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Teaching and Learning Competencies Valued by Engineering Educators: A Pilot Study

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Teaching and Learning Competencies

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INTRODUCTION

At the onset of this paper, it is important to provide context by highlighting two backdrop narratives, which have prompted and guided this research project: -

(i) Since 2015, The National Forum for the Enhancement of Teaching & Learning in Ireland has undergone an extensive consultation process on professional development, resulting in a guiding document entitled the National Professional Development Framework (NPDF) for Staff Who Teach in Higher Education [1].

(ii) The Technological University Alliance for Dublin has placed Dublin Institute of Technology (DIT), Institute of Technology Blanchardstown (ITB) and Institute of Technology Tallaght (ITT) on a merger trajectory towards technological university designation [2] under the Technological Universities Act 2018.

Project Levitus is a cross-institute initiative tasked to develop and pilot a disciplinary-specific (engineering) version of the NPDF, transferrable to other academic disciplines. A steering committee, comprising of engineering educators, teaching and learning specialists, academic managers and HR representatives, has guided the project.

1 OBJECTIVES OF THE STUDY

The project follows three stages: [i] research, [ii] development, [iii] pilot and evaluation. This paper outlines the findings from the research phase, which identifies core and discipline-specific teaching and learning competencies valued by engineering educators, which will inform the later development of a competency framework.

RQ1- What are the perceived core and discipline-specific competencies to be an effective engineering educator?

RQ2- How can these competencies be best addressed by professional development (PD) activities in teaching and learning (T&L)?

2 LITERATURE REVIEW

Three strands of literature inform this review: [i] professional development in higher education [ii] reform in engineering education, and [iii] teaching and learning training.

2.1 Core Teaching & Learning Competencies

Several definitions of competency prevail, with lexes such as skills, knowledge and behaviour to the fore. Competencies can be defined as demand-orientated skills for solving problems [3] or as collaborative skills to engage with students and colleagues [4]. Other competency domains include the learning-scholar, knowledge-expert, learning-facilitator and individual-teacher [5]. The student perspective on what it is to be an effective teacher offers a worthy insight and further enhances these definitions. Teachers' wealth of knowledge and ability to communicate their expertise is important, as is their enthusiasm and passion. Valued behaviours include teachers' openness, approachability, friendliness and an ability to challenge, motivate and stimulate [6]. The NPDF outlines five domains: [i] self, [ii] professional identity, [iii] personal and professional digital capacity, [iv] knowledge [v] professional communication and dialogue. Yet, it is important not to lose sight that teaching and learning competencies must accommodate diverse contexts in which teaching takes place. The challenge is to create a competency framework, which can be continuously adapted.

2.2 Engineering Teaching & Learning Competencies

Engineering today is characterised by a diversity of demands made on professional engineers. Contemporary challenges in their education include: student recruitment and retention, low female participation and a gap between professional engineering practice, based on interdisciplinary problem-solving, and an education model rooted in the sciences. There has been concern for some time now that the education system for producing new generations of engineers is failing to keep pace [7]. Engineering teaching and learning competencies should, therefore, reflect these challenges.

Desired characteristics for PD in engineering education, suggest that it should articulate a clear metaphor for effective classroom learning [8], provide educators with opportunities to broaden their experience, be congruent with andragogic principles [9], build community of practices [10] and prepare educators for leadership roles. Fink et al. [11] explore the challenges of becoming a professional engineering educator, citing reports calling reform [12, 13, 14]. They advocate for integrated curricula, addressing multiple learning styles, a focus on employability skills and socio-economic responsibility. Calling for reforms to be rooted in educational research and cognitive science [15], they remind us that students remain the focus [16, 17].

To identify the competencies required of engineering educators, it is important to understand the knowledge, skills and values they seek to develop in their students. Passow [18] highlighted several ABET competencies important to engineering graduates in their professional work, such as teamwork, data analysis, communication and problem solving. Synthesising a large evidence base, Passow and Passow [19] identified 16 engineering competencies including initiative and creative thinking. Of course, not every engineering educator will possess all these competencies equally; some may be technical specialists, others better able to integrate knowledge and operate across boundaries in complex environments.

The ideal engineering educator can be considered: competent in their own engineering discipline; active in research and maintaining currency; an effective teacher; understanding the role of the engineering education in society; and a role-model engineer for students [20]. Hence, although teaching and learning is only one aspect of engineering educator competence, it remains inextricably linked to a wider role encompassing research, professional practice and community engagement.

2.3 Training Provisions in Teaching & Learning

A snapshot of accredited professional development in Ireland [21] identified 68 teaching and learning programmes from 23 institutions, the majority at NQF Level 9. A snapshot of non-accredited provision identifies four categories [22]: pedagogy, assessment, academic development and digital capacity. Even within the three merging Institutes, there are known provisions. For example, Dublin Institute of Technology's LTTC offers an MA in Higher Education, an MSc in Applied eLearning, a PG Diploma and modules for continuous professional development. These offerings are also available to staff at ITT and ITB.

3 THEORETICAL FRAMEWORK

Implicit for engineering educators is a dual professional identity. Some argue that they are educators and the adjective ‘engineering’ describes what type. Others point out that they are educating for entry into a profession and are, hence, engineers who happen to be educating. Irrespective of which lens, engineering educators inevitably seek to develop inextricably linked competencies as an engineer and educator.

Hence, two streams of theoretical work inform the study. The first recognises the need for engineering educators to translate their engineering knowledge into pedagogically powerful structures that are adaptive to varying student learning needs [23]. The second recognises a need for engineering educators to remain professionally current through research, consultancy and engagement in communities of practice that seek to solve engineering and engineering education problems [11].

4 METHODOLOGY

4.1 Research Design

Given the quest to establish a middle ground between different stakeholder groups, the study leans towards a qualitative-interpretive approach [24]. The project was introduced to staff at the three Institutes at the start the academic year 2017/2018. A survey was then designed through a process of extensive consultation. Using a mixed methods approach, the survey was used to maximise insights from engineering educators, focus groups explored views of students and in-depth interviews sought academic managers' perspectives. The survey data was analysed in MS Excel and a thematic analysis [25] of the interview and focus group transcripts was undertaken in Nvivo. Both the literature review and empirical findings are currently being used to inform the development of the competency framework.

4.2 Population and Sample

Using a voluntary sampling method, the survey link was emailed by champions to participants who could self-select into the survey. Across the three Institutes engineering students were invited to participate in focus groups, and Heads of School and Heads of Department were contacted to request an interview.

4.3 Data Collection and Analysis

An electronic survey elicited responses regarding competence, and PD activities, both valued and needed by engineering educators. Divided into three sections: [i] background information, [ii] professional experience and [iii] professional development in teaching and learning, respondents were asked to rate their values and needs according to a 4-point Likert-type scale. Forwarded to over 300 colleagues, data was elicited from 121 respondents (≈ 40% participation rate).

A focus group guide was developed, whereby students were asked to identify competencies across three domains: educator, engineer and engineering educator. Across the three Institutes 27 students shared insights. Responses were mapped to three competency domains: [i] pedagogical: teaching practice, [ii] content: engineering knowledge and [iii] pedagogical-content: relating engineering practices to T&L.

An interview guide was designed and sent to academic managers. All interviews were recorded. Transcripts were sent to participants for review. Interviews with academic managers (n=8) sought to understand how the current PD in T&L system functions and to identify gaps and improvements. Each transcript was reviewed under three a priori themes [i] support for PD in T&L, [ii] managing PD and [iii] cultural change. All transcripts were read thoroughly by the researchers to familiarise themselves with the data. An initial coding of the transcripts identified nine emerging sub-themes, which were then categorised under three a priori themes (Fig. 4). Interpretation of meaning attributed to coded text extracts was calibrated to further validate the emerging themes.

5 SUMMARY OF FINDINGS

5.1 Results for Research Question One

Question 13 of the survey asked: *What makes a great engineering educator? Rank all the statements from 1 - 6 in order of importance.*

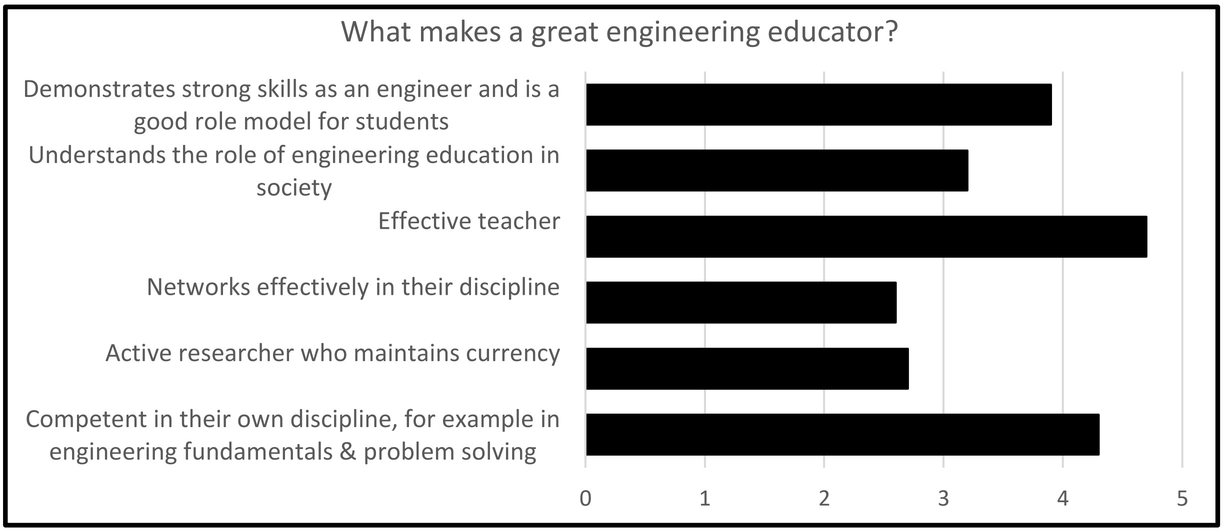


Fig. 1. Relative scores for key attributes of a 'great engineering educator'

The focus group responses were mapped to the draft competency domains. Table 1 provides sample statements with the total number of coded responses for top domains.

Table 1. Sample student responses in respective competency domains

	Domain 1	**Sample responses from students.**	**N**
Pedagogical	Teaching Practice	"Interacting with students in different ways; Makes an effort to be on a one-to-one basis; Up to date notes and not notes that they prepared when they first became a teacher 20 years ago."	**60**
Pedagogical	Knowledge & Skills	"Provide context rather than only reading from slides; Good knowledge in their field; Able to explain things in more than one ways."	**40**
	Domain 2	**Sample responses**	**N**
Content	Communication	"Interpersonal skills; Ability to simplify concepts for non-engineers; Ability to work in a team."	**30**
Content	Engineering Fundamentals	"Strong fundamental knowledge; Great maths skills; Creative thinker."	**22**
	Domain 3	**Sample responses**	**N**
Content-Pedagogical	Role Model as Engineer	"Knowledge and experience in the field; Engages in professional development; They are what we students want to become; We want to be engineers and they are the only examples we have as engineers."	**16**
Content-Pedagogical	Design as Fundamental Engineering Pedagogy	"Ability to apply theory to the practical environment; Technical knowledge of the course they are teaching; Ability to break down complex theories into simple/manageable understanding for the students."	**7**

N = Number of coded extracts from student responses categorised in each domain.

Question 20 of the survey asked: *What value do you place on the following activities to your professional development teaching and learning? Please mark one choice in* *each row.* Table 2 shows the % responses and mean Likert-type score for the top three responses.

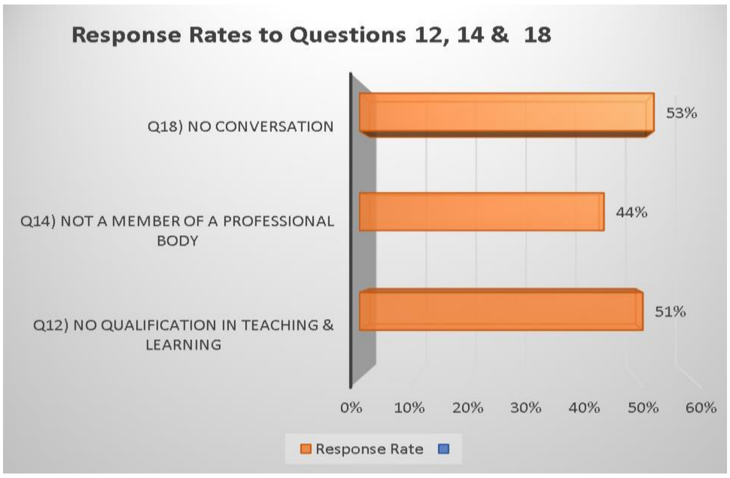
Table 2. Most valued professional development activities

Responses	**No**	**Low**	**Mod.**	**High**	**Average**
Engaging in informal dialogue with your colleagues on how to enhance your teaching	0%	10%	33%	57%	3.5
Engaging in self-study	1%	14%	36%	49%	3.3
Mentoring students	1%	13%	38%	48%	3.3

5.2 Results for Research Question Two

RQ2- How can these competencies be best addressed by professional development activities in teaching and learning?

Several questions in the survey were designed to explore how professional development activities are currently addressed. Specifically:



Q12- *Do you hold any qualifications in teaching and learning? Please mark multiple choices.*

Q14- *Your professional body membership. Please mark multiple choices.*

Q18- *Have you engaged in a conversation with your Head of School/ Department about your professional development in teaching and learning?*

Fig. 2. % Responses to Q12, Q14 and Q18

Question 21: *Select your needs in professional development in teaching and learning.*

Question 23: Select your current needs in professional development in teaching and learning specific to engineering.

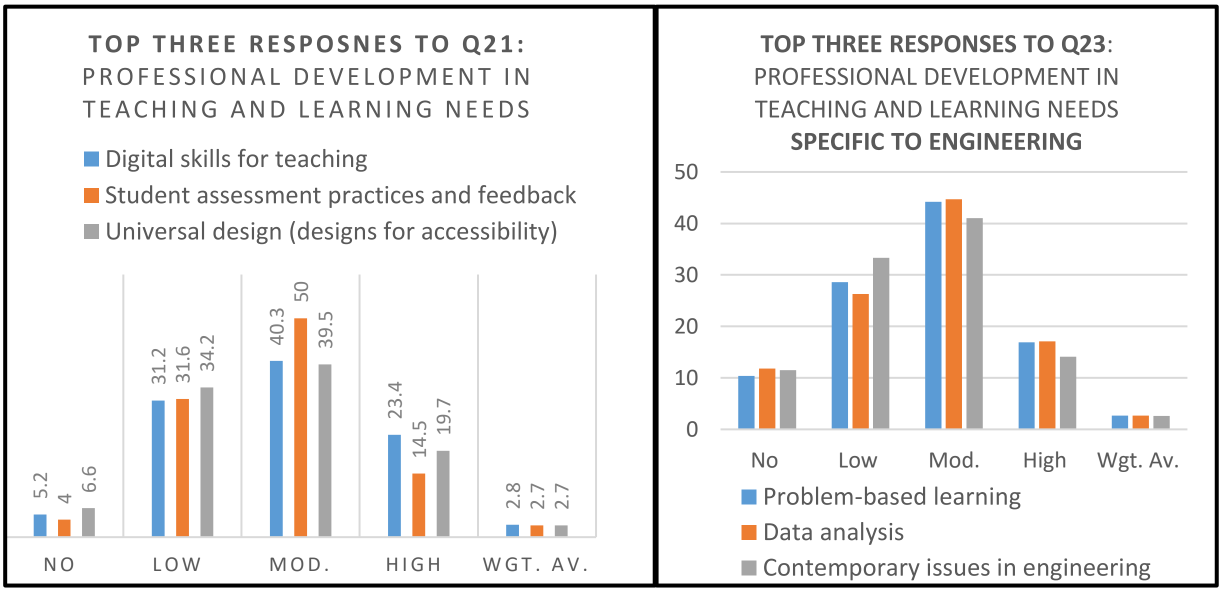


Fig. 3. Top three responses to Q21 and Q23 respectively (Y-Axis shows % response).

Interviews with academic managers revealed nine sub-themes regarding professional development in teaching and learning (Fig. 4):

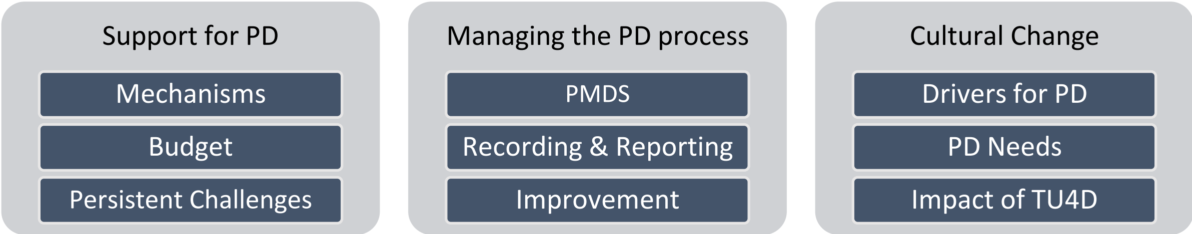


Fig. 4. Sub-themes emerging from interviews with academic managers

6 DISCUSSION

Although there was accord with the competencies identified in the literature review, priorities at times differed, which may reflect institutional culture. The research findings offered several insights into which teaching and learning PD activities engineering educators value most. Student perspectives concurred, validating why these competencies are important. Academic managers highlighted current challenges to support the needs of staff and the conflict between teaching and research.

6.1 What the survey revealed?

The hybrid identity of engineering educators is clearly evidenced in the findings. Echoed by Morell and DeBoer [20], highest ranked responses to what makes a great engineering educator were [i] an effective teacher, closely followed by [ii] discipline competency. The wider role encompassing research, professional practice and community engagement was not considered as important. With the results revealing low levels of engineering professional body membership and an equivalent teaching body membership, an opportunity arises to bridge academic and disciplinary identities.

As teaching and learning is perceived as a central function, this identity vacuum demonstrates a need for funding, support and policy for PD in T&L. Low levels of discussion between educators and academic managers could be addressed through the adaptation of a competency framework as a catalyst for dialogue. An interesting challenge as the Technological University Alliance for Dublin moves forward is where will priorities lie within the teaching and learning versus research space?

Regarding the most valued PD activities in T&L, they were broad and diverse, highlighting the importance of individual values and needs as recognised by the NPDF domain of the self. The activities most valued were non-accredited: collaborative, (e.g. conversations with colleagues); unstructured (e.g. reading articles); and structured (e.g. attending workshops). Receiving an accredited, formal qualification was least valued, so the implications for those involved in developing and delivering PD activities is that short, unaccredited and collaborative workshops should be prioritised.

Regarding teaching and learning PD needs, digital skills for teaching ranked highest followed closely by student assessment and feedback practices. These go hand in hand, as the digital space can offer solutions to assist with more efficient ways to assess and give feedback. The biggest challenge of all though relates to the PD needs of engineering educators specific to their field due to the ever-evolving nature of the discipline. Competencies such as problem-based learning and data analysis were most needed, which Passow [18] also identified. This highlights the importance of seeking regular and systematic feedback from engineering educators regarding their PD needs.

6.2 Focus groups

Students had little difficulty identifying general teaching competency domains. Approachability and flexibility of their lecturers was highly valued as encountered in the literature [6], mirrored by engineering educators as they ranked mentoring students as the third most valued PD activity. As students are already very familiar with the role of an educator, the more allusive and less familiar domains of engineer and engineering educator proved somewhat challenging to define.

As the students grappled to describe what makes a great engineer, it could be argued that there is a need for programmes to include guest speakers who are experts in the engineering field. Embedding a work-based learning component or internship into programmes, may help students to identify clearly with the field of engineering and envisage the types of roles that they may work in.

In the domain of engineering educator, the students found it difficult to pinpoint competencies, but they highlighted the importance of authenticity, i.e. that educators are also experts in their own field, so they can relate real-world examples to classroom problems. This once again strengthens the argument that maintaining professional currency as an engineer is a vital component of teaching excellence. Digital capacity was identified as important by students, also recognised as the highest need by educators, as students discussed the need for engineering educators to be comfortable in the digital learning space, such as recording lectures for further reference and using screencasts to recap on key themes.

6.3 Academic Manager Interviews

A differing landscape exists across the three Institutes regarding PD in T&L in terms of mechanisms to support it, funding and policy. Some departments had designated budgets, whilst others used funds from departmental resources on an ad hoc basis, wary to ask educators about their PD needs. Teaching and learning is considered an intrinsic part of the character of institutes of technology, confirmed by academic managers, further echoed by engineering educators in the survey and by students in the focus groups. Given the failing public sector performance management development system (PMDS) as a model for supporting PD in higher education, academic managers highlighted the need for an alternative system of promoting, recording and recognising PD activities of their staff outside of the HR domain. The emerging technology university will need to not only identify clearly where the balance lies between teaching and learning and research in the future but articulate an alternative model for incentivising and recognising professional development.

7 LIMITATION OF THE STUDY

This research has focused on one small segment of the higher education sector in Ireland. As a qualitative study, it is less concerned with statistical generalisability as it is with the emic perspectives of its participants. The authors make no claims about the transferability of the findings. It is proposed to scale the survey nationally to further investigate the teaching and learning competencies most valued by engineering educators in the broad higher education landscape.

8 CONCLUSION

A wide range of teaching and learning competencies were valued and needed by the engineering educators who participated in this research. In particular, digital skills for teaching, assessment and feedback and universal design suggest as genuine desire amongst educators to maximise access to education. Students reinforced the importance for their educators to be authentic role models as engineers and effective teachers, confirming the significance of the hybrid identity recognised by engineering educator themselves. Also valued by students were traits such as approachability and the ability to explain complex concepts using real-world examples. Engineering as a discipline, is subject to ongoing change and it is these changes that present the challenge in keeping abreast of PD in T&L. The evolving landscape of higher education and the increased demand for competency in digital capacity, as evidenced in this research, serves to highlight the challenge of balancing the professional development of the educator and the engineer. What is clear, however, is that collaboration is most valued, flexibility is required, and a culture of intrinsically motivated lifelong learning should be fostered as we continue to seek to professionalise in our roles.

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