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Scoping review of the literature on undergraduate engineering student perceptions, attitudes, and emotions on failure

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Introduction

This full paper reports a scoping review of the literature on undergraduate engineering student perceptions, attitudes, and emotions on failure.

How students perceive and respond to failure can have a significant impact on their growth and development [1], [2]. This relationship is complex and can draw upon many factors including mindset [3]-[5] (e.g., Dweck's implicit theories of intelligence beliefs), motivation and self-regulation [6], [7] (e.g., measured through the Motivated Strategies for Learning Questionnaire, MSLQ), and emotions [8], [9] (e.g., examined with the Achievement Emotions Questionnaire, AEQ). First, students with a growth mindset can see failure as a learning opportunity whereas those with a fixed mindset may be more inclined to see a failure in terms of their limitations. This mindset can have important consequences in terms of how students engage with academic challenges. Second, failure can motivate some students to adapt their learning strategies while for others, it can serve as a source of demotivation and disengagement. Moreover, self-regulated learners, who can set goals and objectives for themselves, monitor their progress, and adapt their approaches are generally able to navigate better through failure. Third, failure can elicit so-called achievement emotions such as anxiety, frustration, and shame, which can undermine performance. On the other hand, more positive emotions including hope and pride can encourage persistence. Fear also plays a significant role in shaping students' responses to failure. The Performance Failure Appraisal Inventory (PFAI) measures different sources of fear of failure [10], [11], e.g., fear of an uncertain future, fear of experiencing shame and/or embarrassment, and fear of disappointing others. The competitiveness of engineering programs and students can exacerbate these fears, making it more difficult for them to take risks or seek help and feedback. This tension can hinder their ability to see failure as a natural and valuable part of their learning.

These overlapping concepts—mindset, motivation, self-regulation, achievement emotions, and fear—illustrate how deeply failure is tied to students' perceptions and behaviors. Henry *et al.* proposed a framework that identifies mindset, goal orientation, fear of failure, attributions of failure, and coping strategies as key factors in shaping how STEM students approach failure [12]. Based on this framework and the importance of context for interpreting results and meaning, we were motivated to understand further what research has been conducted on *undergraduate engineering students* ***and*** *failure*. In this paper, we report a scoping review of the associated literature. We hope that this review can help guide further research on the topic as well as assist educators identify relevant studies and evidence-based practices to create more supportive learning environments that encourage student growth and a more positive mindset when facing challenges and failure.

Methodology

Of the different types of literature reviews [13], we have adopted a scoping review for our study. In contrast to a systematic review, which aims to answer a specific research question, or an integrative review, which seeks to assess, critique, and synthesize the literature on a topic, our scoping review is exploratory with the objective of identifying the types of research studies that examine undergraduate engineering students' perceptions, attitudes, and emotions with regards to academic failure and summarizing the key themes. We followed the steps for conducting a scoping review: identifying broad questions; identifying relevant studies, selecting studies to be included in the review; generating summaries of the studies; and collating and reporting the results [14], [15].

Search and selection criteria

Our general interest was to understand undergraduate engineering student perceptions of failure and we used an iterative process that included the PICO (population, intervention, comparison, and outcome) [16] and SPIDER (sample, phenomenon of interest, design, evaluation, and research type) [17] frameworks to guide the development of our broad question, search clause, and inclusion/exclusion criteria. The population (or sample) of interest is undergraduate engineering students and the outcome (or phenomenon of interest) focuses on their perceptions and attitudes of failure. Note that not all aspects of the PICO or SPIDER frameworks are relevant for our review (e.g., intervention, comparison, design, evaluation, and research type).

We started with the search clause "(engineering student* or engineering undergraduate* or engineering major*) AND (fail*) AND (perception* or perspective* or attitude*)" to scope the literature. This search was run on the Web of Science database on May 9, 2024 and yielded 2,139 papers. We then scanned the title and abstract of the first 1,000 papers to get immersed with the terms used in the literature. Terms that frequently appeared included motivation, emotion, reaction, response, shame, engagement, learning, and mindset. These formed the themes that we then associated with our overarching question "*What are undergraduate engineering students' perceptions, attitudes, and emotions of failure?*" Our final search clause was the following: ("engineering student*" OR "engineering undergraduate*" OR "engineering major*") AND (fail* OR shame) AND (perception* OR perspective* OR attitude* OR reaction* OR response* OR expectation* OR emotion*) AND (learn* OR engag* OR motivat* OR mindset OR persistence OR resilience OR grit OR competence OR ability OR efficacy). Table 1 maps the terms used in the search clause into the PICO and SPIDER frameworks.

The search clause was run on May 17, 2024 in three databases: Web of Science, Compendex-Inspec, and Scopus (these 3 databases were considered as they ensure access to a relatively comprehensive collection of relevant literature in the field of engineering education). No date range was specified in the search. This produced 133, 245, and 226 papers, respectively, for a combined total of 604 papers. The papers were then screened manually for duplicates; 299 of these papers were removed resulting in 305 unique papers. Three of the researchers examined the same sample of 85 papers and applied the inclusion/exclusion criteria to shortlist studies for inclusion. The inter-rater values (Cohen's kappa) between each pair of researchers were in good agreement (.58, .60, and .70); the average observed agreement was .90 and the average expected chance agreement was .76. The remaining papers were then divided amongst three of the researchers and after analysis, a further 254 papers were removed. Of the remaining papers, 1 was not accessible resulting in 50 papers being retained for full-text reading. Table 2 shows the details of our inclusion and exclusion criteria.

Table 1. Boolean search clause terms categorized into PICO and SPIDER frameworks.

	P/S (Population/ Sample)	**O/PI** (Outcome/ Phenomenon of Interest)				
Search Clause Terms	engineering student*	fail*	AND	perception*	AND	learn*
	engineering undergraduate*			perspective*		engag*
	engineering major*			attitude*		motivat*
		shame		reaction*		mindset*
				response*		persistence*
				expectation*		resilience
				emotion*		grit
						competence
						ability
						efficacy

Table 2. Inclusion and exclusion criteria.

Inclusion criteria	**Exclusion criteria**
Population/sample • Undergraduate engineering students Outcome/phenomenon of interest • Any study examining the perspectives, perceptions, attitudes, and emotions with regards to failure for the selected population • All types of papers, e.g., journal and conference, at all stages of research, e.g., including works-in-progress.	• All populations that do not include undergraduate engineering students • All subjects that do not address the outcome/phenomenon of interest • Papers that examine failure, including engineering or entrepreneurial failure, but without reference to the outcome or phenomenon of interest • Review papers, i.e., papers must report on original data or new studies and findings, and not simply summarize existing work • Papers not written in English • No access

Scoping review

After full-text reading, an additional 23 papers were removed based on our exclusion criteria. Of the 27 papers retained, we summarized the following information for our scoping review: aims/objectives/outcomes, population, duration, and location of the studies; and methodology and instruments used.

Results and discussion

Table 3 summarizes the results of our scoping review.

While the majority of the studies were conducted in the US (16), 11 were completed globally: 7 in Europe (Spain, Portugal, UK, Ireland, and Latvia), 3 in Asia/Pacific Rim (Singapore, Philippines, and Australia), and 1 in Asia Minor (Turkey). This suggests that the topic of undergraduate engineering students' perceptions, attitudes, and emotions associated with failure attracts interest from engineering education and STEM education researchers around the world.

Table 3. Scoping review of the papers summarized in this work.

Reference, source and year of publication	**Aims / objectives / outcomes**	**Location**	**Population and duration of study**	***Methods* and instruments used**	**Themes**
[18], IEEE Frontiers in Edu., 2006	Determine likelihood of persistence based on an evaluation of student intentions upon enrollment, selection of courses, and perceptions of the first year experience.	US	Undergraduate engineering students, 4 years (2001-2005)	*Qualitative (descriptive statistics)* Survey (own tool)	• attrition, retention, and persistence
[19], IEEE Frontiers in Edu., 2009	Examine emotional issues that freshmen engineering students experience due to academic failure. Understand how students deal with failure and engage students in discussions on failure.	US	Freshmen engineering students, 2 years	*Qualitative (descriptive statistics)* Survey (own tool)	• shame and other emotional responses to failure • attrition, retention, and persistence
[20], ASEE Ann. Conf., 2010	Examine an intervention to address emotional issues that freshmen students experience due to academic failure. Understand how students deal with failure and engage students in discussions on failure.	US	Freshmen engineering students, 2 years for survey (8 years for analyzing student academic records)	*Qualitative (descriptive statistics)* Survey (own tool)	• shame and other emotional responses to failure
[21], Asia-Pacific Edu. Researcher, 2011	Examine how negative emotions mediate the effect of critical thinking on achievement.	Philippines	1st year engineering students, 1 year	*Quantitative* Academic emotions questionnaire, motivated strategies for learning questionnaire	• shame and other emotional responses to failure • mindset
[22], Sex Roles, 2013	Examine retention and develop a better understanding of persistence of women in engineering.	US	First semester engineering students and psychology students	*Quantitative* Surveys, motivated strategies for learning questionnaire	• shame and other emotional responses to failure • attrition, retention, and persistence • embracing vs. avoiding failure

[23], J. Eng. Edu., 2014	Examine experience of undergraduate engineering students who chose to leave engineering. Understand factors leading to attrition.	US	Undergraduate engineering students, 1 year	*Qualitative* Journey maps, interviews	• attrition, retention, and persistence • shame and other emotional responses to failure
[24], ASEE Ann. Conf., 2014	Discuss how to cultivate characteristics that are valued in engineers with a pedagogical method that rewards learning from failure. Investigate how students can be motivated to perform beyond their own expectations or perceived capabilities when they are pushed to confront difficult problems and work to solve them in a framework of functional discomfort.	US		*Mixed*	• embracing vs. avoiding failure • mindset
[25], IEEE Revista Iberoamerican Tecnol del Aprendizaje, 2015	Examine the association between students' motivational profiles and their corresponding academic performance.	Spain	Students taking software engineering and computer science courses in 2 institutions, 3 years	*Quantitative* Teamwork behaviour questionnaire, achievement goal questionnaire	• embracing vs. avoiding failure • mindset
[26], Int. Conf. Eng. And Prof. Design. Edu., 2016	Examine response of first year undergraduates in a design experiment / project that forces them to confront failure often.	UK	N/A	*Qualitative* N/A	• embracing vs. avoiding failure
[27], ASEE Ann. Conf., 2016	Examine interventions to reduce attrition.	US	First year engineering students, 2 years	*Quantitative* Mathematics intervention	• attrition, retention, and persistence
[28], REEN Ann. Symp., 2017	Identify the pedagogy of failure and examine the issues behind 'failure' from the perspectives of at-risk students. Increase awareness of how mental health issues can be a source of failure.	UK	First and second year engineering students, 2 years	*Mixed* Data analytics	• attrition, retention, and persistence

[29], Int. Sci. Conf. Rural Env., Edu., Personality, 2017	Study the causes for failure in Mathematics among engineering students, including curriculum, instructional approach, student learning habits and attitudes towards learning, and emotional reactions and personality.	Latvia	First year engineering and IT students, 1 semester	*Quantitative* Survey (own tool)	• attrition, retention, and persistence
[30], IEEE Trans. on Edu., 2018	Study the relationship between effort and performance in an introductory programming course with respect to perceptions on intelligence and mindset. Evaluate intervention on teaching about mindset to foster a growth mindset amongst students.	Turkey	Engineering students (non-CS), duration unspecified	*Quantitative* Mindset for intelligence (Dweck), mindset for programming, generalized self-efficacy scale (Schere and Adams)	• mindset
[31], SEFI Ann. Conf., 2019	Determine if European and American students are similar in terms of mindset predicting academic success. Examine impact of a mindset intervention.	Ireland	First year mechanical engineering students, 1 year	*Quantitative* Surveys on mindset (Dweck, mindset coach)	• mindset
[32], ASEE Ann. Conf., 2019	Understand the beliefs that undergraduate students hold about their intelligence and how these change. Identity practices that increase retention and improve student learning.	US	Undergraduate engineering students, 1 year	*Qualitative* Interviews	• mindset • shame and other emotional responses to failure
[33], Int. Tech., Edu. and Dev. Conf., 2019	Develop profiles of telecommunication engineering students and based on these profiles, adapt resources and training provided, e.g., foundation courses for students with weak backgrounds.	Spain	Telecomm engineering students, 2 semesters	*Qualitative (descriptive statistics)* Survey (own tool)	• attrition, retention, and persistence
[34], Student Success, 2020	Evaluate impact of giving students a 'tough' assessment (with clear explanation of its purpose and of the support that is available).	Australia	First year engineering students, 3 years	*Mixed* *Survey (own tool) and interviews*	• attrition, retention, and persistence • shame and other emotional responses to failure

[35], ASEE Ann. Conf., 2020	Study the relationship between student motivation after a failure and engineering identity. Gain further insight into motivational patterns based on engineering identity.	US	Upper-level engineering students, 1 semester	*Mixed* Engineering identity survey (Godwin), interviews using critical indent technique	• attrition, retention, and persistence • mindset
[36], J. Eng. Edu., 2021	Examine experiences of students with regards to professional shame as a painful emotional state after a failure. Gain insight into social construction of engineering cultures by dominant groups.	US	Upper-level white male engineering students, 1 year	*Qualitative* Unstructured interviews	• shame and other emotional responses to failure
[37], Int. J. STEM Edu., 2021	Determine if the Performance Failure Appraisal Inventory (PFAI) measures properly fear of failure in STEM students. Develop a modified 15-item 4-factor structure for assessing levels of fear of failure.	US	Undergraduate students in STEM, 1 year	*Quantitative* Performance failure appraisal inventory	• embracing vs. avoiding failure • shame and other emotional responses to failure
[38], J. Eng. Edu., 2021	Study professional shame in engineering and the co-construction of social worlds that place expectations on engineering students.	US	Second or third year undergraduate engineering students from 2 institutions, 1 year	*Qualitative* *Ethnographic focus groups*	• shame and other emotional responses to failure
[39], Eur. J. Eng. Edu., 2022	Examine if dissimilar engineering student profiles can be identified, i.e., identify predictive rationales for ways of surviving in higher education. Understand what can predict academic success.	Portugal	First year engineering students, 7 years	*Qualitative* *Semi-structured interviews*	• attrition, retention, and persistence
[40], Int. J. Eng. Edu., 2022	Determine the impact of a sketching practice that provides students with opportunities to experience low-stakes failure. Low-stakes skills building can help shift engineering students' mindsets around sketching and failure in design.	US	Undergraduate mechanical engineering students, 1 semester	*Qualitative* *Sketches and survey (own tool)*	• embracing vs. avoiding failure

[41], J. Chem. Edu., 2022	Explore how challenges faced by students interact with mindset beliefs and course performance (e.g., through their perceptions of success or failure when faced with the challenges.	US	First year chemistry students, 1 semester	*Quantitative* Survey adapted from Limeri	• mindset
[42], J. Chem. Edu., 2023	Understand links between failure, support, uncertainty, and student perception of agency and opportunities, as well as their roles as researchers.	US	Chemical engineering students, 1 semester	*Qualitative* Interviews, observations, and reflective assignment	• embracing vs. avoiding failure
[43], IEEE Conf. Teach., Assess., and Learn. for Eng., 2023	Investigate the ways in which engineering students learn from failure. Identify types of failure and their roles in learning.	Singapore	Engineering students, duration unspecified	*Qualitative* Observations	• embracing vs. avoiding failure
[44], J. Eng. Edu., 2024	Acquire an understanding of students who persisted in their studies through their responses to failure experiences. Recommend removing stigma traditionally associated with failure, normalize failure as an opportunity for growth, have academic policies that promote student resilience and enable learning from failure.	US	Undergraduate engineering students who failed a technical course and persisted in engineering, 1 year	*Qualitative* Interviews	• attrition, retention, and persistence • mindset

Eleven of the studies focused exclusively on freshmen or first year engineering students. The first year experience is pivotal as it forms the basis of student progression through their studies, impacts the formation of engineering identity, and can be a major factor in retention. The focus on the first year makes sense as it can identify ways to support students properly in dealing with failure, especially students considered to be ‘at risk’.

There were 9 quantitative studies, 4 qualitative studies reporting descriptive statistics, 10 qualitative studies, and 4 studies using mixed methods. Studies reporting descriptive statistics tended to involve survey instruments developed locally to address the specific questions being investigated. On the other hand, quantitative and mixed methods studies tended to use validated survey instruments including the MSLQ, AEQ, PFAI, and the implicit theories of intelligence scales. Qualitative studies typically used semi-structured interviews or focus groups.

We identified four broad themes discussed in the papers and grouped them accordingly, noting that one paper may cover multiple topics. The themes and number of associated papers is as follows:

THEME 1 – attrition, retention, and persistence, discussed in 13 papers,
THEME 2 – shame and other emotional responses to failure, discussed in 11 papers,
THEME 3 – mindset discussed in 9 papers, and
THEME 4 – embracing vs. avoiding failure, discussed in 7 papers.

It is not surprising that the most commonly investigated themes focused on students' reactions (including emotional response and in particular, shame) to failure and how this impacts their learning and future studies with regards to motivation, persistence, retention, and attrition. For example, several papers discussed factors that caused students to drop out of engineering after having experienced significant failure (e.g., failing in one or more courses), such as the lack of motivation and poor time management [18], [23]. Others examined students who had persisted in engineering despite experiencing a failure and found that they exhibited characteristics such as grit or developed better self-management skills [27], [35], [39], [44]. With regards to emotional responses, several studies examined how shame is experienced by students. It was found that shame appeared when students perceived themselves as failing to meet the socially constructed expectations of professional engineering [36], [38]. They also connected shame with failure to achieve certain standards, including low scores on academic tasks. This led to behaviours such as hiding from shame or rejecting it by intentionally ignoring the experience. Other studies identified the limited experience with failure preceding their engineering studies as the primary cause of emotional strain experienced by first year students [19], [20].

When considering mindset, a key question arises: does one's mindset influence academic performance? While one study involving a five-week intervention conducted on first year mechanical engineering students failed to identify any significant relationship between student mindset and exam scores [31], other studies found that students with a growth mindset were more likely to overcome the challenges they faced during their courses [30], [41] which, in turn, resulted in better academic performance in the long term. Finally, to encourage students to embrace or confront failure rather than avoid it, several studies considered the impact of introducing students to learning environments that provided opportunities to fail in low-stakes settings. Students reported feeling more comfortable and confident with failure following the experience, now finding it easier to accept failure rather than to fear and avoid it [24], [40], [42].

Based on these studies, there are several actionable recommendations:

- developing and implementing course interventions to foster a growth mindset, including using growth mindset language when providing feedback, to help students develop resilience and persistence, as well as feel supported when facing challenges and failures,
- creating course activities and assessments in a low-stakes environment to allow students to confront and experience failure, while providing the necessary support, thereby promoting resilience and growth, and
- implementing more flexible academic policies that allow students to learn and recover from failures, encouraging resilience and continuous improvement.

Limitations

Although we have followed a structured process to define the inclusion and exclusion criteria for searching and selecting studies to include, there are several limitations to our scoping review. First, the selection process itself may have missed relevant studies. For example, while our inter-rater reliability is generally good, it is possible that individually, we missed suitable papers for inclusion. We also considered only 3 databases, published studies, and papers written in English. We may have identified additional papers by conducting our search in other databases, searching through unpublished work, and examining publications in other languages. Another limitation is that while our review shows that the topic attracts interest from engineering education researchers around the world, 16 papers are from North America (US) and 6 are from Western Europe, thereby emphasizing strongly Western perspectives. This may be due to the greater emphasis placed on supporting students or the accreditation process, but there exists the possibility of a strong cultural bias in understanding students' perceptions, attitudes, and emotions with regards to academic failure.

Next Steps

Many of the studies examined the relationship between failure and one construct, e.g., emotions, mindset, fear, or impact on learning. There were suggestions for different interventions and resources, as well as academic policies that can support students further. Based on the framework proposed by Henry *et al.* in [10], we believe that it will be interesting to conduct a study that investigates multiple constructs at the same time. This can involve a mixed methods study that includes a survey instrument combining items from the MSLQ, AEQ, modified PFAI, and implicit theories of intelligence scales with structured interviews including the critical incident technique where participants can report on their experience following a specific type of failure. Such a study may reveal new patterns, relationships, or mediating effects of how students view and cope with failure.

Conclusions

The papers shortlisted in our review show that the general topic of undergraduate engineering students' perceptions, attitudes, and emotions associated with failure attracts interest globally, with a strong emphasis from North America and Western Europe. Four main themes have emerged from the papers: attrition, retention, and persistence; shame and other emotional responses to failure; mindset; and embracing vs. avoiding failure. A large number of studies also focused on first year students. The different studies involve a mix of quantitative, qualitative (including descriptive statistics), and mixed methods, with many using self-generated survey tools (for descriptive statistics) and the use of semi-structured interviews. The papers reviewed also allow for a greater understanding of the causes of failure, as well as interventions that can be deployed to help students navigate failure, e.g., to improve their mindset or learn to embrace failure rather than seek an avoiding behaviour. We hope that our scoping review provides useful insight on the topic and that by highlighting the different types of studies that have been conducted, it can help guide further research and educators identify evidence-based practices to support students as they negotiate their learning experience.

References

[1] A. Simpson and A. Maltese, "Failure is a major component of learning anything: the role of failure in the development of STEM professionals," *Journal of Science Education and Technology*, vol. 26, pp. 223-237, 2017.

[2] R. Ajjawi, D. Boud, N. Zacharias, M. Dracup, and S. Bennett, "How do students adapt in response to academic failure," *Student Success*, vol. 10, no. 3, pp. 84-91, 2019.

[3] C. S. Dweck, *Self-Theories: Their role in motivation, personality, and development*. Psychology Press, 2000.

[4] G. S. Stump, J. Husman, and M. Corby, "Engineering students; intelligence beliefs and learning," *Journal of Engineering Education*, vol. 103, no. 3, pp. 360-387, 2014.

[5] J. Buckley, A. O'Connor, N. Seery, T. Hyland, and D. Canty, "Implicit theories of intelligence in STEM education: perspectives through the lens of technology education students," *International Journal of Technology and Design Education*, vol. 29, pp. 75-106, 2019.

[6] P. R. Pintrich, D. A. F. Smith, T. Garcia, W. J. McKeachie,. A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ). Report No. NSCRIPTAL-91-B-004. National Center for Research to Improve Postsecondary Teaching and Learning. Ann Arbor, MI, USA, 1991.

[7] O. Adesope, N. Hunsu, B. J. Van Wie, B. Austin, R. F. Richard, P. Dutta, "WIP: A psychometric analysis of engineering students' motivation and learning strategies," *American Society for Engineering Education Annual Conference & Exposition*, June 24-28, 2017, Columbus, OH.

[8] R. Pekrun, T. Goetz, A. C. Frenzel, and R. P. Perry, Academic Emotions Questionnaire (AEQ). User's manual (2nd ed.). Department of Psychology, University of Munich. 2011.

[9] J. Lönngren, I. Direito, R. Tormey, and J. L. Huff, "Emotions in Engineering Education," in *International Handbook of Engineering Education Research*, New York: Routledge, 2023.

[10] D. E. Conroy, J. P. Willow, and J. N. Metzler, "Multidimensional fear of failure measurement: the Performance Failure Appraisal Inventory," *Journal of Applied Sports Psychology*, vol. 14, no. 2, pp. 76-90, 2002.

[11] J. M. Bartels and J. J. Ryan, "Fear of failure and achievement goals: a canonical analysis," *Journal of Instructional Psychology*, vol. 40, no. 2, pp. 42-29, 2013.

[12] M. A. Henry, S. Shorter, L. Charkadoudian, J. M. Heemstra, and L. A. Corwin, "FAIL is not a four-letter word: a theoretical framework for exploring undergraduate students' approaches to academic challenge and responses to failure in STEM learning environments," *CBE – Life Sciences Education*, vol. 18, article 11, 2019.

[13] A. Munn, M. D. J. Oeter, C. Stern, C. Tufanaru, A. McArthur, and E. Aromataris, "Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach" *BMC Medical Research Methodology*, vol. 18, article no. 132, 2018.

[14] H. Arksey and L. O'Malley, "Scoping studies: towards a methodological framework," *International Journal of Social Research Methodology*, vol. 8, no. 1, pp. 19-32, 2005.

[15] M. D. J. Peter, C. Marnie, A. C. Tricco, D. Pollock, Z. Munn, L. Alexander, P. McInerney, C. M. Godfrey, and H. Khalil, "Updated methodological guidance for the conduct of scoping reviews," *JBI Evidence Synthesis*, vol. 18, no. 10, pp. 2119-2126, 2020.

[16] J. P. T. Higgins and J. Thomas, *Cochrane Handbook for Systematic Reviews of Interventions*, version 6.4, 2023. https://training.cochrane.org/archive/v6.4.

[17] A. Cooke, D. Smith, and A. Booth, "Beyond PICO: the SPIDER tool for qualitative evidence synthesis," *Qualtiative Health Research*, vol. 22, no. 10, pp. 1435-1443, 2012.

[18] L. A. Meadows, J. Nidiffer, S. R. Ball, C. G. Davis, C. J. Finelli, and W. W. Schultz, "Work in Progress: An initial assessment of the effect of the first year experience on under-represented student retention in engineering," *IEEE Frontiers in Education*, Oct. 27-31, 2006, San Diego, CA.

[19] D. Budny and J. Tartt, "Do engineering students fail because they don't know how to fail?" *IEEE Frontiers in Education*, Oct. 18-21, 2009, San Antonio, TX.

[20] D. Budny, A. Allen, and J. Tartt, "Dealing with failure and making the transition between high school and college," *American Society for Engineering Education Annual Conference & Exposition*, June 20-23, 2010, Louisville, KY.

[21] F. T. Villavicencio, "Critical thinking, negative academic emotions, and achievement: a mediational analysis," *The Asia-Pacific Education Education Researcher*, vol. 20, no. 1, pp. 118-126, 2011.

[22] C. M. Jagacinski, "Women engineering students: competence perceptions and achievement goals in the freshman engineering course," *Sex Roles: A Journal of Research*, vol. 69, nos. 11-12, pp. 644-657, 2013.

[23] M. Meyer and S. Marz, "Engineering dropouts: a qualitative examination of why undergraduates leave engineering," *Journal of Engineering Education*, vol. 103, no. 4, pp. 525-548, 2014.

[24] E. Jablonski, "Fostering intra- and entrepreneurship in engineering students," *American Society for Engineering Education Annual Conference & Exposition*, June 15-18, 2014, Indianapolis, IN.

[25] J. G. Martín, J. E. Pérez Martínez, A. S. Alonso, “Teamwork, motivational profiles and academic performance in computer science engineering,” *IEEE Revista Iberoamericana de Tecnologias del Aprendizaje*, vol. 10, no. 2, pp. 77-84, 2015.

[26] A. Hall, Y. Bahk, L. Gordon, and J. Wright, “The elastic octopus: a catalogue of failures for disrupting design education,” *International Conference on Engineering and Product Design Education*, Sep. 8-9, 2016, Aalborg, Denmark.

[27] J. Bracey, K. Sadeghipour, C. Baugh, and S. Fagan, “Chasing the holy grail: successful academic persistence and retention of highly motivated first-year engineering students,” *American Society for Engineering Education Annual Conference & Exposition*, June 26-29, 2016, New Orleans, LA.

[28] R. Clark and J. Andrews, “From trailing & failing to learning & progressing: a bespoke approach to failure in engineering education,” *7th Research in Engineering Symposium*, July 6-8, 2017, Bogota, Columbia.

[29] A. Zeidmane and T. Rubina, “Causes of failures in mathematics by engineering students at Latvia University of Agriculture,” *International Scientific Conference on Rural Environment, Education, and Personality*, May 12-13, 2017, Jelgava, Latvia.

[30] F. B. Tek, K. S. Benli, and E. Deveci, “Implicit theories and self-efficacy in an introductory programming course,” *IEEE Transactions on Education*, vol. 61, no. 3, pp. 218-225, 2018.

[31] D. K. Sheridan, M. Carr, L. can den Broeck, “Mind games: an investigation into the response of Irish engineering students to a mindset intervention,” *European Society for Engineering Education Annual Conference*, Sep. 16-19, 2019, Budapest, Hungary.

[32] A. Adams, A. R. Betz, and E. Dringenberg, “Preliminary findings on students’ beliefs about intelligence,” *American Society for Engineering Education Annual Conference & Exposition*, June 15-19, 2019, Tampla, FL.

[33] D. M. Muñoz, J. C. C. Martínez, M. Á. G. Martos, and R. P. de Prado, “Telecommunication engineering student profile at the University of Jaen and improvement actions,” *13th International Technology, Education and Development Conference*, Mar. 11-13, 2019, Valencia, Spain.

[34] K. Wilson and K. F. Wilson, “Student responses to a tough early assessment: a useful “kick up the bum”?,” *Student Success*, vol. 11, no. 2, pp. 28-40, 2020.

[35] C. Bolton, E. Miskioglu, and K. M. Martin, “WIP: Motivation and identity: the impact of identity on recovering from failure,” *American Society for Engineering Education Annual Conference & Exposition*, June 22-26, 2020, held virtually.

[36] J. L. Huff, B. Okai, K. Shanachilubwa, N. W. Sochacka, and J. Walter, "Unpacking professional shame: patterns of white male engineering students living in and out of threats to their identities," *Journal of Engineering Education*, vol. 110, no. 2, pp. 414-436, 2021.

[37] M. A. Henry, S. Shorter, L. K. Charkoudian, J. M. Heemstra, B. Le, and L. A. Corwin, "Quantifying fear of failure in STEM: modifying and evaluating the performance failure appraisal inventory (PFAI) for use with STEM undergraduates," *International Journal of STEM Education*, vol. 8, article no. 43, 2021.

[38] S. Secules, N. W. Sochacka, J. L. Huff, and J. Walther, "The social construction of professional shame for undergraduate engineering students," *Journal of Engineering Education*, vol. 110, no. 4, pp. 861-884, 2021.

[39] D. Da Silva Dias, "Student strategies to survive the academic transition: recycling skills, reshaping minds," *European Journal of Engineering Education*, vol. 47, no. 6, pp. 1050-1060, 2022.

[40] M. Das and M. Yang, "Building confidence and embracing failure through sketching practice," *International Journal of Engineering Education*, vol. 38, no. 6, pp. 1779-1790, 2022.

[41] D. L. Santos and S. R. Mooring, "Characterizing mindset-related challenges in undergraduate chemistry courses," *Journal of Chemical Education*, vol. 99, pp. 2853-2863, 2022.

[42] M. Wilson-Fetrow, V. Svihla, B. Burnside, and A. Datye, "Course-based undergraduate research experiences in a chemical engineering laboratory promote consequential agency," *Journal of Chemical Education*, vol. 100, pp. 3752-3763, 2023.

[43] Q. Huang, T. Willems, A. Kaur, K. W. Poon, B. Samarakoon, and M. R. Elara, "A pedagogical approach of "Learning from Failure" for engineering students: observation and reflection on a robotics competition (RoboRoarZ-Edition2)," *IEEE International Conference on Teaching, Assessment and Learning for Engineering*, Nov. 28-Dec. 1, 2023, Auckland, New Zealand.

[44] A. C. Emberley, D. S. Choi, T. Williams, and M. C. Loui, "Engineering survivors: students who persisted through academic failures," *Journal of Engineering Education*, vol. 113, no. 1, pp. 12-29, 2024.