(RE)DEFINING ENGINEERS' RESILIENCE: AN EXPLORATORY STUDY INTO HOW ENGINEERING STUDENTS UNDERSTAND RESILIENCE (RESEARCH)

N, Wint [1]
Centre for Engineering Education
UCL, UK
0000-0002-9229-5728

I, Direito [2]
University of Aveiro
Portugal
0000-0002-8471-9105

ABSTRACT

In recent years 'resilience' has increasingly been framed as contributing towards success within higher education (HE), particularly within engineering degrees which prepare students for a profession and thus place emphasis on graduate attributes. Engineering degrees are commonly associated with heavy workloads, high rates of attrition and, increasingly, with growing concerns about student mental health. This raises questions regarding the degree to which a focus on resilience can help students manage the pressures associated with their study, whilst also preparing them for the rate of technological advancement and societal change they will experience as graduates. There is currently a lack of research which focuses on how students perceive this apparent need for them to demonstrate and develop

[1]

N Wint
nat.wint@ucl.ac.uk

resilience. In this work we thus take a qualitative approach to understanding how engineering students conceptualise resilience. In so doing, we make use of data collected from semi-structured interviews with twenty-three engineering students at one UK-based university. Interview transcripts were analyzed using reflexive thematic analysis (RTA). Students described resilience and their resilient responses. Workload, the freedom of university, and peers were seen as the biggest threats to resilience, with teamwork being the most frequently cited learning experience in which resilience was required and developed. Participants primarily focused on the need for a plan and goals to aid motivation. Findings may be used to inform future interventions.

1 INTRODUCTION

From a psychological perspective 'resilience' is defined 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" (American Psychological Association, 2019).

In recent years, particularly since the COVID-19 pandemic (Brammer, 2020), there has been an emphasis placed on the benefits of resilience to student success within HE (Beltman, Mansfield, and Price 2011; Brewer et al. 2019; UCAS, 2018; UNITE, 2017). Much of the literature focuses on resilience as necessary for successful navigation of the workplace (Sant 2013), 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).

This perceived need for students to be resilient seems particularly pertinent within engineering. Firstly, because of the reported heavy workload (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) and high rates of attrition (Hunsu, Carnell and Sochacka 2021). Secondly, engineering degrees traditionally prepare students for a profession and therefore place additional emphasis on employability and graduate attributes (Lucas, Claxton and Hanson; Targetjobs), particularly the 'career resilience' (ECITB 2020; NAE 2014; Nieusma and Johnson 1996) needed for technological advancement and change.

In a systematic literature review on how engineering education research (EER) addresses resilience, Winkens and Leicht-Scholten (2023) found the term linked to engineering students as a personal attribute with the reasons for resilience being: 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. Within EER more widely, Huerta et al. (2021) describes resilience as the "enhanced ability to manage or bounce back from stress" (p. 652). Hunsu, Carnell, and Sochacka (2021) introduce the more specific term of 'academic resilience' (Martin and Marsh 2006) as a theoretical framework to explore how students react to academic challenges. Elsewhere the term has been associated with 'coping with

stress' (Ssegawa and Kasule ,2017), an 'internal thriving competency' (Gesun et al., 2021), self-regulation (Concannon et al. 2019) and self-efficacy (Anthony et al. 2016; Concannon et al. 2019). Finally, the term has been used in relation to equity, diversity and inclusion, with studies focused on the resilience of underrepresented students (Khilji and Pumroy 2019; McGivney 2007; Ross, Huff, and Godwin 2021; Servant-Miklos, Dewar and Bøgelund 2021; Samuelson and Litzlerb 2016).

Mapaling, Webb and du Plooy (2023) made use of data from semi-structured interviews to understand students' perceptions of their own resilience in the South African context. Participants alluded to personal resources, and social resources. Students also expressed tension between maintaining self-care and academic attainment, something associated with a lack of acknowledgement for the systematic, structural nature of issues they faced. In a different study (Mapaling, Webb and du Plooy, 2021) in the same context, students identified language and cultural barriers, as well as their educational background, as impacting their ability to adapt to university. In terms of facilitators of resilience, they identified support of lecturers and peers. Finally, in quantitative work into self-perceptions of resilience among 167 first-year engineering undergraduates, white males and females were found to have slightly higher levels of perceived resilience than underrepresented groups (Moreno-Hernandez and Mondisa, 2021).

However, concerns regarding this discourse within HE more widely (Russell-Watts & Stringer, 2018; Stevenson, 2016; Turner et al., 2017), highlight the use of deficit-based approaches which fail to recognize wider structural inequalities (Stevenson, 2016). Within EER, Pawley (2018) describes how the burden of developing resilience is placed on the individual. Such concerns are significant considering the increasing focus on the mental health of engineering students (e.g., Danowitz & Beddoes, 2018), with barriers to seeking mental health support including a stigma, and cultural norms that suggest "engineering students (should) be resilient through mental health challenges" (Jensen et al., 2023, p.13). Such tensions point to a need to further understand the perceptions of engineering students.

As pointed out by Mapaling, Webb and du Plooy (2023) in their work into academic resilience, "there is a lack of literature that engages engineering students to draw on their own perspectives and lived realities" (p. 178). In this work we address the gap in the literature by taking a qualitative approach to understanding how engineering students conceptualise resilience and how university supports its development.

2   METHODOLOGY

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. Questions thus focused on participants' prior educational experience, their understanding of resilience, examples of times they had demonstrated or developed resilience, and their views regarding the need for resilience in education and the workplace.

Ethical approval was obtained. A call for participants was distributed via internal departmental mailing lists within a public research university located in Wales, UK. As of 2021/2022 the student population was approximately 22,000 students, 81 % of which were home students, and 15% of which studied engineering (HESA, 2022). Twenty-three individuals (see Table 1) provided informed consent to participate. Participants varied in terms of engineering discipline studied and year of study (foundation year, undergraduate/UG and postgraduate/MSc). 17 identified as male and six as female, nine being classed as 'home' students and 14 as international. Interviews took place online or in person according to the preference of the participant and lasted between 20 minutes and one hour. Interviews were recorded and transcribed by the first author and analyzed using reflexive thematic analysis (RTA) following the six-stage process proposed by Braun and Clarke (2006).

Table 1: Participant Characteristics

ID	Gender	Age	Nationality	Engineering Discipline	Year of Study
1	M	20	Zimbabwean	Civil	Year 1 UG
2	M	26	Indian	Nanotechnology	MSc
3	M	26	Indian	Power	MSc
4	M	21	British	Materials	Year 1 UG
5	M	39	Iranian	Civil	MSc
6	M	21	Polish	Chemical	Foundation Year
7	M	25	Indian	Mechanical	MSc
8	F	19	British	Electrical & Electronics	Foundation Year
9	F	22	Nigerian	Aerospace	MSc
10	F	20	British	Biomedical	Year 1 UG
11	M	33	Nigerian	Aerospace	MSc
12	M	24	Sri Lankan	Nanotechnology	MSc
13	M	20	British	Electrical and Electronics	Year 3 UG
14	M	25	Indian	Power	MSc
15	M	21	British	Aerospace	Year 2 UG
16	M	23	British	Mechanical	Year 2 UG
17	F	20	Italian	Aerospace	Year 2 UG
18	F	18	Nigerian	Electrical and Electronics	Year 1 UG
19	M	21	British	Mechanical	Year 2 UG
20	F	23	Kenyan	Civil	Year 2 UG
21	M	18	British	Aerospace	Year 1 UG
22	M	32	British	Power	MSc
23	M	23	Polish	Aerospace	Year 3 UG

A limitation is that participants were self-selected. The findings reflect perspectives of students in one university and transferability is limited.

3   RESULTS

Three themes were generated. This paper focuses on themes 1 and 2. Excepts are labelled (1) to (23) to allow readers to identify quotes from the same participant.

3.1 What exactly is a resilient response?

This theme focuses on differences in views and judgements pertaining to resilience and is split into two subthemes. The first (*A. To change or not to change?*) describes differences in how resilience was conceptualised. The second (*B. "it depends on the situation…different situations demand different things from us"*) relates to varying ways participants react to situations that require resilience.

A   To change or not to change?

For participants, resilience was necessary, firstly *"because failure will happen at some point"* (2), and secondly due to the rate of change. In the former case, students generally described resilience by making use of terms such as 'overcome', 'failure', 'setbacks', 'hardships' and 'challenges', and characteristics such as 'strength', 'courage', 'determination', 'perseverance', and 'capacity' were typically considered as prerequisites to a resilient response. One participant made use of engineering-based analogies, for example, by comparing resilience to *"Newton's third law…equal and opposite reactions"* (16), and describing *"pushing, pushing, kind of like Kaizen in the Toyota production system of this constantly iteratively improving"* (16). Resilience was considered particularly relevant within engineering which was *"harder than most degrees"* and *"challenging"* (20). Engineering industry was considered a *"cut-throat environment"* (16) whereby companies were *"highly selective"* (17) and in which resilience was necessary as it is *"not always going to be a good environment"* (1). This sense of hardship was considered to have increased in a world that is *"changing fast"* (22), and in which *"hard work yields less"* (17), with one participant saying that *"it's getting harder, there are more expectations to meet"* (20).

This notion clearly links with the second reason to demonstrate resilience, which was associated with change. Participants made use of terms such as 'flexibility', 'adaptability' and 'transferability', particularly when referring to transitions between education and the workplace. In the workplace, resilience was deemed as beneficial in terms of innovation, creativity, and the flexibility to transfer knowledge to unfamiliar problems. In relation to this, one perspective was that *"resilience would be what we actually learn in this class, and how useful these newly taught for use in the industry"* (5), with one student saying *"you're going to look up and say, okay. I've never seen this before. I don't have a reference to start from, but I'm going to look at it, and I want to find the solution. I'm going to find a way. I'm going to keep looking at it "(*1). In comparison, a different participant who had worked in India, explained that industry did not require resilience as *"you are not allowed to think outside the*

box…you need to go as per their regulations and rules" whereby managers have *"power in their hands"* and in which you *"needed to be loyal to the organization"* (7).

However, there was some variation in views as to what resilience was. For example, on the contrary to those who spoke of flexibility and adaptability, one participant believed that resilient people were *"very steadfast in how they think about their own ideas... you could equate it to being a little bit stubborn in resisting change"* (15).

B "It depends on the situation…different situations demand different things from us"
Participants described different responses to failure, this being articulated clearly by one student who said that how they react *"depends on the situation because different situations demand different things"* (3). For many, their response involved stages, the first involving stress and emotion, with one student saying *"I also do allow myself to be down and to feel sad. …maybe, after a few days get back to my thing because I feel like life must go on"* (20) and another that they *"stress out a lot at the beginning. Then, after that I'd kind of calm down, and actually do something about it"* (10). This stage was typically followed by *"putting it into perspective"* (6) and a more philosophical approach, which was sometimes linked to religion and faith. For example, students told themselves *"there are more opportunities"* (5) and that it's not *"the end of the world"* (6). This helped them look forward, with one saying that *"once something is done, it is done, and you're not getting back that time, so make sure you do that thing better the next time"* (2), and another that you have to *"accept the past is in the past. You can only change what happens in the future"* (15). For one participant, not moving on *"would somewhat cost in the future as well"* (9). This more philosophical approach was often related to having a growth mindset, for example *"the idea that instead of focusing on the fact that last time when I did a lot of work, it didn't go so well, like its instead trying to build on what I did"* (6). One participant described asking themselves *"are you happy with what you have done? If you die tomorrow, are you happy with where you are"* (12), using this as motivation.

A third, more strategic phase was then required, or what one student referred to as *"sober decisions…when I'm in a very clear mind and I know what I am doing"* (12) and involved making use of strategies, and techniques, for example determining *"what the steps are, and how to get it done"* (4) or making use of time management by *"chart(ing) it out on a priority basis"* (3). In some cases, participants described the stages involved, for example questioning *"what could you have done differently?"* (19) and another that they would *"try to understand what might have gone wrong….and if it makes sense to me, I would like really change the way that I do it, because I just it's all about learning from your mistakes"* (3). The need to analyse the situation was mentioned by several participants, one described the need *"to analyze it to the point where I cannot analyze it"* (8). The mix of approaches was perhaps articulated most clearly by one student who said that sometimes *"you just have to accept the situation… look at myself, try and improve myself the best way I can. Also look at the other lens of sometimes there's nothing more you can do, you've done the best you can"* (1). To this end, there appeared to be some level of judgment

required in terms of response, for example if *"It's a lost cause I don't worry about it. But if there is something we could do about that's when I stress out."* (10).

3.2 Facilitating factors and inhibiting influences

This theme focuses on factors impacting resilience levels and is split into two subthemes. The first (*C. The cohort effect*) focuses on the degree to which resilience depends on individuals compared to others around them and the second (*D. Failing to plan and planning to fail*), on the role of planning in enabling resilience.

C. The cohort effect

Many participants spoke of resilience as an individual characteristic. One student said it must *"come from like inside…an internal sort of mental mindset"* (16), another describing it as being *"able to internalize things"* (20). These views were linked to accountability and responsibility, with one participant saying *"I'm not treating this as someone else's mistake. I rather try to take it as my own"* (23), another believing that *"a lot of engineering students just don't really except that reality"* (16).

Despite this focus on the individual, peers were seen as influential, this being unsurprising considering the time spent together in university. One participant claimed that *"if this group of students has a negative outlook, that does not help an individual at all"* (12) and another that *"if I'm surrounded by people who are lazy, then I'll tend to be same"* (21). Another student said, *"say our peers are not succeeding, that would mean the resilience of the group is lower"* (23). A different participant added that it was problematic *"if you have people around you that just are in a perpetual self-doubt situation, and they come to you for confidence"* (16). On the contrary, *"if you're with a group of people that is very studious and resilient… I would be more likely to be like that"* (17). Likewise, one student stated that they *"try to find the people that are resilient and that just gives a boost of morale"* (18) and that if friends show *"show resilience, you kind of want to do the same"* (19).

It is perhaps unsurprising therefore, that teamwork was the main learning activity that was considered to require and help develop resilience. For example, one participant claimed that *"working in a team can help you better understand resilience and learn from the views around how to handle tough situations"* (3) and another that *"when you're in a group you've got the motivation of working with people around you"* (13). Another participant alluded to the accountability involved saying that they had to think *"about the group as a total…so I should deliver this"* (23).

D. Failing to plan and planning to fail:

Participants mentioned several factors influencing resilience including diet and physical health as well as past success. For some, external *"distractions"* were considered as *"test(ing) you a lot"* (1). These distractions were seen as particularly problematic for those new to university *"because now you can do whatever you want to… so like that's also kind of one that pushes my resilience because now I have to keep my morals"* (1). Many participants also mentioned a need to be resilient because of the distraction of social media.

Most of those interviewed spoke about their motivation or goals. For one participant, you were able to be resilient *"once you have goals, no matter what you go through. Sometimes you do slip…. but as long as you have goals"* (20). Perhaps unsurprisingly given the context, the majority of students spoke about career plans, with one speaking of having *"had all the career paths, everything set in plan …. And I didn't want to give up my dream of…I had that mental picture of me"* (2), this meaning that they were motivated to react in a resilient manner when encountering failure. However, sometimes having a clear plan was considered detrimental, with one participant saying that you could be more upset when encountering failure *"if you're a very, planning oriented person and don't like things to not go to plan"* (17). A different student added that *"planning is an important part, but to be too rigid in your planning can also, you know, impacts negatively. So, I'm happy to change the way, to analyze and plan and change the way that I do things"* (3).

For many, it was these goals, and the consequences of not meeting them, which enabled them to take *"a bit of pain for that pleasure later"* (19) with one participant saying that *"having consequences as well helps build that resilience"* (1) and another explaining that sometimes *"the consequences can be quite big if something goes wrong"* (22). Another mentioned that they thought they were *"far more resilient since I've come to university because there is almost a lot more on the line"* (21). However, one participant claimed that unfair consequences "kind of messes with your resilience" (1) explaining that *"there were multiple times I was punished for nothing, and that pushed me to be resilient"* and that *"sometimes I'd work hard in high school, and the reward wouldn't come. But then that would push me to work harder. And then, now that I'm here I sometimes don't work hard but then I get more reward than I deserve… I mean I did the wrong thing"* (1).

4   SUMMARY

The findings suggest the existence of inconsistencies in the way resilience is conceptualised, from being flexible and dealing with change, to being 'steadfast' and 'stubborn'. Participants all saw the benefits of being resilient, this often being discussed in relation to how fast the world was changing technologically, but also in terms of competitiveness. Students described dealing with failure in several ways: by letting themselves feel emotion, by taking perspective, and by planning for the future. How they reacted appeared to depend on several factors including the importance of the situation and how motivated they were. Peers were seen as one of the most influential factors impacting individual resilience, with teamwork being the primary learning experience in which students claimed to develop and demonstrate resilience. Together, the findings point to a need to support students in understanding the situations in which it is desirable to be resilient, as well as assessing the short- and long-term benefits and costs of resilience at an individual level, something which would require students to have an understanding of their own values and moral beliefs.

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