simulating industry: An innovative software engineering capstone	https://ieeexplore-ieee-
Australia	Interviews	Jollands, Margaret, Lesley Jolly, and Tom Molyneaux. 2012. "Project-Based Learning as a Contributing Factor to	https://www.tandfonline.com/doi/abs/10.1
UK	Survey	King, Melanie, and Richard Newman. "Evaluating business simulation software: approach, tools and pedagogy." On the	https://www.emeraldinsight.com/doi/full/10
India	Survey	Kulkarni, Nitin, and A. H. Chachadi. "Skills for Employability: Employers' Perspective." SCMS Journal of Indian	https://search.proquest.com/openview/99b
Finland	Survey	Lappalainen, Pia. 2013. "Pedagogy Enhancing Engineering Graduates' Employability" Proceedings of the European	https://www.kuleuven.be/communicatie/co
Australia	Curriculum evaluation	Lin-Stephens, Serene, Stephen Smith, Marianne Peso, and Vincent Pang. 2016 "The Career information literacy learning	http://aisel.aisnet.org/pacis2016/52/
US	Evaluation	Litzinger, Thomas A, Lisa R Lattuca, Roger G Hadgraft, and Wendy C Newstetter. 2011. "Engineering Education and the	https://onlinelibrary.wiley.com/doi/full/10.1
US	Evaluation	Liu, Yucheng. "Renovation of a mechanical engineering senior design class to an industry-tied and team-oriented course."	https://www.tandfonline.com/doi/abs/10.1
Sweden	Survey + interviews	Magnell, Marie, Lars Geschwind, and Anette Kolmos. 2016. "Faculty Perspectives on the Inclusion of Work-Related	https://www.tandfonline.com/doi/abs/10.1
Chile	Evaluation	Marques, Maíra Rejane. 2016. "Monitoring: An Intervention to Improve Team Results in Software Engineering Education."	https://dl.acm.org
Norway	Case study	Michelsen, Svein, Agnete Vabø, Hanne Kvilhaugsvik, and Endre Kvam. 2017. "Higher Education Learning Outcomes	https://doi.org/10
Australia	Case study	Nair, Chenicheri Sid, Arun Patil, and Patricie Mertova. 2009. "Re-engineering graduate skills: a case study." *European*	https://www.tandfonline.com/doi/abs/10.10
Australia	Survey	Perera, Srinath, Solomon Olusola Babatunde, Lei Zhou, John Pearson, and Damilola Ekundayo. 2017 "Competency	https://www.emeraldinsight.com/doi/abs/10
India	Survey	Rani, V. Roja, and M. Kishore Babu. 2017. "Impact of learning environment and organizational variables on the	http://www.jardc
US	Case study	Richter, D.M. and Paretti, M.C., 2009. Identifying barriers to and outcomes of interdisciplinarity in the engineering	https://www.tandfonline.com/doi/abs/10.1
Malaysia	Survey	Saad, Mohd Shamsuri Md, and Izaidin Ab Majid. 2014. "Employers' perceptions of important employability skills	http://online-journals.org/index.ph
Germany	Evaluation	Sedelmaier, Yvonne, and Dieter Landes. 2015. "A Competence-Oriented Approach to Subject-Matter Didactics	http://online-journals.org/index.ph
India	Evaluation	Shet, R. M., Nalini C. Iyer, P. C. Nissimgoudar, and S. Ajit. 2015. "Integrated Experience: Through Project-Based	https://link.springer.com/chapter/10.1007/

Fiji	Evaluation	Singh, Shaveen, Bibhya Nand Sharma, Anjeela Jokhan, and David Lindley. 2013. "Supporting Sustainable Student	https://ieeexplore.ieee.org/abstract/docum
UK	Evaluation	Soetanto, Robby, Mark Childs, Paul SH Poh, and Jacqueline Glass. 2017. "Designed to be employed? Measuring the	https://www.taylorfrancis.com/books/e/978
Botswana	Survey	Ssegawa, Joseph K., and Daniel Kasule. 2017. "A Self-Assessment of the Propensity to Obtain Future Employment:	https://www.tandfonline.com/doi/abs/10.1
New Zealand	Discourse analysis	Stevens, Matt, and Richard Norman. 2016. "Industry Expectations of Soft Skills in IT Graduates: A Regional	https://dl.acm.org/citation.cfm?id=284306
UK	Evaluation	Tilley, Emanuela, and Kate Roach. 2017 "Ipsative Learning: A Personal Approach to a Student's PBL Experience Within an	https://link.springer.com/chapter/10.1057/
Spain	Curriculum evaluation	Toral, S. L., M. R. Martínez-Torres, F. Barrero, S. Gallardo, and M. J. Durán. 2007. "An Electronic Engineering Curriculum	https://link.springer.com/article/10.1007/s
Romania	Evaluation	Tudor, Sofia Loredana. "The role of non-formal and informal education in competences training—Transversal	https://ieeexplore.ieee.org/abstract/docum
US	Survey	Walther, Joachim, Nadia Kellam, Nicola Sochacka, and David Radcliffe. 2011. "Engineering competence? An interpretive	https://onlinelibrary.wiley.com/doi/full/10.1
China	Case study	Wang, Yanqing, Zhongying Qi, Ziru Li, and Lijie Zhang. 2011. "Institute–industry interoperation model: an industry-	https://link.springer.com/article/10.1007/s
US	Evaluation	White, Su, and Hugh C. Davis. 2013. "Motivating Computer Scientists to Engage with Professional Issues: A Technology-	https://ieeexplore.ieee.org/abstract/docum
US	Survey	White, Su, and Alastair Irons. 2009. "Relating Research and Teaching: Learning From Experiences and Beliefs." ACM	https://dl.acm.org/citation.cfm?id=156290
US	Evaluation	Zareba, Marek, Anna Schuh, and Jaime A. Camelio. 2013 "Accelerated problem solving sessions in university	https://link.springer.com/article/10.1007/s