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RESEARCH ARTICLE

How do engineering students understand and conceptualize individual resilience?

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Abstract

Background: There is increasing focus on developing resilient engineering students, this being linked to the perceived difficulty of degrees and the rate of technological change. Simultaneously, there continue to be issues with diversity and retention, and concerns regarding student mental health, both of which have been linked to resilience. Despite this, beliefs that engineering students hold about resilience and what it means to be resilient remain largely unexamined.

Purpose/Hypothesis: We explore the role of underlying structures and contextual factors in shaping engineering students' perceptions and experience of resilience within engineering education and practice.

Design/Method: We conducted semi-structured interviews with 23 engineering students in a UK-based institution. Transcripts were analyzed using reflexive thematic analysis (RTA).

Results: Students recognized resilience as important within engineering education and practice, but highlighted the detrimental impact that a focus on resilience can have on mental health. Whether resilience was necessary, as well as what constituted a resilient response, appeared to vary depending on the situation and required some level of judgment. Students appeared to believe that the university environment provided the adversity required to develop resilience but played a less significant role in providing the support necessary for positive adaptation.

Conclusions: This work acts to surface implications of situating resilience as a desirable student or graduate attribute without consideration for wider structural inequalities. Failing to expose assumptions regarding the situations which require a resilient response risks further perpetuating the very issues around diversity, retention, and progression, which the development of resilience has been proposed to overcome.

KEYWORDS

Graduate attributes, mental health, professional skills, reflexive thematic analysis, resilience, student development, student experience

1 | INTRODUCTION

There is increasing emphasis placed on the need for engineering students and graduates to develop and demonstrate resilience, this being attributed to both the difficulty and stress associated with an engineering degree (Beddoes & Danowitz, 2022; Cross & Jensen, 2018; Godfrey & Parker, 2010; Jensen & Cross, 2021; Stevens et al., 2007; Wilson et al., 2022) and the rate of change within the workplace (ECITB, 2020; National Academy of Engineering, 2004; Nieusma & Johnson, 1996). At the same time, there exist growing concerns for students′ mental health, with reported increases in suicidal ideation (5.8%–10.8%), the use of mental health services (18.7%–33.8%), and diagnosed mental health conditions (21.9%–35.5%) between 2007 and 2017 (Lipson et al., 2019). Such concerns are particularly acute within engineering (Beddoes & Danowitz, 2022; Danowitz & Beddoes, 2018; Danowitz & Beddoes, 2020; Hargis et al., 2021; Jensen et al., 2023; Jensen & Cross, 2021; Lipson et al., 2016; Posselt & Lipson, 2016), with one study reporting engineering students to be twice as likely to experience mood and anxiety disorders compared with the general college population (Danowitz & Beddoes, 2018). Mental health symptoms impact academic performance, satisfaction with the college experience, and retention (Bruffaerts et al., 2018; Deberard et al., 2004; Eisenberg et al., 2012; Hartley, 2011) and can impair students from engaging in the workforce, thus impacting global competitiveness (Danna & Griffin, 1999; Davlasheridze et al., 2018). Furthermore, the role of identity, race, ethnicity, and gender in shaping help-seeking behavior (Downs & Eisenberg, 2012; Masuda et al., 2012) has implications for ongoing issues around the attraction and retention of diverse individuals. Given what is known about the role of resilience in managing stress and mental health (Asghar & Minichiello, 2023; Huerta et al., 2021; Ssegawa & Kasule, 2017), along with critiques which propose that deficit-based approaches to resilience overlook wider structural inequalities (Stevenson, 2016), continued work focused on understanding resilience is important for outcomes and equity in the field. Previous research has highlighted a cultural expectation for "engineering students to be resilient through mental health challenges" (Jensen et al., 2023, p. 13), something that prevents them from seeking mental health support. We extend this work by exploring engineering students′ views about the importance and relevance of resilience within engineering, as well as the means by which it is developed. By studying the perceptions of a sample of engineering students in an institution based in the United Kingdom (UK), we surface previously unexamined beliefs and lived experiences regarding the need for them to be resilient.

2 | BACKGROUND

Resilience is a multifaceted construct that is conceptualized differently across a range of fields, including materials science, ecology, and psychology. A systematic literature review on its use within engineering education research (EER) (Winkens & Leicht-Scholten, 2023) showed it to be used both in relation to individuals (e.g., graduate attributes) and systems (e.g., engineering systems, see Hollnagel et al., 2006). In considering the resilience of engineering students, this work focuses on the former.

2.1 | Resilience as a psychological concept

The study of resilience in human development has primarily taken place within the field of psychology, where it is considered as the capacity to maintain adaptive outcomes, in the presence of adversity. The American Psychological Association (APA, 2018) defines the term as "the process and outcome of successfully adapting to difficult or challenging life experiences, especially through mental, emotional, and behavioral flexibility and adjustment to external and internal demands."

As a psychological concept, resilience can be considered in a variety of ways, this having implications for its application in engineering education. For example, it can be viewed as a process of change (Brooks & Goldstein, 2004) where the focus is on the interaction between an individual and their context (Luthar et al., 2000; Tudor & Spray, 2017). It is also perceived as an individual trait (Maltby et al., 2015; Maltby & Hall, 2022) which can be learned and developed (Fletcher & Sarkar, 2013), and which is sometimes referred to as "resiliency," linked to an individual's characteristics, and measured through a number of different psychometric tests (Bartone et al., 1989; Block & Kremen, 1996; Connor & Davidson, 2003; Smith et al., 2008; Wagnild, 2009). Resilience is often measured indirectly, whereby associated

psychological concepts (e.g., optimism, autonomy, conscientiousness, and emotional stability) are used to explain resilient outcomes. However, approaches to measuring resilience are generally seen as problematic within the wider literature, with the term being considered as conceptually weak and overlapping with other constructs. Furthermore, there is a lack of justification for the selection of items within instruments, and many are specific to one context or population (Atkinson et al., 2009). The conceptual and theoretical adequacy of some of the scales is therefore questioned (Windle et al., 2011).

Before moving on to an overview of the study of resilience within EER, there is a need to differentiate the term from other psychological concepts. One term that is often used interchangeably with resilience is "grit." Both are used in relation to the ability to persevere through hardships and are considered key to coping with mental health pressures, thus being linked with improved educational success and personal well-being of students (Stoffel & Cain, 2018). Whereas "grit" has been explored in EER as being synonymous with "perseverance" in the face of setbacks (Direito et al., 2019), it is important to note that the construct is a combination of "perseverance" (ability to work hard and consistently towards a goal, even when experiencing setbacks) and "passion" (consistency of interest—the ability to hold the same interests over time) and is defined as the "perseverance and passion for long-term goals" (Duckworth et al., 2007). Whereas grit is goal-oriented, with a clear focus on achieving long-term objectives, resilience generally refers to the ability to maintain or regain mental health after experiencing adversity or stressful and negative experiences and is more focused on positive adaptation in response to challenging experiences. Thus, resilience is considered to be an inherent attribute of grit (Stoffel & Cain, 2018).

2.2 | Engineering education research on individual resilience

In a relatively recent systematic literature review of the use of resilience within EER, Winkens and Leicht-Scholten (2023) summarize five reasons for student resilience: persistence in completing studies; adapting to changes in educational settings during COVID-19; learning from failures and errors; coping with stress, adversity, and challenging situations; and resilience as a desired attribute, outcome, or competence. In fact, the resilience of students has been investigated in various engineering education–based studies. Gesun et al. (2021) describe resilience as an "internal thriving competency," with Ssegawa and Kasule (2017) defining "resiliency" as "coping with stress," something that they deem necessary for managing the self. The same authors make use of the more specific term "academic resilience," as a desirable graduate attribute (Ssegawa & Kasule, 2017), something that is shown to have a high correlation with the professional success of engineers (Berberat & Goldschmid, 1989; Harvey et al., 1994). Similarly, Huerta et al. (2021, p. 652) claim that resilience is instrumental to becoming a good engineer, referring to it as an intrapersonal, noncognitive competency and the "enhanced ability to manage or bounce back from stress."

Other work has focused on the factors that influence, and are impacted by, resilience. For example, Hunsu et al. (2021) adopt "academic resilience" (Martin & Marsh, 2006) as a theoretical framework that conceptualizes resilience as an interaction between risk or adversity, protective factors and positive adaptation, and use it to explore how students cope with academic stress, adaptability, academic engagement and achievement, and student retention. Paul et al. (2021) demonstrated the negative relationship between stress and overall GPA as buffered by resilience and moderated by student engagement. Buckley et al. (2023) describe how resilience can support students in overlooking or minimizing environmental factors that may otherwise negatively affect their sense of belonging. Mapaling et al. (2021) describe how language and cultural barriers, as well as educational background, impact students' ability to adapt to university and highlight the supportive role of lecturers and peers as facilitators of resilience.

Other factors that have been suggested to play a role in the development of resilience in the context of engineering education include social support (Ecklund, 2013; McGivney, 2007), formal and informal support systems including student services and family and friends (Ross et al., 2025; Rulifson & Bielefeldt, 2020), and culture and identity (Moreno-Hernandez & Mondisa, 2021; Ross et al., 2021; Samuelson & Litzler, 2016). 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).

2.3 | Development of resilience in engineering education

Despite this interest, there is little work that describes the use of teaching approaches involved in its development (Winkens & Leicht-Scholten, 2023), with the small number that do exist focusing on courses that involve overcoming

failure (Simpson et al., 2018) and the uncertainty and difficulties experienced during problem-based and active learning (Winkens & Leicht-Scholten, 2023), challenge-based learning (Membrillo-Hernández et al., 2019), project management and teamwork (Čavrak et al., 2019; Neumeyer & Santos, 2023; Silva et al., 2020), and entrepreneurship education (Mapaling et al., 2023; Neumeyer & Santos, 2023; Täks et al., 2014). Mindfulness and other contemplative practices have also been used to foster and promote resilient behavior and academic resilience (Huerta, 2018; Huerta et al., 2021), as well as interventions focused on mental health and well-being (Mapaling et al., 2021). To this end, Asghar and Minichiello (2023) call for a more balanced examination of mental health advocating positive psychology and mental health strengths, such as hope, resilience, and optimism.

2.4 | Resilience as a normative concept

Resilience also features within EER focused on issues of diversity, equity, and inclusion (DEI). Long and Mejia (2016, p. 214) frame resilience as an asset saying that "It is a serious problem when society inaccurately stereotypes minorities as low-income and poorly educated, while ignoring their resilience, efforts to change the status quo, and contributions to American society." McGivney (2007) and Servant-Miklos et al. (2021) focused on the resilience of mature students. Elsewhere, researchers have explored the resilience of women (Khilji & Pumroy, 2019), African American and Latino students (Samuelson & Litzler, 2016), and Black women (Halkiyo & Hailu, 2023; Ross et al., 2021) within engineering.

Although resilience is primarily framed as positive within EER, there is a need to engage in debates around it being descriptive or normative (evaluative) in nature. For example, Thorén and Olsson (2017) claim that the application of resilience to a specific scenario requires the use of a normative framework, with Ferrarello (2021) highlighting a need to define the reference point to which a resilient system should return.

It is thus important to highlight work that makes use of critical approaches to studying resilience. For example, within neoliberal logic, resilience can be considered as emphasizing "self-awareness, reflexivity and responsibility. It encourages the idea of active citizenship, whereby people, rather than relying on the state, take responsibility for their own social and economic well-being" (Joseph, 2013, p. 42) "in the context of austerity and worsening inequality" (Gill & Orgad, 2018, p. 2018). It can thus be considered as a "neoliberal form of governmentality that places emphasis on individual adaptability" (Joseph, 2013, p. 38) which centers "innovativeness, enterprise, responsibility and flexibility" (O'Malley, 2010, p. 488).

In the context of higher education (HE), concerns regarding the use of resilience (Russell-Watts & Stringer, 2018; Stevenson, 2016; Turner et al., 2017) highlight the adoption of deficit-based approaches that fail to recognize wider structural inequalities (Stevenson, 2016). More specifically within EER, Pawley (2019) highlights the ways in which the "ruling relations" of US engineering departments act to "unduly impact minoritized students." She describes how neoliberalism places emphasis on the individual, who carries the burden of responsibility for obtaining the knowledge and cultural capital already acquired by the privileged who bring it with them to university. She alludes to the levels of resiliency necessitated and proposes a shift in "burden of responsibility from the individual to the institution" (p. 21). These perspectives are particularly important given increasing concerns about the mental health of engineering students (Beddoes & Danowitz, 2022; Danowitz & Beddoes, 2018; Danowitz & Beddoes, 2020; Hargis et al., 2021; Jensen et al., 2023; Jensen & Cross, 2021; Lipson et al., 2016; Posselt & Lipson, 2016). For example, a stigma and cultural norms that require "engineering students to be resilient through mental health challenges" (Jensen et al., 2023, p.13) have been cited as barriers to students seeking mental health support. In a study focused on understanding students' perceptions of their own resilience within a South African context, Mapaling et al. (2023) reported that participants expressed tension between maintaining self-care and academic attainment, something associated with a lack of acknowledgment for the systematic structural nature of issues they faced. Such tensions point to a need to further understand the perceptions of engineering students, with Mapaling et al. (2023) claiming there to be "a lack of literature that engages engineering students to draw on their own perspectives and lived realities" (p. 178) with respect to resilience.

The literature thus highlights how the significance, perceptions, and experiences of resilience within engineering education are shaped by a variety of factors including challenging course loads, the global pandemic, a changing workplace, and increasing mental health issues. Despite the evident growing interest in resilience, there is little work that describes the use of teaching approaches involved in its development (Winkens & Leicht-Scholten, 2023), this being complicated by the variety of ways in which the term is conceptualized. Furthermore, several factors have been found to influence its development, with the lack of acknowledgment for structural systemic issues resulting in students

experiencing tension. In this work, we seek to address a gap in the understanding pertaining to how contextual factors and systems impact how engineering students conceptualize resilience, as well as the importance they place on its development. In doing so, we make use of a critical realist (Bhaskar, 1975) lens which acknowledges the role of underlying structures or mechanisms that shape individual perceptions and experiences.

2.5 | Research purpose and questions

This work makes use of semi-structured interviews to uncover how 23 UK-based engineering students conceptualize and experience resilience. In so doing, it addresses the following research question:

> What underlying structures and contextual factors shape engineering students' perceptions and experience of resilience within engineering education and practice?

The answer to this question will help understand the degree to which a common definition of resilience exists for engineering students and the extent to which they feel their education should support their resilience. This understanding will help identify areas in which future research is needed to understand the different aspects of resilience, the situations in which it may be developed, and thus the design of effective interventions.

3 | POSITIONALITY

In this section we consider the six fundamental aspects of research impacted by our positionality, as outlined by Secules et al. (2021).

Natalie: I am currently an engineering lecturer and therefore consider myself an "insider." As a researcher, I am drawn to the richness of qualitative data, but I recognize that my training and socialization within a positivistic paradigm means that I am sensitive to arguments around the rigor and quality of qualitative research. As an educator, I have been encouraged to help students to develop resilience but feel conflicted and have concerns regarding the potential negative consequences associated with resilience-based interventions. I am increasingly aware of the impact that the marketization of HE has on the development of students who are often viewed as customers and who tend to resist the type of challenging situations that are often associated with the development of resilience. At the same time, I have concerns about the rise in mental health issues within engineering education. I am also aware of the way in which the discourse around resilience emphasizes the role of the individual and have concerns about the impact this has on equity and social justice. To some degree, this concern is a result of my own experience, having been told that I should exhibit increased levels of resilience on numerous occasions, often in reaction to speaking about the upset I feel after experiencing, what I consider to be, injustice. I acknowledge that my positionality as a female engineering lecturer has shaped the topic and questions associated with this research, as well as the processes involved in data collection and analysis.
I am aware that I need to question the extent to which analysis is limited, or expanded by, my own feelings and views. Working with Inês provides the opportunity for me to check, and to question, the limits of my own reflexivity.

Inês: I am an engineering education researcher with a background in (clinical and health) psychology. My academic training emphasized positivist approaches to understanding cognition and behavior, as well as the psychometric assessment of psychological constructs and traits. I have conducted studies on individual attributes such as grit and growth mindset that challenged my perspective on how psychology constructs are studied in engineering education and my approach to these constructs as a researcher. I am committed to examining psychological attributes and their influence on personal development and well-being from an asset-based perspective, and to considering the critical role of social contexts. More recently, my

research interests have expanded to include resilience, emotions, and empathy in engineering education. A key motivation to engage in this study was to understand how resilience is conceptualized in engineering education, as prior literature reviews indicated that psychological constructs are inconsistently defined in the field. I do not hold a teaching position, which places me outside the traditional educator role often associated with EER. Nevertheless, this positioning enables me to bring a complementary perspective to this study through interdisciplinary dialogue with Natalie.

4 | METHODOLOGY

This research seeks to understand the importance of individuals' subjective experiences and provide a platform for student voices to be heard. A broadly experiential orientation is thus adopted, this being underpinned by a critical realist ontology and contextualist epistemology.

According to critical realism (Bhaskar, 1975), the social world can only be understood on the basis that unobservable structures cause observable events. A critical realist approach thus combines a realist ontology (a real world exists) with an interpretative epistemology (emphasizes subjective experiences).

This approach is seen as appropriate given the complex nature of the higher education system in which individual activities are shaped by social context and in which underlying structures or mechanisms (e.g., psychological, social, cultural) influence how people perceive and experience resilience. Adopting critical realism thus allows for understanding personal accounts of resilience while acknowledging the role of culture and interpretation.

4.1 | Participants

Ethical approval was obtained from the Engineering Ethics Committee at the UK-based public research-intensive university at which this study took place. As of 2022/2023, the population was approximately 21,510 students, 80% of whom were home students, and 14% of whom studied engineering. Approximately 8% of engineering students were postgraduate (taught) students and 91% undergraduate (HESA, 2022). A call for participants was distributed via internal mailing lists and posters that were placed within the main buildings. Participants were asked to identify as being taught engineering students (either undergraduate or taught master's) and were provided with the following information regarding the study: "There is growing pressure for engineering students to demonstrate their resilience within both academic and industrial settings. This research focuses on understanding the ways in which you interpret the term 'resilience' and the experience you have of developing resilience within an academic context. We hope to understand how important you feel development of resilience is for success within your future career. We hope to gather insight into the ways you feel you have developed resilience and the opportunities which you are given to demonstrate your resilience."

Twenty-three individuals provided informed consent to participate and agreed to provide demographic information (see Table 1). Each participant was given a £15 Amazon gift voucher in exchange for their time. Participants were studying a variety of engineering disciplines: 14 were international and 9 were from the United Kingdom; 17 identified as male and 6 as female; 14 were undergraduate and 9 were enrolled in postgraduate taught (MSc) programs, some of whom had worked in industry between their undergraduate and master's programs.

4.2 | Data collection

Data was collected via semi-structured interviews, which involve social interaction based on a conversation (Rubin & Rubin, 2012; Warren & Karner, 2014), allowing knowledge to be "constructed in the interaction between the interviewer and the interviewee" (Brinkmann & Kvale, 2015, p. 4) and providing researchers with the opportunity "to understand the world from the subjects' point of view, to unfold the meaning of their experience, to uncover their lived world" (p. 3). The use of in-depth semi-structured interviews ensured that both the research questions and the literature-based concepts associated with resilience were covered while also allowing the researcher to direct conversation in ways that had not previously been envisaged and/or to cover aspects that appeared to be meaningful to the

TABLE 1 Participant information.

ID	Gender identity	Age	UK/international	Current engineering discipline	Current year of study
1	M	20	International	Civil	Year 1 UG[a]
2	M	26	International	Nanotechnology	MSc
3	M	26	International	Power	MSc
4	M	21	UK	Materials	Year 1 UG
5[c]	M	39	International	Civil	MSc
6	M	21	International	Chemical	Foundation Year[b]
7[c]	M	25	International	Mechanical	MSc
8	F	19	UK	Electrical & Electronics	Foundation Year
9	F	22	International	Aerospace	MSc
10	F	20	UK	Biomedical	Year 1 UG
11[c]	M	33	International	Aerospace	MSc
12[c]	M	24	International	Nanotechnology	MSc
13	M	20	UK	Electrical and Electronics	Year 3 UG
14[c]	M	25	International	Power	MSc
15	M	21	UK	Aerospace	Year 2 UG
16	M	23	UK	Mechanical	Year 2 UG
17	F	20	International	Aerospace	Year 2 UG
18	F	18	International	Electrical and Electronics	Year 1 UG
19	M	21	UK	Mechanical	Year 2 UG
20	F	23	International	Civil	Year 2 UG
21	M	18	UK	Aerospace	Year 1 UG
22[c]	M	32	UK	Power	MSc
23	M	23	International	Aerospace	Year 3 UG

[a]UG = Undergraduate.
[b]Within the UK, Integrated Foundation Year programs are typically offered to those entering higher education without meeting the traditionally accepted entrance requirements and they are thus designed to help develop the skills and knowledge necessary for progression into the first year of a traditional degree scheme.
[c]Indicates participants who had experience working in industry between undergraduate and postgraduate levels.

participant. It was therefore possible to explore subjective meanings, experiences, and specific details of each participant (Guba & Lincoln, 1994), which is considered important given the relationship between resilience and life experience and personal challenges.

The interview protocol was informed by the authors' interests in critical literature, which highlights the lack of acknowledgment for the systematic, structural nature of issues impacting resilience, and that around student mental health and the workload and difficulty associated with engineering degrees. Participants were thus asked questions including how they would define resilience generally and within the context of engineering education; factors which they felt impacted their resilience levels; examples of times and ways in which they had demonstrated and developed resilience both within and outside university; their belief pertaining to the role of educators and the university in supporting resilience; how they believed resilience should be developed within the context of higher education; and the advantages and disadvantages of being resilient within education, the engineering profession, and life more generally.

Interviews lasted between 20 and 60 min and were conducted by the first author who kept a reflexive journal as a "self-critical account of the research process" (Nowell et al., 2017, p. 3). Entries included details about feelings and thoughts experienced, as well as ideas regarding data interpretation. This allowed them to reflect on their role in the research process and to ask themselves questions which helped them to understand and interrogate their initial responses.

4.3 | Data analysis

Interviews were transcribed by the first author who analyzed the transcripts using RTA. In broad terms, TA is referred to as "a method for developing, analyzing, and interpreting patterns across a qualitative dataset, which involves systematic processes of data coding to develop themes" (Braun & Clarke, 2022, p. 4). In making use of the term reflexive TA (RTA), Braun and Clarke (2019) situate researchers as interpreters of meaning, framing subjectivity as an asset. RTA is considered a useful method when studying under-researched areas (Braun & Clarke, 2006) and its focus on interpretation of patterns of meaning across data sets is suitable when exploring how people make sense of abstract, multidimensional concepts such as resilience. It is particularly useful during the study of phenomena present within the social world of researchers, whose personal views and perceptions form part of data interpretation.

RTA is flexible in nature and is not used with specific theoretical frameworks. This has implications for the research process, and researchers should ensure that their methodological decision making is clearly communicated. Thus, in considering subjectivity as an asset, we acknowledge reflexivity as being "about more than just one's positionality—it is about the role of the researcher as an active agent in the production of knowledge" (Trainor & Bundon, 2021, p. 707). Throughout this work, we intend to communicate our role in the production of knowledge and our reflexive process in relation to the six-stage analytical process proposed by Braun and Clarke (2006), with Table 2 providing a summary of research quality practices.

Familiarization "involves both closeness and familiarity (immersion) and distance (critical reflection)" (Braun & Clarke, 2022, p. 43). During this stage, audio recordings of the interviews were transcribed verbatim and read by the first author. Journal entries were made throughout these stages and included any thoughts, ideas, and emotions encountered. While re-reading each transcript, the first author made notes about ways in which they were interpreting and making sense of the data, including reasons they believed that participants may be making sense of resilience in the way that they were; whether their sense-making was consistent with their expectations of the work and any surprises they experienced; any reasons they may have been interpreting the data in the way they were; and whether the data could be interpreted in any other ways. In some cases, possible answers to these questions were recorded. For example, they found themselves getting quite upset and angry when students claimed that educators did not care and thus wrote down reasons they felt this way, as well as ideas regarding what the participants meant and felt. A document detailing the way each participant made sense of resilience was produced, as well as a summary outlining overarching thoughts and potential patterns across the dataset.

Coding involves working through the entire dataset and "identifying segments of data that appear potentially interesting, relevant, or meaningful for your research question" (Braun & Clarke, 2022, p. 35). Coding allows for systematic engagement and means that the subsequent theme development can be based on robust analysis. Prior to coding each

TABLE 2 Research quality practices.

Process	Criteria
Transcription and familiarization	Prolonged engagement with the data (Lincoln & Guba, 1985). Data transcribed in detail and checked against recordings Documentation of reflective thoughts and those about possible codes and themes Each data item given thorough attention. Each transcript read multiple times. Three rounds of coding.
Coding and theme generation	Peer debriefing/collaborative coding. Reflexive journaling Audit trail of code generation Collation of all extracts for each theme Themes move beyond topic summaries Initial themes checked against coded data and original transcripts Themes checked to ensure internal consistency and presence of a central organizing concept Diagramming of themes to make sense of theme connections.
Analysis and interpretation	Analysis and data match each other and thus the evidence supports claims made in the analysis. Analysis addresses the research question Data is contextualized to aid transferability Result include interpretation along with description.

transcript, the first author read the corresponding reflexive journal entries to remind them of any initial thoughts they had had. This process allowed them to reflect upon the way that their positionality may impact what they found interesting and meaningful within the data. They then began manually tagging any data they found interesting or relevant to the research questions with a code label.

Coding followed an inductive approach (while recognizing that pure induction is impossible) and, during the first round, focused on semantic codes. Codes were added during the second and third rounds of reading, and coding became more focused on latent codes. A process of code simplification and refinement took place and, in cases where there were similar codes across transcripts, codes were combined. The codes evolved throughout the process and began to include references to what the authors thought was most interesting or important about the meaning. In cases where code labels lacked nuance and depth and were being used to capture multiple meanings instead of a singular idea, code refinement was guided by Braun and Clarke's (2013) suggestion that "good" codes that "capture the essence of what it is about that bit of data that interests you and informative enough to capture what was in the data, and your analytic take on it" (p. 210). For example, the original code label "resilience as navigating change" was parsed out to include information about different types of change (ability to transfer knowledge and skills, navigating transitions from university to work, and adaptability and flexibility). Similarly, "educators impact student resilience" was parsed out into the different attributes that encourage resilience (e.g., providing encouragement, being motivational, availability, role modeling). A list of final codes and associated data extracts was compiled. It was ensured that, together, the codes captured and reflected the diversity of meaning that had been commented upon within the journal entries. The first author was aware that their positionality influenced what interested them in the data (e.g., their interest in the marketization of HE, and equity and mental health issues within engineering education), and that they had their own understanding of resilience within engineering education. They thus made a conscious effort to separate their personal response to the data from that which was relevant and useful to the overall analysis. While considering subjectivity as an asset, they were mindful that their response would not be the only possible response to the data. A collaborative coding process was used to enhance understanding and interpretation, and to examine the limits of their reflexivity. The aim of this was to question and interrogate their beliefs regarding what they considered important insights rather than to reach a consensus about data coding. Thus, in some cases they wrote a note to discuss their interpretation of the data, as well as their coding, with the second author. Theme generation involved "identifying shared patterned meaning across the dataset" and compiling "clusters of codes that seem to share a core idea or concept" (Braun & Clarke, 2022, p. 35). Themes thus differ from topic summaries which collect responses around a topic (e.g., factors which impact resilience). While a topic summary may focus on definitions of resilience and thus contain many micro-patterns, this would be thin and more like a code. For example, looking beyond semantic responses in the data, we noticed patterning across definitions of resilience (for example related to change). However, this patterning was not just related to the definitions of resilience provided and was not limited to the data instances where definitions of resilience were given. Instead, the authors looked across the entire dataset for instances where change was mentioned (for example, it was also used in relation to reasons resilience is necessary).

Initial themes were generated. A thematic map allowed visualization of the "overall story the analysis tells, identifying boundaries around themes, and connections across themes" (Braun & Clarke, 2022, p. 102). For example, it allowed the authors to identify interesting ideas that did not fit within the rest of the story. Development and review of themes involved reengaging with coded data extracts to ensure there was meaningful data to evidence the theme. It was ensured that themes had an identifying central organizing concept, with some nuance and diversity, as well as clear boundaries. During this process, the authors engaged in questioning the assumptions made by both themselves and participants as part of a pattern of meaning, wider meanings that patterns relied on, why the pattern mattered, and the implications of a pattern in light of the research question, and for participants the audience of the work, as well as society in general. Unallocated codes were collected for potential use during any further theme development. All data extracts were then revisited to ensure that they contributed towards one clear central concept and provided different manifestations of the concept, and that each theme was clearly demarcated with a clear synopsis and informative title that signaled both its meaning and analytic direction. Vivid data extracts from a range of data items were selected to illustrate analytic points and represent the different facets of each theme.

The contextualized nature of qualitative research is in tension with notions about transferability of findings to other contexts (Polit & Beck, 2010), and, as researchers, the authors thus recognize the need to resist the urge to frame lack of generalizability as a limitation of their research (Braun & Clarke, 2022). They do, however, recognize the benefit of reflecting on the way the context shapes findings and interpretations, and of connecting understanding of an issue

with something broader. To help allow some degree of transferability, they have thus attempted to demonstrate "sensitivity to context" (Yardley, 2017) in the reporting of this research.

4.4 | Limitations

There are several limitations associated with this study. The sampling approach adopted means that participants were self-selected, and all were from one UK-based university. It is likely that participants had an interest in resilience, and indeed, some of those interviewed admitted wanting to share their views regarding the resilience of other students, or, what they perceived to be the lack of support from the institutions. The sample was not fully representative of the population, with both international and postgraduate-taught students being overrepresented. These students are likely to have significantly different experiences from home students, with many having experience in the workplace, different education systems, and living away from family and friends.

5 | FINDINGS AND DISCUSSION

In this section, three overarching themes (summarized in Table 3) are presented to describe how 23 UK-based engineering students conceptualize and experience resilience, and the factors they believe impact its development.

5.1 | Theme 1: Conceptual understanding; contradictions and confusion

5.1.1 | Subtheme 1: Contradiction; to change or not to change?

This theme describes a pattern of contradiction that was present within the dataset, evident at quite a semantic level but which also includes latent approaches.

TABLE 3 A summary of the overarching themes and sub themes.

Theme name	Sub theme	Central organizing concept
Theme 1 Conceptual understanding; contradictions and confusion	Subtheme 1 Contradiction; to change or not to change?	Contradictory understandings of resilience as change or as resistance to change
	Subtheme 2 "I don't really think there's a difference... to be honest"; confusion between resilience and related concepts	Understanding of resilience relative to related terms
Theme 2 Resilience requires hardship and suffering		The perception that the development of resilience requires undergoing hardship
Theme 3 Judging what constitutes a resilient response and expectations regarding how it presents	Subtheme 1 "It depends on the situation...different situations demand different things from us"	The judgment needed for an individual to decide when resilience is required and what constitutes a resilient response in different instances.
	Subtheme 2 Judgment of others; resilience as socially desirable	The value judgment associated with a resilient response shown by others
	Subtheme 3 A two-way process; the resilience of others impacting your own	The judgment of others' resilience levels impacting your own

Students seemed conflicted as to whether resilience involved resistance to change or adaptability/flexibility, this relating to work within the field of ecological sciences and sustainability (Dovers & Handmer, 1992; Handmer & Dovers, 1996) which describes three typologies of resilience: as resistance to change; as incremental change or change at the margins; and as adaptability and flexibility.

For example, some participants were explicit in making use of terms such as "flexibility," "adaptability," and "transferability," with one student providing an example of resilience by saying that it involved engineers being able to "adapt to the situation... find alternative ways to complete the project" (14). One alluded to change by making use of engineering-based analogies, for example, by describing "Kaizen in the Toyota production system of this constantly iteratively improving." Another appeared to suggest that resilience involved reversible change saying, "Newton's third law...equal and opposite reactions," adding that an equal response to a situation was the bare minimum necessary to constitute resilience (16). The latter analogy is synonymous with "bouncing back," a term commonly used within resilience discourse, and which relates to claims that the application of resilience to a specific scenario necessitates the use of a normative or ontological framework (Thorén & Olsson, 2017). For Ferrarello (2021), the normativity of the concept highlights a need to understand the reference point that a resilient system needs to return.

Resilience was also seen as the flexibility to transfer knowledge to unfamiliar problems, with one student defining it as "adjusting what you've learned and what you've done to specifically solve the problem... out of context when I've not been educated in this aspect" (11). They saw this as particularly relevant during transitions when there was a need to "adjust to the environment" (11), for example, between education and practice. A different participant believed that "resilience would be what we actually learn in this class, and how useful these newly taught information is for use in the industry" (5). Other students were less explicit, and one appeared to imply that resilience involved the ability to adapt in new and unfamiliar situations by saying that resilience was developed by forcing "myself to talk and interact with people in my course" (6). The need to be flexible and adaptable meant that planning was sometimes considered to be detrimental with one student claiming that being "too rigid in your planning can impact negatively" and that they were therefore "happy to change the way that I do things" (3). Similarly, another participant claimed 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).

In comparison to those who linked resilience with the ability to deal with change, others described it as "sticking to our own stubborn decisions" (7), saying 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). A participant who had worked in India prior to their study described differences in resilience levels between both India and the United Kingdom, as well as between the workplace and education. In relation to the workplace, they claimed that if "managers say 'I want this output,' you should only give that output" and that "you are not allowed to think outside the box...you need to go as per their regulations and rules" (7), this suggesting the need to be rigid. They compared this to education, where, as a student "You are not affected, or like influenced by someone else's decisions. You are free to take your own decisions... you can explore many opportunities". This student believed that they had a choice which allowed flexibility to adapt. They concluded by saying that resilience was therefore not necessary and that "you can easily get rid of resilience in education" where they would be "less resilient" or less likely to develop resilience (7).

The same participant seemed to believe that sticking to your own views or decisions, or being headstrong, was necessary for ethical and responsible engineering practice as you may need to resist "some people bribing you." They later added that they "needed to be loyal to the organization" because managers have "power in their hands" and the "next day you might be out of the organization if you say anything against them" (7). Another linked resilience to personal values and described it as "fighting for what you believe, standing true to it" (18). Resilience thus seemed to be associated with a lack of choice and resistance to change, and a lack of resilience with freedom and flexibility to make decisions.

It was interesting to note that the same participant saw resilience as preventing innovation within the workplace, saying that resilience would mean "there's no development," comparing "a senior of manager of 20 years, who is working in the same domain" to "the junior, who comes new with the new technologies" but would have to "follow the same things," concluding that this would result in a lack of "any development in that sector (7). This insight speaks not only to the way in which some associated resilience with resistance to change but also to a culture of engineering and industry in which innovation is valued. On the contrary, other participants referred to the benefits of the adaptability associated with resilience saying that it could 'help me to find the new ways of doing my job and be more useful...use the different sources of knowledge to be more successful on the subject...to do the jobs in the economic way, with the low cost. It would be affordable for more people'" (5). Similarly, one participant claimed that "we wouldn't have had

the advancements today" without resilience (10), and another alluded to the increased efficiency which resulted saying that "a resilient person would produce more results, would achieve more, would get more things done" (9).

The relationship between innovation and both individual resilience (e.g., Caniëls et al., 2022) and system resilience (e.g., Rocchetta, 2024) has been explored elsewhere, and is particularly relevant in the context of engineering, which is associated with a culture of developing optimal and innovative solutions (Godfrey & Parker, 2010). Emphasis on efficiency and reduced cost are based in neoliberal ideas (Balan, 2023), and within neoliberal logic, students' perceptions of resilience can thus be understood in the context of rolling out neoliberal governmentality (Joseph, 2013).

5.1.2 | Subtheme 2; "I don't really think there's a difference...to be honest"; confusion between resilience and related concepts

This theme describes a pattern evident both explicitly, at quite a semantic level, and implicitly within the dataset, which was related to misunderstandings around the conceptualization of resilience.

Some students appeared to conflate resilience with related concepts; this confusion, at times, was made explicit. For example, some used perseverance as a synonymous term, with one describing resilience as "having failures but then sort of persevering through it" (4). Another who defined resilience as "pushing...fighting... even though you're struggling and see it through until the end...gotten then objective...even if you fail the first time you keep going at it, and you don't give up" compared the concept with perseverance saying, "I don't really think there's a difference to be honest" (1). At a more latent level, this misunderstanding can be inferred from instances in which students described resilience as "consistency over a long period of time. I think it's more about like the period of time that all the hard work is applied over" (19), with another participant describing 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 which may threaten achieving that. Consideration for dreams and goals points to students' conflating resilience with grit, which, as a concept, considers the role of "perseverance and passion for long-term goals" (Duckworth et al., 2007). A different student shared their confusion defining resilience as "keep(ing) going if you are struggling", then adding "I don't think that's the same as it's more determination rather than resilience but I'm not 100%. Maybe they're a bit blurred" (22).

Other participants claimed that "most people confuse resilience with like suffering" (18), with another claiming that although "resilience in itself is not bad. It's the things people associate with it like 'I'll sleep when I'm dead'" (12). Such findings suggest that, irrespective of accepted benefits of resilience, inconsistencies in its definition may lead to unanticipated and undesirable outcomes which may cause some to view it negatively.

5.2 | Theme 2: Resilience requires hardship and suffering

Many students appeared to associate resilience with enduring hardship, which required you to "grind through no matter what" (19) and involved "slogging away" (19) as well as "pushing...fighting... even though you're struggling" (1). One international student who claimed that there was less of a need to be resilient in the UK seemed to infer that its development necessitates hardship by saying that they "wake up. The shower is always hot. The bed is always comfortable and stuff...it's hard to be resilient if everything is so easy" (1).

At a latent level, such beliefs around resilience appeared to be associated with the culture of engineering as well as that of the university and more widely within society. For example, engineering programs were perceived as "harder than most degrees" and "challenging", meaning that students were "more resilient than just the surface or the average person" (20), with some suggesting that this meant that engineering students were distinct or "a different kettle of fish" (16), thus requiring different treatment. This appeared to result in a mismatch in the support provided by the university and that desired by students, with one participant saying that they were not "struggling the same way that the university expects" (16) and that the university failed to address the actual problem of the course being "tough," instead providing services which addressed symptoms of the problem. To this end, the university was considered to "have only made it worse.... like you have a certain amount of resilience at the beginning, and then you use it" (17). Lecturers were also claimed to "doubt you when you fail... they don't really care" (18). It is thus unsurprising that some students believed that educators supported resilience by providing encouragement as by acting as "leaders, like the ones who are guiding us" (14). This was suggested to involve acting as, or providing examples of, role models who "share their

experience" (3) or talking about graduates "just so you know this is extremely possible" (16). It was also suggested that they "initiate the curiosity in someone, like the desire to learn" (12), as well as providing motivation to learn by making explicit "why you have to learn this" (12). The availability and responsiveness of educators was also viewed as beneficial, with one student believing that their resilience was supported by lecturers who were "trying their best to give me as much as they can, and they even make themselves available" (9).

The level of hardship experienced appeared to vary depending on student characteristics and was considered particularly acute in the case of minoritized students. For example, one participant spoke of "horror stories of women being groped and stuff... I think that requires a lot of resilience. Also, I wouldn't want to work in like a super macho cultural workplace. I couldn't come to work... I know I couldn't handle it. It's too much. That would require a lot of resilience" (8). A different participant described "the boys mocking and laughing." They later added that "the first semester has really shown how resilient I have to be, because I haven't seen other ladies in engineering...and maybe like...maybe switch to another course or something" (18).

Such findings are consistent with previous work, which has found hardness to be a central feature of engineering culture, based on student perceptions (Deters et al., 2024), and which has described engineering as a "meritocracy of difficulty" (Stevens et al., 2007) associated with heavy workload (Godfrey & Parker, 2010), thus necessitating resilience. To this end, it is perhaps unsurprising that students did not appear to believe that there is a need for any additional interventions to support in the development of resilience, with one student claiming that "having assignments and having deadlines" (20) was enough to support in the development of resilience, and another saying it is built by "doing what you're supposed to do" (19). This perception of resilience as an innate part of HE is consistent with the views of Tudor and Spray (2017), who describe the academic stress or risk factors caused by overwhelming course loads. Similarly, the engineering industry was considered a "cut-throat environment" (16) in which companies were "highly selective" (17) and where resilience was necessary as it is "not always going to be a good environment" (1).

The role of culture and discourse was highlighted by a different participant who claimed that resilience can go "into the hustle culture, some people take it to the extreme" (12), with others saying that resilience "can be pushed in a way that it now becomes a bit toxic" (20) as "you're being pushed 24-7 you have to be this way. You have to go to the team. You have to make sure you submit things on time. Sometimes you just want to have a break from everything" (20). For one student, this emphasis on resilience within society was detrimental to its development, claiming that discourse was putting "students off being resilient", saying that "from experience, for like Gen Z they just want to be like, 'oh, yeah, this is not good for me, I'm quitting'" (18).

The findings thus highlight the role of societal and engineering culture in which resilience appears to be valued and expected and in which stress and its clinical symptoms are normalized (Whitwer et al., 2025). They also demonstrate the implications such norms have for students, for example, in terms of their help-seeking ability (Jensen et al., 2023), particularly if the need to be resilient has been highlighted during either their education, or the recruitment process, or more widely within society.

5.3 | Theme 3: Judging what constitutes a resilient response and expectations regarding how it presents

5.3.1 | Subtheme 1: "It depends on the situation...different situations demand different things from us"

Those interviewed described a range of factors that influenced the process of resilience, this variation being clearly articulated by one student who said that it "depends on the situation because different situations demand different things...as it has got different time frames" (3). There thus appeared to be some level of judgment as to whether a resilient response was either required or worthwhile, this being informed by several factors including degree of control, end goals, consequences, and the degree of motivation involved.

In some cases, students appeared to consider the degree of control they had over the outcome of a resilient response. For example, one participant explained that if "it's a lost cause I don't worry about it. But if there is something we could do about it, that's when I stress out" (10) and another said that they would "try and improve myself the best way I can", but that "sometimes there's nothing more you can do, you've done the best you can" (1).

The goals involved were also seen as determining resilience, with one participant claiming that you were able to be resilient "once you have goals, no matter what you go through" (20). For many, it was these goals, and the

consequences of not meeting them which determined a need to be resilient, with one participant saying that "having consequences as well helps build that resilience" (1). For example, one student considered themselves to be "far more resilient since I've come to university because there is almost a lot more on the line" (21). The same participant spoke of a need to consider the "consequences" of an action, describing situations at school in which they were "punished for nothing...that pushed me to be resilient because you have to not complain about it, because when you start complaining about it that is when you make it worse" and in which they "work(ed) hard in high school, and the reward wouldn't come." They also referred to the freedom associated with living away from home where "you can do whatever you want to" (1), and that "If you really wanted to, you could just sit in your room all day every day for the whole semester" (21), suggesting that a certain level of discipline is required.

Many participants considered the need to compare short- and long-term consequences, saying that resilience required taking "a bit of pain for that pleasure later" (19), with some considering the trade-offs in terms of mental health, saying that "an extreme work mindset" could result in "burn out" later (12). To this end, a different individual spoke of a need for balance as "if you keep pushing yourself, you're going to end up hurting yourself" (1). With regard to different timescales, some believed that GenZ students were unable to be resilient because, whereas "resilience helps you get better outcomes in the future and they're just interested in now" (18) and would therefore decide "this is not good for me, I'm quitting." Such views, alongside reference to distractions posed by social media, are in keeping with work that suggests the "instant gratification" characterized by today's students is at odds with the development of resilience and its associated characteristics (McIntosh & Shaw, 2017). This is consistent with evidence that Gen-Z desires better work–life balance and greater meaning in their work, seeking satisfaction through their life experiences rather than through activities generated by their careers (Moses & Hall, 2023). These findings relate to those of McIntosh and Shaw (2017) who surveyed 6500 UK-based students, with two-thirds claiming that they take on short-term discomfort for long-term gain. The authors consequently listed willpower and self-control as essential during the development of resilience, citing the work of Mischel (2015), which is focused on delayed gratification.

The varying factors that participants considered when deciding whether a resilient response was required suggest the need for students to develop an ability to judge the circumstances under which they are willing to be resilient. For example, Mahdiani and Ungar (2021) caution that although "the field of resilience research assumes everyone benefits from the presence of resilience-enhancing qualities, some contexts make these factors harmful to the long-term survival of the individual" (p. 150). This ability to judge "whether every adverse context calls for a resilience response" (Mahdiani & Ungar, 2021, p. 150) seems particularly important given the recognition of the potential costs associated with demonstrating resilience, with some describing potential harm to both physical and mental health.

5.3.2 | Subtheme 2: Judgment of others; resilience as socially desirable

This theme relates to the way in which students judged and critiqued the resilience levels of peers, something which was particularly apparent in interviews with international students, who tended to believe that home students complained more. Some participants were critical of others who were unable to manage deadlines or who wanted more support, with one questioning "are you like a baby or something?" (1) and another appearing to be judgmental of the propensity of their generation to focus on short-term benefits which could result in them quitting. One participant believed that "a lot of engineering students just don't really accept that reality" that they were responsible and accountable for their own actions and failures, describing it as "tragic," later referring to those who lacked resilience as "lazy" and "not really contributing" (16). Such views appeared to be associated with a value judgment, with one student claiming that resilience is needed if a "person wants to get anywhere in life that is where they can provide value to other people" (15), this again speaking to a neoliberal form of governmentality, whereby individuals "take responsibility for their own social and economic well-being" (Joseph, 2013, p. 42).

Some attributed the perceived lack of resilience to the way in which university, and society more widely, "accommodated a lot of things that in the past would not have been things that could be excuses...we are lowering the standard", providing the example "where people act irrational...then they come with excuses of, maybe they are not emotionally stable, or at that time they are going through some sort of mental health issues, and they really might not be anything that has to do with the mental health issue at that time". The participant appeared to suggest that there were some situations in which mental health should not be used to justify lack of resilience, concluding by saying that "Regardless of if you are emotionally stable, you have issues with mental health, you are supposed to do it this way" (9).

Although most students saw feedback as important in supporting resilience, other students viewed the emphasis on student voice as detrimental to the development of resilience, with one seemingly critical student adding that they had seen posts on "students' forums such as we have three deadlines for one week, it's not bearable blah blah blah!", stating that there is a line that should not be crossed (23). Within neoliberal logic, the emphasis on increased teacher support and student feedback mentioned by students, can be considered a consequence of the marketization of higher education, which, in the United Kingdom, has seen an increase in the use of student evaluation of teaching (SET) and the introduction of the teaching excellence framework (TEF) which measures "excellence" in terms of student satisfaction. To this end, previous work described how engineering academics believed that both SET and TEF resulted in a lack of student resilience (Wint & Direito, 2024).

Students thus seemed to lack empathy for peers and failed to have a nuanced understanding of the factors that may impact their resilience, appearing to place the burden of developing resilience on these individuals. Such findings are reminiscent of deficit-based approaches that fail to recognize wider structural inequalities (Stevenson, 2016) and are consistent with the views of Turiel et al. (2016), who criticize "assessing more and less or better and worse possession of a trait by individuals" (p.6). The "more or less syndrome" (Turiel et al., 2016 p.26) in psychological research of "positive" constructs works against social justice, providing justification for individual differences without taking account of their wider context. These gaps in understanding are particularly worrying when considering the focus on mental health issues, as well as evidence of students engaging in unfavorable comparison with others, something that is likely to be exacerbated by their use of social media, and which has been reported previously in relation to the resilience of students (McIntosh & Shaw, 2017).

This finding is particularly interesting in the context of engineering, which is often associated with a meritocratic culture, which posits that success results solely from individual talent and effort, and which fails to acknowledge systemic barriers that affect different groups unequally (Friedman et al., 2024). This perspective considers disparities as personal failings rather than structural inequities (Cech, 2013; Seron et al., 2018) and, to some degree, explains the lack of understanding or compassion for other students, particularly women, who may be struggling and relates to a culture exclusive of underrepresented, minoritized groups (Cech, 2022).

5.3.3 | Subtheme 3: A two-way process; the resilience of others impacting your own

This theme focuses on the impact that judgment or comparison had on individuals' resilience. The relative situations in which people found themselves were considered as both positively and negatively impacting resilience, this being most clearly articulated by one student who described their sixth form, where "there was a lot of overachievers", continuing by saying that "at the start of the year, I felt, like being surrounded by them I was almost inspired to do better. But by the end of the year.... I lost a lot of confidence...seeing other people do so well stressed me out because I was like, 'oh, why aren't I doing as well as this?'" (6). Many participants mentioned the role of social media in facilitating comparison with others, something that was typically considered to be detrimental. Other participants described comparing their situation to others more generally, with one explaining how "working with children got back my ability to fight back because I could see like, you know, this was just a small fight in my life" (2) and another saying, "when I look at what I did I'm like, wait, you know, my life is actually pretty good. Maybe I can actually be a bit tougher" (16). Another described their reaction to getting lower grades than expected saying "I'm not going to like, be on the street. I'm going to...I'm going to have an opportunity" (21).

Course peers were seen as highly influential, this being unsurprising considering the time spent together in university. One participant claimed that "if I'm surrounded by people who are very lazy, then I'll tend to be same" (21). Another student said, "say our peers are not succeeding then basically that would mean the resilience of the group is lower" (23). On the contrary, it was considered that "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 go find the people that are resilient and that just gives me the boost of morale" (18) and that if friends are "showing resilience you kind of want to do the same" (19).

It is perhaps unsurprising therefore, that teamwork was the main learning activity considered to both 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). Others alluded to the accountability involved saying that they had to think "about the group as a total...so I should deliver this" (23). This student appeared to be

concerned with how they were perceived by others, this seemingly acting as motivation for their own resilience. The same seemed to be true of a different female student, who was concerned about those who "expect you to give up" if you are a "woman in engineering", saying that there was "a lot of motivation attached" to a desire to "prove that ladies can do more ... I do want to show that you could do it if you try" (18).

In comparison to those who recognized the significant role that others played in impacting their resilience, some participants appeared to believe that individuals should take responsibility for ensuring that others did not impact upon them. For example, one spoke of resilience as an individual characteristic or "a mentality, a way of thinking" (1) that involved being "able to internalize things" (20) with one student claiming that it "comes from like inside...like an internal sort of mental mindset" (16).

Together, the findings highlight the role of social relations in supporting resilience, with many students alluding to the concept of collective resilience, a concept that identifies and acknowledges complexities involved in assessing the role of community influences on individual resilience, and which has been used to explore the ability of communities to recover after disasters (Mukherjee & Mandal, 2022). This builds upon previous work pertaining to the significance of social networks and communities in building resilience (e.g., Strayhorn, 2010).

6 | IMPLICATIONS FOR RESEARCH AND PRACTICE

The findings point to several considerations for the engineering education community. More generally, individuals should reflect on their own beliefs and assumptions regarding resilience, as well as its significance within both engineering and wider society. Such reflection should allow educators to understand how contextual factors including institutional policies and processes, as well as their own practice, contribute to shared socialization and shape engineering students' perceptions and experiences of resilience within engineering education and practice. This may include consideration of how team membership and dynamics act to differentially impact the resilience, experience, and attainment of those involved. It might involve questioning how workload and assessment strategies act to reinforce the beliefs of those who view engineering as a meritocracy, or who consider becoming an engineer as necessitating hardship. It may also inspire thought around how assessment could be reformulated in such a way that encourages empathy, collective resilience and help-seeking behavior, and which provides opportunities for failure and growth.

While these suggestions are based on the recognition that beliefs about resilience are primarily transmitted implicitly, it is apparent that there is a need for explicit reference to the differences between resilience and related concepts, as well as instruction about the sociocultural factors that impact upon resilience and the wider systemic issues that tend to place the burden of developing resilience on the individual. In this regard, the prevalence of strategic goals focused on resilience as a graduate attribute means that there is a need for higher educational institutions (HEIs) and employers to examine their underlying values and provide strong messaging regarding what is meant by the term and how they believe it presents as a graduate attribute. Given its conceptual weakness, there is a need to consider the potential risks associated with an emphasis on resilience without such messaging.

Based on the findings, educators should explore how they can

- facilitate discussions that support students in developing an understanding of the systemic nature of resilience and the differential impact that influencing factors have on individuals. This, alongside support in developing empathy for others, will help students to appreciate different experiences;
- support students in developing their ability to provide social support to team members while respecting their own boundaries and capacity. This may involve helping students to understand how others impact their individual resilience and providing tools to help them manage working with those who threaten resilience levels;
- be intentional in their efforts to foster environments that support protective factors such as motivation (e.g., Hunsu et al., 2021). For example, studies have identified a relationship between educators' enthusiasm and students' positive emotions (Frenzel et al., 2009), interest (Keller et al., 2014; Quinlan, 2019), and motivation (Patrick et al., 2000). To help create a supportive environment, it may be useful to draw upon Tormey's (2021) model of student–teacher relationships in higher education, which includes three dimensions: the degree of warmth students and teachers feel towards each other (affection/warmth); whether they trust each other (attachment/safety); and whether they feel admiration for one another (assertion/power), with warmth, trust, and admiration enhancing the overall student experience.

- support student mental health and well-being (Mapaling et al., 2021) by exposing students′ coping mechanisms and healthy ways to manage stress, as well as approaches from positive psychology (Asghar & Minichiello, 2023) including optimism and the use of mindfulness and contemplative practices (Huerta, 2018; Huerta et al., 2021);
- support students in developing self-awareness and skills in reflection which will allow them to understand their own values, motivations, and purpose;
- equip students with tools that assist them in flexible planning, time management, and goal setting. Developing such skills will support in students' ability to navigate unexpected situations that occur while working toward long-terms goals.

This work also has implications for researchers. Given the findings pertaining to the individualized nature of resilience, as well as the cultural differences in how resilience is conceptualized, there is a need to understand how resilience is understood by a broader range of students in other types of institutions and geographical locations that incorporate non-Western perspectives. The study of resilience in engineering education has often been guided by Western psychological theories, focusing on individual coping mechanisms and strategies. Future research could broaden our understanding of resilience as a collective phenomenon by incorporating indigenous philosophies, such as Ubuntu (Occhio et al., 2023), and theories such as the relationship-resourced resilience (RRR) theory, which includes the concept of "flocking" (Ebersöhn, 2012). Such work is particularly necessary given evidence pertaining to the role of peers and staff in supporting resilience, and work framing resilience as a collective phenomenon. Although this work was not aimed at understanding any differences in the way that resilience is perceived across engineering disciplines, findings did point toward the role of cohort size and diversity in impacting resilience, both of which vary significantly between disciplines. Further work could therefore focus on how findings vary between those studying in different engineering programs. It is also important to understand resilience from the perspective of a wider range of stakeholders involved in educating engineers including employers. Finally, the increased use of generative artificial intelligence (GAI) is likely to impact the development of resilience in both negative (e.g., encouraging short-cuts and reliance, undermining problem-solving ability, reducing self-efficacy) and positive ways (e.g., provision of personalized and inclusive support, helping to reduce stress). It would thus be interesting to explore the relationship between the use of GAI and student resilience and to ensure that cultivating AI literacy and strategies to foster critical engagement are designed to leverage potential benefits for resilience and academic success.

7 | CONCLUSIONS

This study adds to our understanding of resilience within engineering education by demonstrating the confused and conflicting ways by which it is conceptualized by students and by providing insights into the structures and contextual factors that they perceive as influencing their resilience levels. Together, the themes generated present a situation in which students understand resilience as involving hardship, which is viewed as part of the normal course of an engineering degree. Although the participants recognized the complex and numerous factors that impact resilience, they considered its development to be an individual responsibility. Many were thus critical of those who they perceived as exhibiting less resilience and alluded to the presence of a social hierarchy. Students' understanding of resilience as an individual trait is consistent with dominant neoliberal discourse and is presented as maintaining and perpetuating the cultural status quo of engineering as a meritocracy that values innovation and efficiency.

The work acts to surface the implications of situating resilience as an important student and graduate attribute, without explicitly communicating what is meant by the term (for example, in comparison to similar concepts) or discussing value-based assumptions regarding its social desirability as a trait or process. Failing to expose assumptions regarding expectations around resilient responses risks further perpetuating the very issues around diversity, mental health, retention, and progression, which the development of resilience has been proposed to overcome.

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DATA AVAILABILITY STATEMENT

The datasets used during the current study are available from the corresponding author upon reasonable request.

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