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(Re)Defining Engineers' Resilience: Part I An Exploratory Study Into How Engineering Educators Understand And Teach Resilience

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(RE)DEFINING ENGINEERS' RESILIENCE: PART I AN EXPLORATORY STUDY INTO HOW ENGINEERING EDUCATORS UNDERSTAND AND TEACH RESILIENCE (RESEARCH)

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ABSTRACT

In recent years 'resilience' has increasingly been framed as a positive attribute that can play a role in the success of university students. The need for students to develop and demonstrate resilience seems particularly pertinent within engineering education. Firstly, engineering degrees are often associated with heavy workloads. This, alongside high rates of attrition and increases in mental health issues, suggests a need for students to demonstrate resilience. Secondly, engineering degrees prepare students for a profession, and it is likely that courses place emphasis on graduate attributes such as resilience. Finally, the rate of technological advancement and societal change places additional demands on graduates to adapt to career changes.

Despite the emphasis on the benefits of demonstrating resilience, there is a lack of research focusing on how it is understood and taught within engineering education. In this work we take a qualitative approach to understanding how engineering educators

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conceptualise resilience; whether they feel a responsibility to help students develop resilience; their approach to doing this; and their general perception about the resilience levels of students. In so doing, we make use of data collected from semi-structured interviews with thirteen individuals involved in the education of engineers. Interview transcripts were analyzed using reflexive thematic analysis (RTA). We find that the conceptualisation of resilience in engineering education varies, thus impacting the design of effective interventions.

1 INTRODUCTION

'Resilience', defined by the American Psychological Association as "the process and outcome of successfully adapting to difficult or challenging life experiences, especially through mental, emotional, and behavioural flexibility and adjustment to external and internal demands" is increasingly used in relation to engineering education.

In recent years, and more noticeably since the COVID-19 pandemic (Brammer, 2020), there has been an increasing emphasis on resilience as a personal attribute that can play a positive role in the success of students within higher education (HE) (Beltman, Mansfield, and Price 2011; Brewer et al. 2019; UCAS, 2018; UNITE, 2017). Indeed, various authors have highlighted the need for resilience to be taught and promoted in order that students develop the skills necessary to navigate the workplace (Sant 2013), with studies focusing specifically on 'graduate resilience' (Morgan, 2016; Hodges 2017), 'academic resilience' (Hunsu, Carnell, and Sochackam 2021; Martin and Marsh 2006), and 'career resilience' (London 1983).

The need for students to develop and demonstrate resilience seems particularly pertinent within engineering. Firstly, the heavy workload associated with studying towards an engineering degree has been highlighted on several occasions (Armstrong 1996; Brainard, Staffin-Metz, and Gillmore 1999; Godfrey and Parker 2010; Rosenblatt and Lindell 2021; Seymour and Hewitt 1997; Stevens et al. 2007; Stevens et al. 2008). This, alongside high rates of attrition (Hunsu, Carnell and Sochacka 2021), and mental health issues (Danowitz & Beddoes, 2018), suggests a need for engineering students to demonstrate resilience. Secondly, an engineering degree, by its nature, prepares students for a profession. It is therefore likely that courses place additional emphasis on employability and graduate attributes (Lucas, Claxton and Hanson; Targetjobs). Finally, the rate of technological advancement and change in society necessitate 'career resilience' (ECITB 2020; NAE 2014; Nieusma and Johnson 1996).

In a systematic literature review on if and how engineering education research (EER) addresses resilience, Winkens and Leicht-Scholten (2023) found the term linked to engineering students as a personal attribute or to systems (e.g., infrastructure). In the case of the former, the reasons for being resilient were divided into five categories: persistence in completing studies; adapting to changes to educational settings during COVID-19; learning from failures/errors; coping with stress, adversity and challenging situations; and resilience as a desired attribute, outcome or competence.

With respect to persistence, Huerta et al. (2021) describes resilience as the "enhanced ability to manage or bounce back from stress" (p. 652), an intrapersonal, noncognitive

competency that is instrumental to becoming a good engineer. Hunsu, Carnell, and Sochacka (2021) introduce the more specific term of 'academic resilience' (Martin and Marsh 2006) as a theoretical framework to explore the way in which students react to academic challenges experienced within engineering education. In their study into the attributes of engineering students, Ssegawa and Kasule (2017) list 'resiliency' as necessary for managing the self and define it as 'coping with stress'. Gesun et al. (2021) define resilience as an 'internal thriving competency' within their model of thriving within engineering education. Elsewhere, the resilience of engineering students has been linked to both self-regulation (Concannon et al. 2019) and self-efficacy beliefs (Anthony et al. 2016; Concannon et al. 2019).

Moreover, within EER, the term is commonly used in relation to issues of equity, diversity and inclusion. For example, studies have been focused on the resilience of mature students (McGivney 2007; Servant-Miklos, Dewar and Bøgelund (2021), the resilience of women (Khilji and Pumroy 2019) African American and Latino students (Samuelson and Litzlerb 2016) and black women (Ross, Huff, and Godwin 2021).

As highlighted by Winkens and Leicht-Scholten (2023), although the term is frequently used within EER, few papers detail associated competencies or concrete teaching approaches, and instead point to a lack of knowledge and understanding of associated definitions. As highlighted by Payne (2012), there are many issues associated with the existence of differences in the way such constructs are interpreted, and it appears as though further research is required so that educators are able to understand the different facets of resilience and the context in which it may be taught.

These findings are particularly relevant when considering the need for both 'top down' (e.g., communicating a clear strategy by management) and 'bottom up' (e.g., individual engagement and commitment) approaches to systematic curriculum change (Kolmos, Hadgraft and Holgaard 2016) and issues which occur in the absence of educator 'buy in'. For instance, previous research has highlighted issues faced by academics when presented with a lack of clarity on role boundaries, for example, around promoting student wellbeing (Laws and Fielder 2012). In this work the authors claimed that the combination of increasing expectations of academics' performance, as well as the institutions' slowness in responding to student needs, has led staff to avoid deep investment in their students' well-being. They highlight the need for a focus on ongoing professional development and workload allocations which include 'emotion work'.

In this work we address the gap in the literature by taking a qualitative approach to understanding how engineering educators conceptualise resilience; whether they feel a responsibility to help students in developing their resilience; their approach to doing this; and their general perception about the resilience levels of their students.

2   METHODOLOGY

2.1 Study Design

The study is situated within a qualitative research paradigm allowing and focusing on understanding the meaning participants drew from experiences over a variety of

contexts. It adopts an interpretivist constructionist approach (Denzin and Lincoln 2003; Lincoln and Guba 2005; Smith 1992). In-depth semi-structured interviews were selected as the method for data collection as they provided the opportunity to explore subjective meanings, experiences, and specific details of each participant (Guba and Lincoln 1994). A semi-structured interview protocol was developed to ensure coverage of key research questions and dimensions of resilience identified in the literature, but also allowed the opportunity for the interviewer to guide the discussion in directions that had not previously been considered and/or that were interpreted as meaningful for the interviewee.

2.2 Participants

Thirteen individuals provided informed consent to participate. Participants varied in experience and came from both academic (both research and teaching focused) and professional services (e.g., employability) roles (Table 1).

Table 1. Participant Information

ID	Relevant participant information
1	White female academic with industry experience. Involved in curriculum design and student engagement.
2	White male academic acting as Employability Mentor responsible for industry placements.
3	White male academic with industrial background and involved in training of graduate engineers. Employability Mentor responsible for industry placements.
4	Arab male academic involved in internationalisation. Teaches a variety of cohorts of various sizes at different levels. Experience in the UK and internationally.
5	White male research focused professor. Teaches to small cohort sizes. Experience teaching in a variety of UK based universities.
6	White female Programme Director. Teaches variety of students at different levels
7	White male early career academic, multidisciplinary teaching
8	White male early career researcher, experienced teaching assistant and involved in supporting research students
9	White male cross discipline careers consultant
10	Chinese male research focused academic. Teaches a variety of engineering programmes and cohorts of sizes. Experience in the UK and internationally
11	White male research focus professor. Teaches small cohorts of up to 40
12	White male research focused professor. Teaches small cohorts of up to 40.
13	White female teaching focused professor with experience in industry

2.3 Procedure and data analysis

Ethical approval was obtained from Swansea University College of Engineering Ethics Committee. Online interviews lasted between 40 and 90 minutes and were conducted, recorded, and transcribed by the first author. Interview transcripts were analyzed using reflexive thematic analysis (RTA). RTA was utilised for several reasons. Firstly, it is generally considered a useful method during the study of under-researched areas. Secondly, its flexibility allows for both inductive and deductive theme generation which captures both semantic and latent meaning. Finally, it is considered a reasonably accessible method which we believe to be important when considering: 1) the varied audience of EER; and 2) a relative lack of any consensus as to acceptable theoretical

frameworks or research methodologies for use within the space. The authors followed the six-stage analytical process proposed by Braun and Clarke (2006).

2.4 Limitations

A limitation of the sampling method is that participants were self-selected and thus likely to have an interest in promoting resilience. A number of participants were involved in employability activities and, at times, had a remit to teach resilience, specifically career resilience. Some participants were heavily involved in training researchers and their answers were framed by their work in this area. The majority of participants were White, and all were from UK based universities. Given the findings pertaining to cultural differences in how resilience is conceptualised, there is a need to understand resilience within engineering education in other geographical locations. It is also important to understand differences and similarities between how resilience is conceptualised, developed, and demonstrated by a range of stakeholders involved in the education of engineers. Interviews with both students and employers will therefore form the next stages of this research.

3   RESULTS

Three overarching themes were generated 1) finding the middle ground 2) boundaries and limits to what the educator can do and 3) being pulled in different directions; tensions and barriers involved in developing resilience. This paper is focused on themes 1 and 2.

3.1 Finding the middle ground

This theme is split into two subthemes and focuses on finding the middle ground in terms of A) the way in which resilience is conceptualised B) teaching of resilience.

  A. *"People kept telling me that that wasn't what resilience was."*

The majority of definitions given for resilience consisted of two components: firstly, the need for failure, adversity, trauma, stress, or rejection; and secondly a reaction which allows you to overcome the issue, sometimes referred to as 'bouncing back'. In many cases resilience required 'changing', 'adapting' or not carrying on the same way. These terms were often mentioned in relation to the changing profession, world of work, capitalism and technological change, with one participant saying resilience is *"increasingly important mostly because society, driven by technology, is changing rapidly"* (11). However, there were some contradictory views regarding the relationship between resilience and change. In relation to engineering projects, one educator suggested that as *"your understanding of the problem changes"* you change your process and resilience is *"about overcoming the problem, so the product got finished, the product was made, and the product was changed"*. However, they later went on to say, *"some people told me resilience was about the company staying the same, the same the shape, not changing to external forces"* (7).

The ability to undergo change and be resilient was related to having a growth/flexible or fixed/inflexible mindset, with one participant saying that resilience is developed by

"having that growth mindset and that ability to kind of learn and improve and deal with feedback and deal with obstacles" (9), and others speaking of the role of feedback and reflection. In the majority of cases participants associated resilience with having a growth mindset. However, the same individual that questioned whether resilience involved changing or staying the same under external pressures, commented that the latter definition would be consistent with people who *"don't want to change their mind about it. they're not really open to the idea. They are very resilient"* (7), this suggesting that those with a fixed mindset are more resilient.

B. How far is too far?

There was much discussion about the extent to which resilience could be taught, with one educator claiming students naturally developed resilience as *"we are already challenging them, you know, by setting exams, assignments …you're already sort of setting them up and not everyone is going to succeed"* (4), implying further interventions may not be necessary. Other participants referred to resilience as a 'by product' of teamwork, problem solving, providing students with incomplete information, other professional skills, complexity, and exposure to authentic tasks. Some also spoke of helping students to develop their ability to reflect and by supporting their wellbeing and encouraging them to make *"good habits, you know…like to, de-stress and focus yourself"* (8). Others focused, not on the content taught, but rather on the way in which it was taught, saying that accessible, available, inspiring, and enthusiastic lecturers that nurture students, help with resilience.

Many considered resilience as coming from practice and experience, with one individual *saying "you develop resilience by having stuff go wrong, having setbacks in your life"* (11) and another that *"it's just practice really…you do things that are hard, and you will learn skills from doing them that will make you more resilient"* (8). Such comments raised questions about the degree to which educators should go to help students in developing their resilience. For example, one educator involved in employability questioned, *"is it ethical at all? because that would potentially put a lot of stress on students. Can we just stress our students for the hell of it and come out of it and say, 'you got something out of it, well done'?"* (2).

Others spoke of the risk posed to mental health. One educator questioned whether focusing on resilience is *"going to make them (students) kind of more anxious and more stressed about that, and maybe lead to a bit more than negative spiral"* (9). Another spoke of being *"careful not to, you know, not to overburden… as much as you want students to be resilient, if they're struggling, you help them"* (11).

3.2 Boundaries and limits

This theme consists of two subthemes: C) the factors that impact upon resilience and the degree to which 'the system' in which an individual resides limits their ability to develop resilience; and D) the types of resilience which fall under the remit of engineering educators, and the extent to which their work is boundaried.

C Resilience as highly individual but impacted by the system.

Participants identified multiple factors which influenced resilience levels, with some questioning the role of nature vs. nurture, and the role of the individual in developing their own resilience vs. the role of external factors in impacting resilience levels.

Of interest were comments regarding both how the institution and discipline may impact resilience levels. For example, when speaking about attrition of students, one educator claimed that their university was *"a bit of anomaly actually…but some people around [names institution] say it's kind of like once you get into [names institution] you stay in [names institution], like people just don't leave"* (13), this suggesting a link between resilience and university status. The discipline being studied was believed to impact upon resilience with one participant claiming the *"engineering degree is notoriously tough"* (1), and another seemingly suggesting that resilience was less important for engineers as *"students are less resilient to ideas that might upset them and do not want to discuss those ideas… it's not something I come across because that's not the nature of engineering education, is it really? To discuss nuanced political and sociological ideas. We teach things which are more or less, proven facts if you if you think about the traditional chalk and talk stuff."* (11)

There was therefore a general recognition that resilience levels were heavily impacted by context with one educator saying *"I really see resilience as not just individual. It's social, it's contextual. And I don't like it when it's used to discuss individual resilience (…) I think that's missing a bigger picture"* (1), and another that *"We're also aware of the fact that, you know resilience is a kind of holistic thing which affects your whole, you know, your whole life at university it's not just about one aspect"*(9). Others spoke about the way in which the burden of developing resilience and to change is placed on the individual rather than the system, and of how this can lead to a tolerance of adversity in the case of minoritized students: *"like women have to be resilient to be able to do, you know, to get up to the glass ceiling, right? They have to adapt and I think in many ways, we have to recognize that that's happening, you know, that people are going to keep changing the goalposts and that, there is an element of power to it, right? That those that don't have power have to be more resilient, if you like, to be able to get anywhere"* (13).

The multifaceted nature of resilience meant participants generally believed its development required personalised approaches which consider contextual factors.

D Limits of the educator

The holistic nature of resilience raised questions about boundaries to the educator's role in its development and supporting students. One participant, involved in employability, described the decision as where to draw the line, *"a tricky one, because it is a holistic thing… you can't just isolate it, and say I want to have good wellbeing within my career, because if you're not happy at work and if you're stressed at work, it does affect all of the other aspects of your life"* (9).

The 'types' of resilience that fell within the remit of educators appeared to vary depending upon their role as either a lecturer or academic mentor. Most participants mentioned the role of academic mentors, with one saying *"you get outside the*

teachings sort of remit and you see the student with their personal life and how that interacts and interferes sometimes with their academic life" (2), and another claiming that it was easier to help students who you did not directly teach as they were worried *"if I say something it will affect my relationship with the lecturer"* (10). These quotes highlight the different roles that educators may have in different capacities of their work and reveals the complexities associated with determining the limits of their work. Other educators advocated for *"treating students as whole people"* (13). A different participant said, *"I think well because we're all humans and all humans help to develop each other and just because we're in an educational setting doesn't take away that human need to support and help each other"* (1). One participant spoke of limits to the ability to do this saying, *"it is absolutely draining… but sometimes you can't help feeling that, if a student fails, then you're failing with them…I've got to stop engaging emotionally with them…I'm the one who's going to fall apart"* (2).

4   SUMMARY AND ACKNOWLEDGMENTS

The findings suggest the existence of inconsistencies in the way resilience is conceptualised, from the ability to change to the ability to "stay the same shape". Such vast differences have implications for the way in which educators support students. Educators described varying approaches to developing resilience with some describing it as an innate part of HE or as a by-product of complexity and problem solving in engineering. Others described equipping students with tools which would allow them to be resilient. This was particularly important given the positivistic nature of engineering and student resistance to open ended problems. Such findings are consistent with the work of Nieusma and Johnson (1996) who focused on career resilience within engineering and claimed that engineering education, in fact, conveys "skills, habits and values that work against flexibility".

Participants recognised individual resilience as impacted by environmental factors including engineering culture and institution type, with some talking about the way in which the burden to change is placed on the individual rather than the system. Such concerns have also been expressed by Mahdiani and Ungar (2021) who question "whether every adverse context calls for a resilience response" In their work they provide the example of poverty, in which resilience may means adapting to the idea of meritocracy. Pawley (2018) highlights the impact of neoliberalism on minoritized students, and alludes to the levels of resiliency necessitated, proposing a shift in "burden of responsibility from individual to the institution" (Pawley 2018).

The results demonstrate inconsistencies in the way resilience is understood, conceptualised, as well as the means by which it is developed in students. Given the emphasis on both resilience as a graduate attribute, but also on student mental health, there is a need for HEIs to provide strong messaging regarding what is meant by the term and how they believe it presents as an attribute of engineering graduates. It is also clear, especially the in light of the equality, diversity and inclusion (EDI) issues already present within engineering, that educators should understand and take on responsibility for providing an environment which allows all students to succeed.

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