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REVIEW ARTICLE

# Emotions in engineering education: A configurative meta-synthesis systematic review

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## Abstract

**Background:** The study of emotions in engineering education (EEE) has increased in recent years, but this emerging, multidisciplinary body of research is dispersed and not well consolidated. This paper reports on the first systematic review of EEE research and scholarship.

**Purpose:** The review aimed to critically assess how researchers and scholars in engineering education have conceptualized emotions and how those conceptualizations have been used to frame and conduct EEE research and scholarship.

**Scope/Method:** The systematic review followed the procedures of a configurative meta-synthesis, mapping emotion theories and concepts, research purposes and methods, and citation patterns in the EEE literature. The review proceeded through five stages: (i) scoping and database searching; (ii) abstract screening, full text sifting, and full text review; (iii) pearling; (iv) scoping review, and (v) in-depth analysis for the meta-synthesis review. Two hundred and thirteen publications were included in the final analysis.

**Results:** The results show that the EEE literature has not extensively engaged with the wide range of conceptualizations of emotion available in the educational, psychological, and sociological literature. Further, the focus on emotion often seems to have been unintentional and of secondary importance in studies whose primary goals were to study other phenomena.

**Conclusions:** More research adopting intentional, theorized approaches to emotions will be crucial in further developing the field. To do justice to complex emotional phenomena in teaching and learning, future EEE research will also need to engage a broader range of conceptualizations of emotion and research methods, drawing on diverse disciplinary traditions.

KEYWORDS

configurative review, emotion, emotional intelligence, engineering education, meta-synthesis, systematic review

## 1 | INTRODUCTION

This paper describes an integrative, systematic review of the literature on emotions in engineering education (EEE), a rapidly emerging field of research and scholarship that explores the role of emotions in teaching and learning about technology and engineering (Lönngren, Bellocchi, et al., 2021). As an interdisciplinary field, EEE relates to (i) discipline-based research in the field of engineering education and (ii) educational research on the role of emotions in teaching and learning. With this review, we hope to support future EEE research and scholarship, based on a critical assessment of the ways in which researchers and scholars in engineering education have conceptualized emotions and how those conceptualizations have been used to frame and conduct EEE research and scholarship. In the field of education, emotion research emerged during the 1990s (e.g., Boler, 1999; Hargreaves, 1998) and has steadily increased since then. Today, a large body of educational research expands on early work by demonstrating how profoundly emotions impact teaching and learning in a wide range of subject areas and educational contexts (e.g., several chapters in Loughran & Hamilton, 2016; Pekrun & Linnenbrink-Garcia, 2014b; Zembylas & Schutz, 2016). In recent years, the field has also seen a marked increase in published literature reviews focusing on specific emotional phenomena in diverse educational domains, such as test anxiety and emotional intelligence in nursing education, emotions in teacher education, teachers' emotional labor and emotion management, children's emotions in design-based learning, emotions in technology-based and virtual learning environments, the influence of academic emotions on learning, and emotions in science education (Chen, 2021; J. P. Davis & Bellocchi, 2018; Dugué et al., 2021; Henritius et al., 2019; Loderer et al., 2020; Olson et al., 2019; Shapiro, 2014; Tan et al., 2021; Wang et al., 2019; Zhang et al., 2020).

Also in engineering education, research interest in emotions has increased substantially in recent years (Lönngren, Bellocchi, et al., 2021). Traditionally, engineering has been described as purely rational, and emotions have often been described as a threat to technological development, a description which also reflects broader societal perceptions of engineering (Kellam et al., 2018; Lönngren, Adawi, & Berge, 2021; Ottemo et al., 2021). Today, however, many engineering education researchers acknowledge that engineering is an inherently *social* profession, characterized by complex social relationships, distributed knowledge and production systems, unclear power structures, and conflicting value systems. As social relations involve human beings, who constantly and inevitably experience, express, and are influenced by emotions, engineering involves both rationality and emotion. Therefore, it has become increasingly evident that it is important to understand the role of emotions in engineering education in teaching, learning, and becoming engineers. Some engineering educators have also expressed a desire to develop students' socio-emotional (professional) competencies and their understanding of the roles emotions can play in, for example, human-centered design practices, engineering ethics and sustainability, decision making related to technological risks, professional identity development, and assuming professional responsibility for the societal effects of technological development (Bairaktarova & Plumlee, 2022; Gupta et al., 2015; Huff et al., 2021; Lönngren, Adawi, & Berge, 2021; Roeser, 2012; Sunderland et al., 2014).

Despite the increasing interest in emotions, EEE research and scholarship has not yet evolved into a coherent field with a sufficiently large body of high-quality empirical studies that could be compared and/or combined to identify, for example, effective teaching and learning approaches (Lönngren, Bellocchi, et al., 2021). This limitation, which is shared by other fields, makes it impossible to meaningfully synthesize empirical findings from EEE research and scholarship at this point. It is possible, however, to conduct a meta-synthesis systematic review to organize existing research and approaches in the field and offer directions for future work—that is what we hope to do with this paper.

## 2 | OUTLINE OF THE META-SYNTHESIS SYSTEMATIC REVIEW

The purpose of our review is to critically assess how researchers and scholars in engineering education have conceptualized emotions and how those conceptualizations have been used to frame and conduct EEE research and scholarship. We conducted a configurative meta-synthesis, which is a type of systematic review that is well suited for integrating disparate bodies of research (Siddaway et al., 2019).

We focused particularly on the ways in which EEE authors engaged with conceptualizations of emotion. Concepts and theories often guide researchers' attention to particular phenomena, and they can thus influence the directions in which a field develops (Swedberg, 2016). Emerging fields, such as EEE, may be particularly sensitive to this type of influence and may therefore benefit from taking special care in selecting and applying concepts and theories. We addressed the following research questions (RQs):

1. How have emotions been conceptualized in EEE research and scholarship?
2. How have conceptualizations of emotions been used to frame and conduct EEE research and scholarship?

## 3 | AUTHOR POSITIONALITY

This review was conducted by an international and interdisciplinary group of researchers. We are based in academic contexts in seven countries (Australia, Denmark, Malaysia, Sweden, Switzerland, United Kingdom, United States) and four continents (Asia, Australia, Europe, North America), but some of us have cultural backgrounds in additional countries (Germany, Ireland, Italy, Portugal, Venezuela). Our disciplinary backgrounds include engineering education, science education, psychology, sociology, and engineering. As a group, we are more familiar with qualitative research approaches (e.g., interview studies, discourse analysis, and phenomenological analysis) than with quantitative or mixed-methods approaches, which may have influenced what information we extracted from the reviewed articles and how we interpreted it. Further, several authors are particularly interested in sociological and critical perspectives on EEE (which partly explains our surprise at the lack of such research in the reviewed literature) and engineering ethics education (which may have influenced some of our screening decisions, for example, when we decided to include publications on empathy).

We decided to embark on this project as we lacked a clear understanding of the status of EEE research and scholarship, which we experienced as a major obstacle to engaging in EEE research ourselves. We approached our work with this review as a collaborative exploration and learning opportunity informed by (i) published guidance on conducting and reporting systematic reviews (Borrego et al., 2014; Gough et al., 2017; Grant & Booth, 2009; Page et al., 2021; Siddaway et al., 2019), and (ii) our own previous experiences of conducting various types of structured literature reviews (Bellocchi & Amat, 2022; J. P. Davis & Bellocchi, 2018; Direito et al., 2021; Lönngren & van Poeck, 2021; McKenzie et al., 2019; Olson et al., 2019). The diversity in our group triggered many critical discussions about our methods, findings, and implications for engineering education research. We also enjoyed a high level of mutual trust and openness for each other's perspectives, which we experienced as one of the largest assets in our analyses.

To facilitate project organization, we appointed a core decision-making group consisting of five authors (JL, AB, ID, JH, RT) who met regularly throughout the project to discuss project framing and organization, search and screening procedures, analytic approaches, and findings. The first author led the work in the core group, communicated important decisions to the rest of the group, assigned research tasks to group members, and monitored progress in each step of the project.

## 4 | BACKGROUND: EMOTION THEORIES IN EDUCATION RESEARCH

Emotions are often distinguished from affect, mood, and feeling (cf. Turner, 2007). Precise definitions vary, but most emotion researchers use *affect* as an umbrella concept referring to emotion, mood, and phenomena such as attitudes, motivation, and engagement. *Emotion* is typically used to describe affective experiences that are discreet and of short duration, while *mood* is understood as more diffuse and longer lasting. *Feeling* is regarded as one of the components of emotion (Fiedler & Beier, 2014).

The term *emotion* is commonly used as a collective noun for experiences that are captured under a diverse range of linguistic labels, such as ennui, anxiety, happiness, *Schadenfreude*, and anger. Whereas some labels are shared and taken to have similar meanings across cultures, others are unique to a culture- and language-sharing group (Feldman Barrett, 2017; Russell, 1991). Theoretically, emotions are often understood as a *multi-componential* phenomenon (Turner, 2007). Scherer's (2005) multi-componential model is one of the most widely used approaches, describing emotions in terms of five components: (i) motor expression, such as gestures and facial expressions; (ii) neurophysiology, including arousal and biomarkers; (iii) subjective feeling; (iv) motivation, and (v) cognition. Emotion is defined as "an episode of interrelated, synchronized changes in the states of all or most of the five organismic subsystems in response to the evaluation of an external or internal stimulus event as relevant to major concerns of the organism." (p. 697).

At the same time, emotions have been studied in a wide range of disciplines, and there are many ways of defining and conceptualizing them with no available consensus (Shuman & Scherer, 2014). Because the aim of our review was to critically assess how emotions were conceptualized and how conceptualizations of emotions were used in EEE research and scholarship, we deliberately chose to *not* apply one specific emotion theory or definition: such a

reductionist approach would have made it impossible for us to capture and map a wide range of conceptualizations used in the field. However, as a background for our review design and results, we present an overview of emotion theories that are commonly used in educational research and reflected in some of the studies we reviewed: psychological, sociological, and critical theories (Chubbuck & Zembylas, 2008). Readers who are interested in more in-depth discussions of different types of emotion theories are advised to engage with the wider literature on emotions in education (e.g., Bellocchi, 2019; Pekrun & Linnenbrink-Garcia, 2014b; Zembylas & Schutz, 2016).

## 4.1 | Psychological theories of emotion

In psychological research, emotions are typically conceptualized as complex, intrapersonal phenomena that result in physiological, neurological, and cognitive changes in individuals' minds and bodies. This perspective is commonly used to explore (a) the function of emotion in mediating a person's response to their environment, and (b) how emotion and cognition interact in this process. Researchers in this tradition highlight the role of *appraisal*, that is, the processes through which an individual evaluates whether a phenomenon or situation is aligned with their own values and goals (Moors et al., 2013; Pekrun, 2006). For example, students may appraise their performance in an exam based on their grade expectations and their ambitions for further education (Pekrun, 2006). Appraisal, in turn, is typically theorized to occur through two processes. Primary appraisal is described as rapid, automatic, and unconscious. It does not generate emotions per se but determines emotional valence (ranging from displeasure to pleasure) and activation (ranging from low to high activation responses; Murphy & Zajonc, 1993; Russell, 2003; Zajonc, 1980). Primary appraisal regulates readiness to respond to a given situation (Frijda, 1986, 2007). Secondary appraisal involves cognitive evaluation of a situation, resulting in a more nuanced placement on the valence and activation dimensions, and it allows individuals to experience distinct emotions, such as boredom, anger, or awe (Oatley et al., 2006).

Education research employing *cognitive appraisal theories* often focuses on individual students' or educators' emotions, the impact emotions may have on performance, or emotional management skills. For example, Pekrun and Linnenbrink-Garcia's (2014c) framework of *academic emotions* has been widely used to explore four types of appraisal-based emotions: *Achievement emotions* are associated with appraising one's academic performance, for example, anxiety or pride regarding exam results. *Epistemic emotions* are linked to the appraisal of cognitive processes involved in developing new knowledge. For example, students who encounter facts or ideas that are not readily integrated into their existing mental models may experience curiosity or frustration as they try to make sense of the new information. *Topic emotions* involve appraisal of the studied topic or subject matter. Examples include climate [topic] anxiety and love of mathematics [topics]. Finally, *social emotions* are linked to the appraisal of social relationships, for example, related to psychological safety (e.g., trust or anxiety) or affection (e.g., love or loneliness). In addition to studying academic emotions, cognitive appraisal perspectives have been used in research on socio-emotional competencies and generic skills, such as emotional regulation (Jarrell et al., 2022) and collaborative problem solving (Avry et al., 2020). Also discipline-based education research has applied cognitive appraisal theories, for example, studying shame related to professional identity development of engineering students (Huff et al., 2021) and test anxiety among nursing students (Shapiro, 2014).

## 4.2 | Sociological and critical theories of emotion

Sociological and critical perspectives conceptualize emotions as social constructions rather than uniquely biological or psychological phenomena. Theories of emotion within these fields facilitate "studying the social nature of emotions and studying the emotional nature of social reality" (Bericat, 2016, p. 495). In other words, emotions are explored as phenomena that influence, and are influenced by, social structures, norms, identities, and power relations (Zembylas, 2016). Education researchers in this tradition have, for example, focused on *emotional capital*, which Cottingham (2016) defines as "one's trans-situational, emotion-based knowledge, emotion management skills, and feeling capacities, which are both socially emergent and critical to the maintenance of power" (p. 454, italics omitted). As a scientific concept, emotional capital can direct our attention to ways in which experiences and expressions of emotion are regulated in education, for example, in discourses stressing the importance of fostering emotional intelligence and regulation (Zembylas, 2007). Other frequently used concepts are Hochschild's (1979, 1983) notions of *feeling rules* (social norms about who is expected to feel which emotions, how to feel them, and in which situations) and *emotional labor* (the effort professionals perform when they express emotions that are socially expected but not aligned with their inner feelings or when they try to correct

inner feelings to align with social norms and expectations). Emotional labor is pervasive in educational settings because educators often suppress negative emotions to "convey support, encouragement, and a safe place for their students" and to facilitate students' engagement with learning activities (Fraser & Brandt, 2013, p. 146). Education research has, for example, explored emotional labor in higher education (Lawless, 2018), science education (Zembylas, 2004), and social justice education (Rivera Maulucci, 2013).

Education researchers have also employed feminist and critical perspectives, studying how social structures—such as cultural ideologies, beliefs, and social norms—constrain and construct interpretations, expressions, and arousal of emotion (Stets & Turner, 2008; Turner & Stets, 2005). The interplay of emotion and power has been an important focus in education, with researchers exploring how emotions are rendered invisible and controlled and how such control of emotions relates to control of other social practices (Boler, 1999). Emotions have also been conceptualized as cultural practices that bind communities together while positioning others on the outside (Ahmed, 2010, 2014) or as something that is used to achieve political purposes, such as consensus or conflict (Zembylas, 2007). Education research from these perspectives has, for example, studied how emotions frame educational policies (Lindgren & Rönnberg, 2018, p. 57), how disgust contributes to racial discrimination (Matias & Zembylas, 2014), and how shame can contribute to intercultural understanding and solidarity (Zembylas, 2008).

## 5 | METHODS

Systematic reviews are used to synthesize prior work, identify the state of the art for research in emergent fields, and map new directions for research (Borrego et al., 2014; Page et al., 2021; Siddaway et al., 2019). Research methodologists have described several types of systematic reviews suitable for different research purposes. Gough et al. (2017) distinguish between two broad types: *Aggregative* reviews, which are common in well-developed fields with substantial bodies of empirical research, aim to synthesize all empirical findings from previous research. *Configurative* reviews, on the other hand, aim to synthesize research with a focus on mapping "the range and nature of concepts found" (p. 61). That is, configurative reviews categorize a field in terms of research foci—rather than summarizing empirical findings. As the empirical research base for EEE is highly disparate (Lönngren, Bellocchi, et al., 2021), we did not find enough empirical findings that were similar enough to be synthesized in a meaningful way.

Because we were particularly interested in developing a better understanding of the nature and status of EEE research and scholarship, we chose to conduct a configurative review of the type *meta-synthesis*, which is well suited for reviews aiming to "synthesize qualitative [and quantitative] studies on a topic in order to locate key themes, concepts, or theories that provide novel or more powerful explanations for the phenomenon under review" (Siddaway et al., 2019, p. 756). Our specific focus was on synthesizing EEE research and scholarship in terms of authors' conceptualizations of emotion.

In designing the methods for this review, we adapted a review protocol developed by Siddaway et al. (2019), which specifies instructions for conducting meta-syntheses. Our review proceeded through the following stages: (i) scoping and database searching; (ii) abstract screening, full text sifting, and full text review; (iii) pearling; (iv) mapping the literature through a scoping review; and (v) in-depth analysis for the meta-synthesis review. In reporting on the aims, processes, and results from this review, we followed the PRISMA 2020 statement (Page et al., 2021), which outlines widely accepted guidelines for reporting on systematic review studies.

### 5.1 | Scoping and database searching

When we started working on this review, we could not find any published overview of the EEE literature, and we were not aware of any engineering education researchers who had systematically explored the field. As a result, we had little guidance in deciding on search criteria and predicting the types and number of studies we could find. Therefore, we began by iteratively applying different combinations of keywords and filters until we were satisfied that we had not missed any publications that we knew existed while also avoiding retrieval of a high percentage of publications beyond the scope of our review.

The term "emotion" is widely used in psychological, sociological, and critical emotion research, and it is therefore particularly useful for retrieving publications drawing on a broad range of theoretical perspectives. However, we quickly realized that only searching for the term "emotion" could miss publications focusing on *specific* emotions (e.g., anxiety, sadness, or confusion). Because the number of words used to refer to specific emotions is immense (in English, some have estimated over 2000 unique labels for different emotions at one extreme, with older 19th and 20th century classifications listing 100, and the situation is similar for other languages; Dixon, 2003; Russell, 1991), it was impossible to include all possible words for specific emotions as separate search terms. As a compromise, we included the terms "affect" and "feeling" in our database searches. Although we were not planning on reviewing the literature on these terms, we were confident that most papers focusing on specific emotions would mention emotion, affect, and/or feeling in the title, abstract, and/or keywords. Our final search string was as follows: ((emoti* OR affective OR feeling*) AND ("engineer* educat*" OR "technology educat*" OR "engineering stud*" OR "engineering instruct*" OR "engineering facult*")).

We searched 10 databases, including 3 general databases (Scopus, Web of Science, Academic Search Complete), 2 educational/social science databases (ERIC, IBSS), 1 psychological database (APA PsycInfo), 1 engineering database (Engineering Village), and 3 databases specialized on eBooks and theses (eBook Collection, Dissertations & Theses Global, Open Thesis). In those databases that offered such an option (Academic Search Complete, ERIC, and APA PsycInfo), we restricted our searches to peer-reviewed publications, but we did not apply any additional limitations such as year of publication or language. This search yielded 3529 records, which were added to a shared literature management library in Zotero. We manually went through all records to exclude duplicates, retaining 2175 unique records (Figure 1), a number that greatly exceeded our expectations.

## 5.2 | Abstract screening, full text sifting, and full-text review

To iteratively narrow our focus on the most relevant publications, we followed a three-stage screening process: (i) abstract screening, (ii) full text sifting, and (iii) full text review (Borrego et al., 2014; Siddaway et al., 2019). In designing our screening criteria, we combined two widely used approaches: the primarily quantitatively oriented PICO approach (*P*opulation, *I*ntervention, *C*omparison, and *O*utcomes) and the more qualitatively oriented SPIDER approach (*S*ample, *P*henomenon of *I*nterest, *D*esign, *E*valuation, and *R*esearch type) (Cooke et al., 2012). This combination was necessary because our review covered qualitative, quantitative, mixed-methods, and non-empirical studies. For example, not all reviewed studies included an "intervention" or a "comparison" of results across different treatment options, and we therefore excluded those criteria from the PICO approach. Similarly, we excluded "research type" and "design" from the SPIDER approach because we aimed to map the range of research approaches and methods authors reported on rather than reviewing research of a specific type. Following Siddaway et al. (2019), we prioritized *inclusivity* during abstract screening (employing broad inclusion criteria to capture the full breadth of existing EEE research) and *specificity* during full text sifting and full text review (employing narrower criteria to identify the most relevant publications).

We developed two detailed codebooks using Microsoft Excel, one for abstract screening (codebook 1, middle column in Table 1) and the other for full-text sifting and full-text review (codebook 2, right column in Table 1). The codebooks outlined stepwise procedures to screen for the SPIDER/PICO criteria *S*ample & *P*opulation (Step 1), *P*henomenon of *I*nterest & *O*utcomes (Step 2), and *R*esearch type (Step 3), as well as Accessibility (Step 4, only for full-text sifting and full-text review). Publications excluded in an earlier step were not screened for the remaining steps. For example, publications passing Step 1 but not Step 2 were excluded at Step 2, meaning that they were not screened for Steps 3 and 4. The screening criteria for each step are summarized in Table 1.

To ensure that all members of the research team understood and applied the codebooks in a similar manner, the codebooks contained examples to illustrate each inclusion/exclusion criterion. In addition, all reviewers participated in training sessions prior to abstract screening and full-text sifting. During these sessions, we noticed, for example, that many publications did not focus on emotion per se, but on closely related phenomena: Many publications did not use the term "emotion" (or terms denoting specific emotions) as a noun. Instead, they used "emotional" as classifying adjectives that were combined with nouns such as "intelligence" or "learning." To clarify the screening criteria, we agreed to use the expression "conceptualizations of emotion" to denote both emotions and emotional phenomena. Each publication was then screened independently by two researchers, and disagreements were resolved by a third researcher. The number of publications excluded at each step is shown in Figure 1.

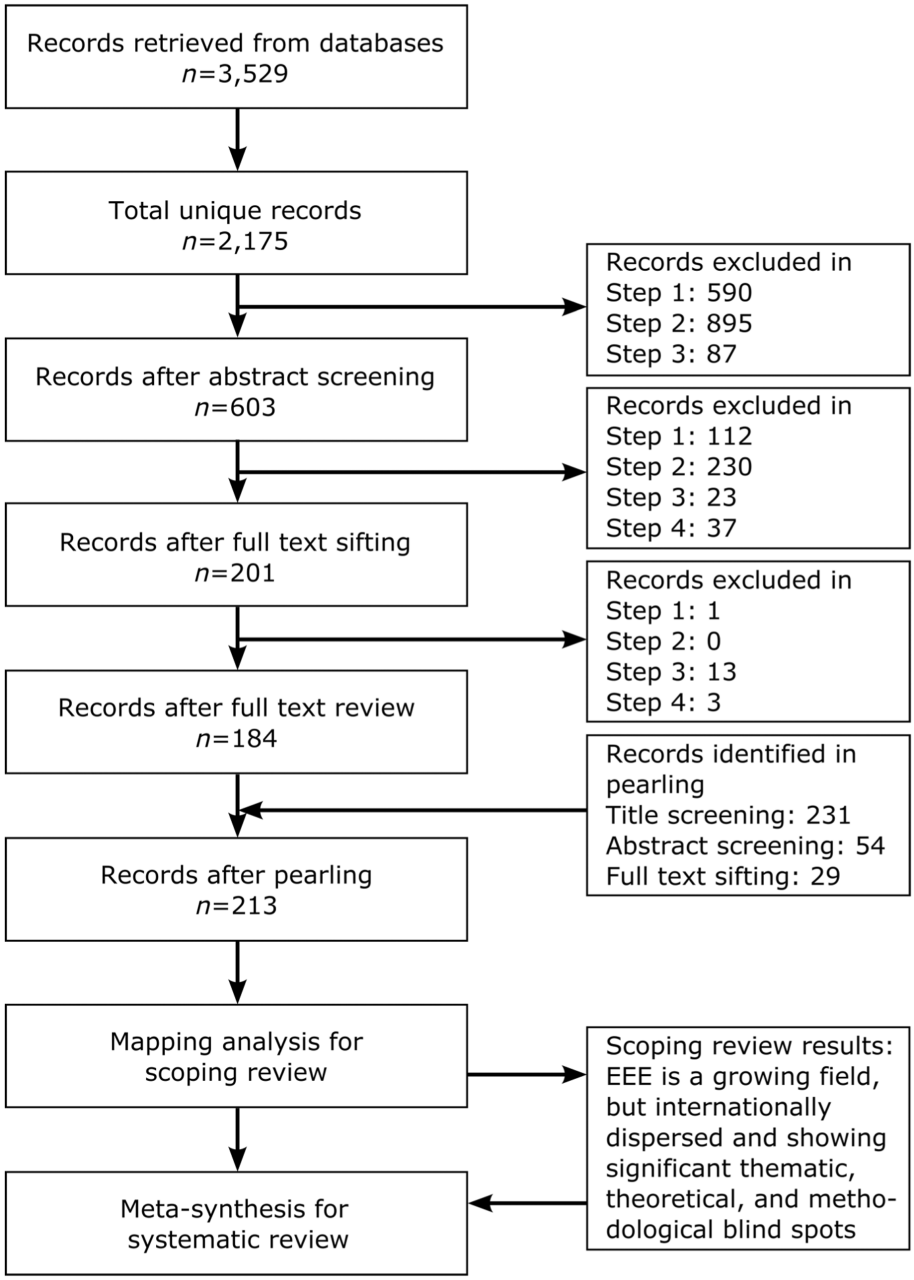


**FIGURE 1** Overview of the selection and analysis process.

## 5.3 | Pearling

Pearling, also called hand-searching, is used to identify publications that may have been missed in the initial database searches, for example, by manually going through the reference lists of included publications (Borrego et al., 2014; Siddaway et al., 2019). In our work with this review, we noted that several EEE publications we knew about were missed in the initial searches, for example, publications in *Science and Engineering Ethics* which focused on education but did not make this focus explicit in the title, keywords, and/or abstract. To mitigate this and other potential oversights, we hired six student assistants who created a Microsoft Excel database with all references from the 184 publications retained after full text review, resulting in a table of 8311 references (including duplicates). We reviewed all titles in the database, selecting 231 potentially relevant publications for abstract screening, full-text sifting, and full-text review. Twenty-nine of these publications were retained and added to the dataset, resulting in a final set of 213 publications (Appendix) for review and a total number of 9759 items in the reference database.

**TABLE 1** Steps and criteria for abstract screening, full-text sifting, and full-text review.

| SPIDER/PICO criteria | Abstract screening (codebook 1) | Full-text sifting and full-text review criteria (codebook 2) |
|---|---|---|
| Step 1: Sample/ population | *Included*<br>• Focus on actors (e.g., students, instructors, administrators) or settings in engineering, technology, or computer science education<br>• Focus on engineering work, if explicitly linked to engineering education<br>*Excluded*<br>• Focus on science education and/or engineering work only | *Included*<br>• Relevant for the education of future engineers and/or engineering education research<br>*Excluded*<br>• N/A |
| Step 2: Phenomenon of interest/ outcomes | *Included*<br>• Mention of emotions or outcomes related to emotions in engineering education<br>*Excluded*<br>• The term "emotion" is not used and no specific emotions (e.g., anxiety, sadness) are mentioned. | *Included*<br>• Substantive focus on emotions or outcomes related to emotions in engineering education<br>*Excluded*<br>• Mention of emotion in passing/as tangential topics<br>• The term "emotion" is not used and no specific emotions (e.g., anxiety, sadness) are mentioned. |
| Step 3: Research type/N/A | *Included*<br>• Scientific publications on (non-)empirical research or scholarship, including works in progress[a]<br>*Excluded*<br>• Reflective practice, popular science and non-scientific publications | *Included*<br>• Scientific publications on (non-)empirical research or scholarship, including works in progress[a]<br>*Excluded*<br>• Primarily descriptive accounts of educational activities; popular science and non-scientific publications |
| Step 4 | *Included*<br>• N/A<br>*Excluded*<br>• N/A | *Included*<br>• N/A<br>*Excluded*<br>• Not accessible through authors' library resources<br>• Full text in a language the authors could not read[b] |

[a]Works in progress were included because (i) it was not always obvious if publications described final or preliminary results, and (ii) works in progress provide important indications for which directions the still-emerging field is developing in.
[b]The following languages were included: English, German, French, Spanish, Portuguese, Italian, Danish, Swedish, Norwegian, and Malaysian. However, after screening, only publications written in English and Spanish remained.

## 5.4 | Mapping the literature through a scoping review

To develop an initial understanding and a broad overview of the retrieved publications, we extracted and collated descriptive information about publication outlets, authors' origins, keywords, use of common emotion concepts, research approaches (types of research, research methodologies, data collection methods), and contexts (e.g., educational contexts, pedagogical approaches used). During this process, which we refer to as a *scoping review*, each publication was read by one researcher. Each reviewer entered the information he or she extracted in a shared spreadsheet using the online version of Microsoft Excel. For each type of information, we used predefined categories with an option to add free-text comments. Authors' keywords were analyzed deductively, categorizing keywords according to terms included in the EER taxonomy (Finelli, 2020). Free-text comments were analyzed inductively through thematic clustering, creating, and applying new categories until we were able to categorize all publications. Thereafter, we extracted descriptive statistics.

## 5.5 | In-depth analysis for the meta-synthesis review

The in-depth analysis proceeded in two stages. Stage I focused on extracting information from the publications and adding it to shared spreadsheets, again using the online version of Microsoft Excel. This was done independently by

two researchers for each of the 213 publications. In stage II, the focus shifted toward interpretation and critical analysis, and each analysis was performed by two collaborating researchers.

### 5.5.1 | RQ 1: Analyzing conceptualizations of emotion

InsStage I of the analysis for RQ 1, two researchers independently coded each publication for four levels of engaging with conceptualizations of emotion: (0) no explicit conceptualization, (1) citing literature containing conceptualizations, (2) applying conceptualizations, or (3) developing new conceptualizations (Table 2). Inconsistencies were resolved by a third researcher.

In stage II of the analysis, two researchers independently performed inductive coding to categorize the conceptualizations of emotion that authors engaged with. In this process, the researchers constructed codes using authors' own terms for emotion concepts and theories as far as possible, even when authors did not provide clear definitions or conceptualizations of those terms. Many emotion concepts used by authors refer to multiple phenomena (e.g., empathy has been found to refer to eight distinct phenomena; Batson, 2009) and/or have overlapping meanings (e.g., empathy is typically viewed as a component of emotional intelligence; Mayer et al., 1999). Therefore, our final codes do not form a parsimonious set (e.g., the codes "empathy" and "socio-emotional competencies/skills" have overlapping meanings).

In summarizing the results from this analysis, we first distinguished between emotion concepts (e.g., concepts referring to specific emotions, such as anxiety or frustration; or emotional phenomena, such as emotional intelligence or emotional labor) and emotion theories (e.g., explaining how emotions develop and/or relate to each other). Thereafter, we summarized the findings for emotion concepts and theories separately.

### 5.5.2 | RQ 2: Analyzing how conceptualizations of emotions have been used to frame and conduct EEE research and scholarship

Our analysis for RQ 2 focused on (i) how conceptualizations of emotion may have impacted EEE research—in terms of which functions the different conceptualizations performed in the publications; (ii) how previously published work was used in conceptualizing emotions—in terms of citation and co-citation patterns; and (iii) overall coherence in the studies described in the EEE literature—in terms of alignment between conceptualizations of emotion and research purposes and methods.

#### *Analyzing functions performed by conceptualizations of emotion*

In stage I of the analysis, two researchers independently extracted information from each publication regarding functions performed by conceptualizations of emotion. In stage II, two researchers collaborated to code the extracted information inductively.

**TABLE 2** Coding scheme for determining the level of engagement with conceptualizations of emotion.

| Level | Explanation | Example |
|---|---|---|
| 0 | No explicit conceptualization: readers are assumed to share the authors' understanding of "emotion" | Students were asked to draw "emotion maps" of their emotional "journeys," but these concepts were not defined (Ge & Leifer, 2020) |
| 1 | Literature containing conceptualizations was cited, but no conceptualization was applied in data analysis and/or theoretical argument | Goleman's work on emotional intelligence was cited in the methodology section, but the concept was not defined (Zallio & Berry, 2018) |
| 2 | Conceptualizations were applied in data analysis and/or theoretical argument in such a way that they influenced the nature of the results/discussion; may include minor adaptation of existing theory | The Academic emotions framework was described in the literature review, the Achievement emotions questionnaire used in data analysis, and findings discussed in terms of achievement emotions (Husman et al., 2015) |
| 3 | New conceptualizations were developed, beyond minor adaptations | An empirically based model was developed to explain the role of emotional openness in ethical risk management (Guntzburger et al., 2018) |

*Analyzing citation and co-citation patterns*

To develop a better understanding of the overall ecosystem of EEE research and scholarship, we analyzed citation and co-citation patterns, using the above-mentioned reference database developed by student assistants. We first identified all authors ($n = 34$) whose work was referenced more than 20 times across the included publications and categorized these authors according to their primary disciplinary fields. In this process, we relied on information about authors' professional affiliations/roles published on institutional or other professional websites. We also categorized each scholar's major theoretical contributions in emotion research, based on the titles of all their publications included in our reference database.

We then conducted a co-citation analysis to identify research hot spots (clusters of co-citations) and ways in which these hot spots were interconnected in the EEE literature. We defined "co-citation" as (a) authors published together (e.g., Mayer and Salovey) and/or (b) authors published independently but were later both cited in another publication in our dataset. To visualize co-citation patterns, we constructed a co-citation network graph (Figure 5), using the openly available "igraph" package (Pedersen, 2020) which features a backbone layout (Nocaj et al., 2015).

*Analyzing alignment between conceptualizations of emotion with research purposes and methods*

Previous findings indicated that many EEE publications reported on emotions as incidental findings from studies that were not initially designed to study emotions (Lönngren, Bellocchi, et al., 2021), meaning that conceptualizations of emotion were introduced *after* data collection. These findings raised concerns that conceptualizations of emotion might not always be well aligned with the stated research purposes and/or methods.

In stage I of the analysis of alignment between conceptualizations and research purposes, two researchers independently extracted information from each of the 150 publications that engaged with conceptualizations of emotion. In this process, "research purpose" was operationalized as intended research outputs, such as model development, competency assessment, or understanding of relationships between variables. In stage II, two researchers collaborated to (i) review and comment on the information extracted in stage I, and (ii) develop and apply inductive codes to categorize research purposes. Each publication was coded for one ($n = 119$) or two ($n = 31$) purposes.

Another pair of researchers then collaborated to rate the alignment between conceptualizations of emotion and research purposes on a three-level scale (not aligned, somewhat aligned, well aligned). In publications categorized as *well aligned*, the stated research purpose explicitly addressed emotions and the authors presented clear conceptualizations. The category *not aligned* captured publications in which (i) the stated purpose did not involve a focus on emotion, but the article reported on results on emotions, or (ii) the purpose focused on emotion, but emotion was not conceptualized with scientific references. Publications coded as *somewhat aligned* focused on emotions in the purpose statements and the conceptual section of the publication, but the two did not correspond entirely. For example, the purpose of a publication could be framed as understanding engineering students' *emotions*, but it could then provide a conceptualization of *emotional regulation* rather than emotions per se.

Finally, another pair of researchers worked together to rate the alignment between conceptualizations of emotion and research methods, relying on a previously conducted categorization of research methods used in the included publication (Lönngren, Bellocchi, et al., 2021). The two researchers employed the same three-level scale as above (not aligned, somewhat aligned, well aligned). For a publication to be categorized as *well aligned*, it needed to include an explicit description of how the research purpose was aligned with the method of investigation. The category *not aligned* captured publications that did not use methods that were aligned with conceptualizations of emotion (e.g., evaluating student performance in a study framed as focusing on empathy). Publications coded in the *somewhat aligned* category included papers in which authors did not clearly describe how their methods were aligned with their conceptualizations of emotion. Only publications that both engaged with conceptualizations of emotion and described empirical studies were included in this analysis ($n = 114$).

# 6 | RESULTS

## 6.1 | Scoping review results

In our initial mapping of the EEE literature, we focused on publication outlets, authors' national origins, research foci, and research approaches. We observed that the field has grown exponentially in the past two decades and that it appears to have grown faster than the broader educational literature. However, a substantial portion of the

213 publications in our review were conference papers (43%). By far the largest portion of these (19%) were presented at the Annual Conference and Exhibition of the American Society of Engineering Education. Forty-two percent of the publications were journal articles, most commonly (5%) published in the *International Journal of Engineering Education*, followed by the *European Journal of Engineering Education* (3%). Theses represented 11% of the included publications, while books and book chapters only contributed 3% (Figure 2).

Five hundred and twenty-two authors from 40 countries contributed to the publications in our dataset, with a large majority based in the United States. Similar to findings from a review of publications in the broader field of engineering education research (Jesiek et al., 2011), international collaborations were relatively rare (7%), and we found only two groups of authors who frequently published together (Walther, Kellam, and Villanueva in the United States; Muhamad, Sahari, and Saibani in Malaysia). Furthermore, a large majority of authors (84%) contributed only to a single publication. In other words, many authors primarily published on topics other than emotions, indicating that they explored emotions as a side topic rather than their primary research focus. This conclusion is supported by our finding that many publications (33%) did not have emotions as their primary focus. Rather, emotions emerged as important in research focused on other topics, such as experiences of collaborative learning (Chance & Williams, 2020) or uncertainty in engineering design (Cummings, 2015).

The most common type of studies reported in the EEE literature was quantitative studies (43%), followed by non-empirical (22%), qualitative (18%), mixed-methods (12%), and multi-method (5%) studies (Figure 3), and a majority of studies relied on self-report measures (reporting on one's own emotions, e.g., through questionnaires or interviews, 73%). The prominence of quantitative methods mirrors trends in engineering education research (Malmi et al., 2018) and the prominence of self-report measures mirrors trends in educational emotion research (Pekrun & Bühner, 2014; Shuman & Scherer, 2014). Further, a large majority of EEE studies were conducted in higher education contexts (84%), indicating important research gaps in primary and secondary education, which have also been identified in reviews of engineering education research (Borrego & Bernhard, 2011; Jesiek et al., 2011). In terms of research foci, we found a large prevalence of publications on emotional intelligence and anxiety, both of which are also prominent in educational emotion research (Keefer et al., 2018; Pekrun & Linnenbrink-Garcia, 2014c). The main themes identified through abductive coding of research foci were (i) academic emotions, primarily focusing on performance-related anxiety;

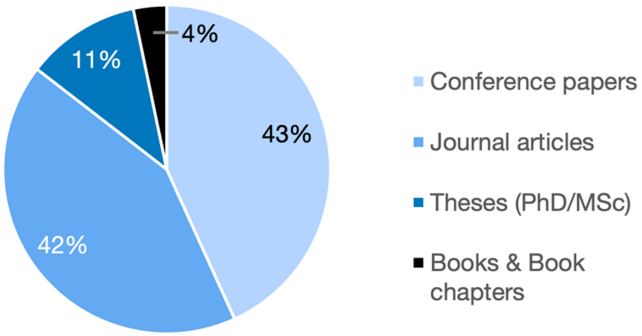


**FIGURE 2** Distribution of publications across publication outlets.

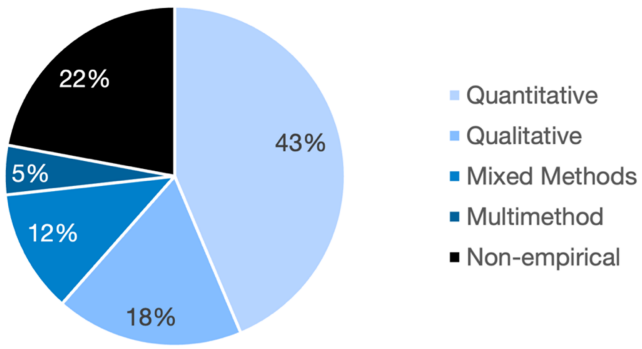


**FIGURE 3** Distribution of study types across publications.

(ii) emotions and ethics, focusing on emotional empathy, care, and moral emotions; (iii) emotional intelligence and other socio-emotional competencies, such as emotional regulation, motivation, and generic skills; and (iv) mental health or, more commonly, lack thereof (Lönngren et al., 2023; Lönngren, Bellocchi, et al., 2021).

#### 6.1.1 | Scoping review summary

Overall, the scoping review painted a picture of EEE as a rapidly emerging, highly dispersed field of research and scholarship with substantial blind spots (cf. Steinert & Roeser, 2020; Wagner, 1993). More importantly, the scoping review suggested that many EEE studies were triggered by incidental observations of the importance of emotions in teaching and learning rather than an intentional selection of research foci and relevant conceptual or theoretical frameworks. These observations are troubling because concepts and theories carry (sometimes implicit) values and assumptions that influence research. Concepts, for example, guide researchers' attention to certain aspects of social realities, and "the skillful use of existing concepts [therefore] presupposes that the researcher knows quite a few concepts, so you [they] have something to draw on and play around with" (Swedberg, 2016, p. 32). To better understand the nature and status of EEE research and scholarship, it was therefore imperative to explore how EEE authors engaged with concepts and theories of emotion, which we did by addressing our two research questions.

### 6.2 | RQ 1: How have emotions been conceptualized in EEE research and scholarship?

One hundred and fifty of the 213 publications (70%) engaged with conceptualizations of emotion (emotion concepts and/or theories) to some degree (levels 1–3 in Table 2), while 63 publications (30%) *did not provide any explicit conceptualization* of emotion (level 0). Authors can have legitimate reasons for not including conceptualizations, but such reasons were not brought forward in the publications in this category. Fifteen percent of the publications *cited literature containing conceptualizations*, but they did not apply the conceptualizations in empirical analyses or theoretical arguments (level 1). In other words, almost half of the included publications (45%) did not apply any emotion concepts or theories (Table 3). In 53% of the publications, *conceptualizations were applied* (level 2), but these publications varied regarding the depth and quality of engagement with conceptualizations and often did not define emotion concepts clearly. Only four publications (2%) *developed new conceptualizations* of emotions (level 3). This is perhaps unsurprising, and it may even be a desirable outcome, because further increasing the number of conceptualizations of emotion for education research is unlikely to benefit the field. Finally, among the 150 publications engaging with conceptualizations of emotion, almost all (99%) engaged with emotion *concepts*, but only 10 publications (7%) engaged with emotion *theory*.

#### 6.2.1 | Use of emotion concepts

In the 149 publications engaging with *emotion concepts*, emotional intelligence (or emotional quotient) was used most often ($n = 71$), followed by emotional awareness ($n = 41$), and emotional management/regulation ($n = 36$). These three concepts were often used together in the same publications, which is reasonable because emotional intelligence often is conceptualized as including abilities to become aware of/recognize and manage/regulate emotions. The broader terms (socio-)emotional competencies/skills ($n = 15$) were also frequently used, but often primarily as a synonym for emotional intelligence (e.g., emotional intelligence as an emotional competence) and/or to describe certain aspects of

**TABLE 3** Level of engagement with conceptualizations of emotion across publications.

| Level of engagement | Results |
|---|---|
| 0: No explicit conceptualization | 63 (30%) |
| 1: Citing literature containing conceptualizations | 33 (15%) |
| 2: Applying conceptualizations | 113 (53%) |
| 3: Developing new conceptualizations | 4 (2%) |

emotional intelligence (e.g., social skills as an aspect of emotional intelligence). A few authors also framed (socio-)emotional competencies/skills in terms of other broad concepts, such as professional skills, soft skills, or teamwork skills (e.g., Riemer, 2004; Silva et al., 2020).

Another commonly used concept was empathy ($n = 20$). In many cases, empathy was conceptualized as a cognitive-emotional aspect of emotional intelligence (cf. social skills) or professional responsibility and decision-making skills (Hess & Fila, 2016). Empathy was also described as a dynamic process (e.g., Tanu et al., 2017) and a practice orientation characterized by concern for others (Walther et al., 2017).

In terms of specific emotions, anxiety was used in the greatest number of publications ($n = 17$), followed by stress ($n = 12$), shame ($n = 8$), anger ($n = 8$), joy ($n = 8$), hope ($n = 6$), happiness ($n = 5$), and frustration ($n = 5$). Anxiety was often discussed in relation to academic performance and conceived of as a type of academic emotion (achievement emotion). Most of the publications using the concept of academic emotion ($n = 14$) focused on achievement emotions, but a few also focused on social emotions (e.g., Huff et al., 2018; Vitasari et al., 2011) and topic emotions (e.g., Villanueva et al., 2018). A few publications dealt with emotions that could have been conceptualized as epistemic emotions (e.g., frustration during learning), but none of the reviewed publications made this connection.

In Table 4, we also included affect ($n = 13$) and motivation ($n = 11$) because several authors used these terms as emotion concepts. However, readers should keep in mind that we did not include these terms in our sampling criteria and the number of publications in engineering education focusing on affect and motivation is far greater than the entire EEE literature.

A large majority of the publications (91%) engaged with at least one of the nine most used emotion concepts. Thus, the EEE literature appears to be dominated by a small number of concepts, and we see great potential for expanding the scope of EEE research and scholarship. We also note that the prominence of research on anxiety, emotional intelligence, and socio-emotional competencies mirrors similar trends in the broader educational literature (Keefer et al., 2018; Pekrun & Linnenbrink-Garcia, 2014c).

### 6.2.2 | Use of emotion theories

We identified only two types of *emotion theories* that EEE publications engaged with: multi-componential theory (MCT; $n = 6$), which aims to explain how emotions function as cognitive appraisal (Scherer, 2005), and/or control-value theory (CVT; $n = 4$), which aims to explain emotional experiences in learning processes (Pekrun, 2006). We note that both

**TABLE 4** Number of publications engaging with the nine most commonly used (in ≥5 publications) emotion concepts.

| Emotion concepts | Number of publications in which used |
|---|---|
| Emotional intelligence/quotient | 71 |
| Emotional awareness | 41 |
| Emotional management/regulation | 36 |
| Empathy | 20 |
| Anxiety | 17 |
| Socio-emotional competencies/skills | 15 |
| Academic emotions | 14 |
| Affect | 13 |
| Stress | 12 |
| Motivation | 11 |
| Anger | 8 |
| Joy | 8 |
| Shame | 8 |
| Hope | 6 |
| Frustration | 5 |
| Happiness | 5 |

MCT and CVT are cognitive appraisal theories, which further strengthens our conclusions regarding the limited scope of EEE research and scholarship. We did not find any EEE publications drawing on sociological or critical theories of emotion, even though such theories are commonly referred to in the wider education literature (Chubbuck & Zembylas, 2008; Zembylas & Schutz, 2016). For example, Hochschild's (1979, 1983) work on *feeling rules* (norms regarding who is expected to feel and express which emotions) and *emotional labor* (the effort one exerts to express emotions according to what is considered appropriate and desirable in an organization or profession) has lately received increasing attention in the sociological education literature (Wang et al., 2019). In the EEE literature, Hochschild's (1979, 1983) work has been cited only in three publications, and it has not been used to conceptualize emotions. We were also surprised to find no publications that critically engaged with discourses of rationality in engineering and engineering education (cf. Kellam et al., 2018; Lönngren, Adawi, & Berge, 2021). We suspect that these discourses may be so pervasive in the EEE literature that they are often taken for granted.

#### 6.2.3 | RQ 1: Summary

The results for RQ 1 strongly suggest that a large part of the existing EEE literature has not thoroughly engaged with conceptualizations of emotion. We also found that the literature, so far, has engaged with only one type of emotion theory (cognitive appraisal theories) and a small number of emotion concepts (emotional intelligence and related concepts being the most commonly used, followed by empathy, anxiety, and socio-emotional competencies/skills). We did not find any EEE publications applying sociological or critical theories of emotion; nor did we find any emotion concepts derived from such theories.

### 6.3 | RQ 2: How have conceptualizations of emotions been used to frame and conduct EEE research and scholarship?

#### 6.3.1 | Functions performed by conceptualizations of emotion

Among the 150 publications engaging with conceptualizations of emotion, we identified four types of functions that conceptualizations performed (Figure 4). By far the most common ($n = 93$) function was to *quantify the presence of emotions and/or socio-emotional competencies*. In publications coded for this function, authors used terms for specific emotions or emotional valence ($n = 37$) to categorize emotions and quantify how often/to which degree participants reported experiencing those emotions. Authors also used terms for specific socio-emotional competencies ($n = 58$) to categorize competencies and measure to which degree students demonstrated those competencies. For example, Deveci (2016) used the concept of "boredom" to quantify the degree to which first-year engineering students experienced that emotion in a communication course. The prominence of quantitative functions mirrors the prominence of EEE publications focusing on emotional intelligence, which is often framed as an emotional competency and studied using quantitative psychometric instruments (Lönngren et al., 2023).

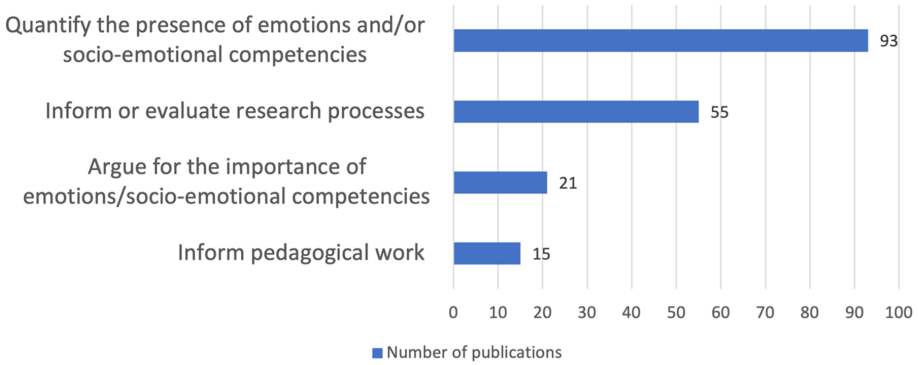


FIGURE 4 Number of publications coded for different functions performed by conceptualizations of emotion.

The second most common ($n = 55$) function was to *inform or evaluate research processes*, which could include applying concepts for correlation analyses and/or predictions ($n = 30$), guiding analytic attention and interpretation of qualitative data ($n = 11$), theoretically framing other phenomena (e.g., ethics, understanding; $n = 15$), and/or developing/evaluating analytic instruments or procedures (e.g., measure validity, develop a laboratory protocol; $n = 2$). For example, Adams and Turns (2020) applied "emotional labor" as an analytic perspective to characterize experiences of educational innovation.

In 21 publications, conceptualizations of emotion were used to *argue for the importance of emotions* ($n = 7$) or *socio-emotional competencies* ($n = 14$) in engineering education and practice. For example, Riemer (2004) discussed "emotional intelligence" in an argument for the importance of emotions in facilitating communication competencies among engineering students. Based on our previous knowledge of the EEE literature, we had expected a larger number of publications in this category. The lower-than-expected number may be explained by our analytic focus on publications in which authors supported their arguments with the help of conceptualizations of emotion—rather than including all publications in which these types of arguments were brought forward (which often occurred in the introduction section).

Finally, in 15 publications, conceptualizations were used to *inform pedagogical work*, describing how concepts informed authors' development of new teaching practices (e.g., an intervention or e-learning platform; $n = 6$), describing how authors used concepts to evaluate pedagogical approaches (e.g., suitability or effectiveness; $n = 10$), and/or suggesting approaches that readers could try in their classrooms ($n = 7$). An example of this function is found in Zatarain Cabada (2018), who used concepts representing specific emotions to develop an e-learning platform that used facial emotion recognition to personalize student feedback (e.g., providing motivational feedback if boredom was detected).

### 6.3.2 | Citation patterns

The three most frequently (>100 times) referenced authors (Goleman, Mayer, Salovey) are widely known for their work on emotional intelligence (Table 5). Even other authors who have written about emotional intelligence (Caruso, Petridis, Bar-On, Schutte, Malouff) were among the most referenced. Together, these eight authors accounted for 5% of all references, which further strengthens our finding of a large prevalence of publications focusing on emotional intelligence. Outside the emotional intelligence field, the most referenced author was Pekrun, whose work has often focused on academic emotions. Other frequently cited authors associated with research on academic emotions were Goetz, Husman, and Perry. These four authors accounted for 2% of all references. A few of the frequently referenced authors have focused specifically on emotions in engineering and engineering education, dealing with empathy and ethics in engineering (Hess, Walther, and Strobel) or emotional intelligence and transversal skills (Riemer). These four authors also accounted for 2% of all references.

In terms of disciplinary backgrounds, many of the most referenced authors (Tables 5 and 6) were psychologists ($n = 19$; including Goleman even though his work has focused more on popularizing concepts from psychological research than conducting original research; excluding Damasio, who holds a professorship in psychology, but whose research has primarily focused on neuroscience). Most of the remaining 15 authors are known for their work in engineering and/or engineering education. Finally, the frequently referenced authors included two philosophers (one of whom, Roeser, has worked primarily on emotion) and one scholar in Science and Technology Studies (Lucena, whose primary focus has been on humanitarian engineering and social justice). Sociologists of emotion, on the other hand, were not represented among the frequently referenced authors, and even in the overall database, prominent sociologists were largely absent. For example, Hochschild's work was referenced only five times in 3 of the 213 papers; Stets was referenced only once; and Kemper, Thoits, or Turner was not referenced in any of the included publications.

### 6.3.3 | Co-citation patterns

To visualize co-citation patterns, we developed a co-citation network graph (Figure 5), in which frequently cited authors are shown as orange nodes. The size of each node represents the author's PageRank Centrality (Brin & Page, 1998), which roughly translates to the frequency with which an author has been cited in the included publications. The turquoise (numbered) dots represent the 213 papers in our dataset. Lines indicate that the respective author has been cited

**TABLE 5** Reference frequencies for authors referenced >20 times.

| Name | Number of citations (publications in which cited) | Primary research discipline | Major contributions in cited work |
|---|---|---|---|
| Daniel Goleman | 134 (70) | Popular psychology | Popular psychology model of emotional intelligence |
| John Mayer | 125 (53) | Psychology | Emotional intelligence ability model |
| Peter Salovey | 124 (58) | Psychology | Emotional intelligence ability model |
| Reinhard Pekrun | 95 (31) | Psychology | Control value theory of academic emotions |
| Justin Hess | 46 (12) | Engineering | Empathy and emotion in engineering education and engineering ethics |
| Marc Riemer | 41 (24) | Engineering Education | Engineers' communication skills, transversal skills, and emotional intelligence |
| Joachim Walther | 39 (21) | Engineering | Empathy in engineering education model |
| Thomas Goetz | 38 (21) | Psychology | Control value theory of academic emotions |
| Johannes Strobel | 37 (19) | Engineering | Theory of empathy and care in engineering education |
| David Caruso | 35 (22) | Psychology | Approaches for training and measuring emotional intelligence skills |
| Konstantinos Petrides | 35 (24) | Psychology | Emotional intelligence trait model and assessment |
| Nadia Kellam | 34 (18) | Engineering | Empathy and engineering teaching |
| Albert Bandura | 34 (18) | Psychology | Social cognitive theory and self-efficacy beliefs |
| Reuven Bar-On | 31 (25) | Psychology | Emotional intelligence trait and ability model and assessment |
| Jenefer Husman | 29 (10) | Psychology | Engineering student's stress |
| António Damasio | 29 (18) | Neuroscience | Somatic marker hypothesis on the role emotion plays in cognition |
| Raymond Perry | 29 (21) | Psychology | Control value theory of academic emotions |
| Adrian Furnham | 29 (21) | Psychology | Emotional intelligence assessment |
| James Parker | 28 (14) | Psychology | Trait emotional intelligence |
| Michael Davis | 27 (17) | Philosophy | Ethics in professions |
| Richard Boyatzis | 26 (22) | Psychology | Emotional intelligence in management and leadership |
| Nicola Schutte | 25 (21) | Psychology | Self-report emotional intelligence assessment |
| Sabine Roeser | 25 (9) | Philosophy | Moral intuitions and risk |
| Carla Zoltowski | 24 (13) | Engineering | Human-centered design |
| Barbara Karanian | 24 (6) | Engineering | Storytelling and emotion in engineering design |
| Richard Felder | 24 (21) | Engineering | Student performance and retention; measurement of anxiety |
| John Malouff | 24 (21) | Psychology | Self-report emotional intelligence assessment |
| David Watson | 23 (11) | Psychology | Positive and negative affect model |
| Paul Pintrich | 23 (13) | Psychology | Self-regulated learning and motivation |
| William Oakes | 22 (13) | Engineering | Human-centered design and service learning |
| Juan Lucena | 22 (18) | Science and Technology Studies | Humanitarian and social justice engineering |
| Sheri Sheppard | 22 (16) | Engineering | Persistence and engagement; engineering design |
| Idalis Villanueva Alarcón | 21 (6) | Engineering | Affect and emotion in engineering students and teachers |
| Howard Gardner | 21 (12) | Psychology | Multiple intelligences model |

*Note*: Institutional authors, such as ABET, were not included.

**TABLE 6** Reference frequencies by disciplinary affiliation for authors referenced >20 times.

| Authors' disciplines | Number of authors in discipline | Number of citations for author | Number of publications by author |
|---|---|---|---|
| (Popular) psychology | 19 | 908 | 488 |
| Engineering | 10 | 293 | 145 |
| Philosophy | 2 | 52 | 26 |
| Engineering education | 1 | 41 | 24 |
| Neuroscience | 1 | 29 | 18 |
| Science and technology studies | 1 | 22 | 18 |

*Note*: Institutional authors, such as ABET, were not included.

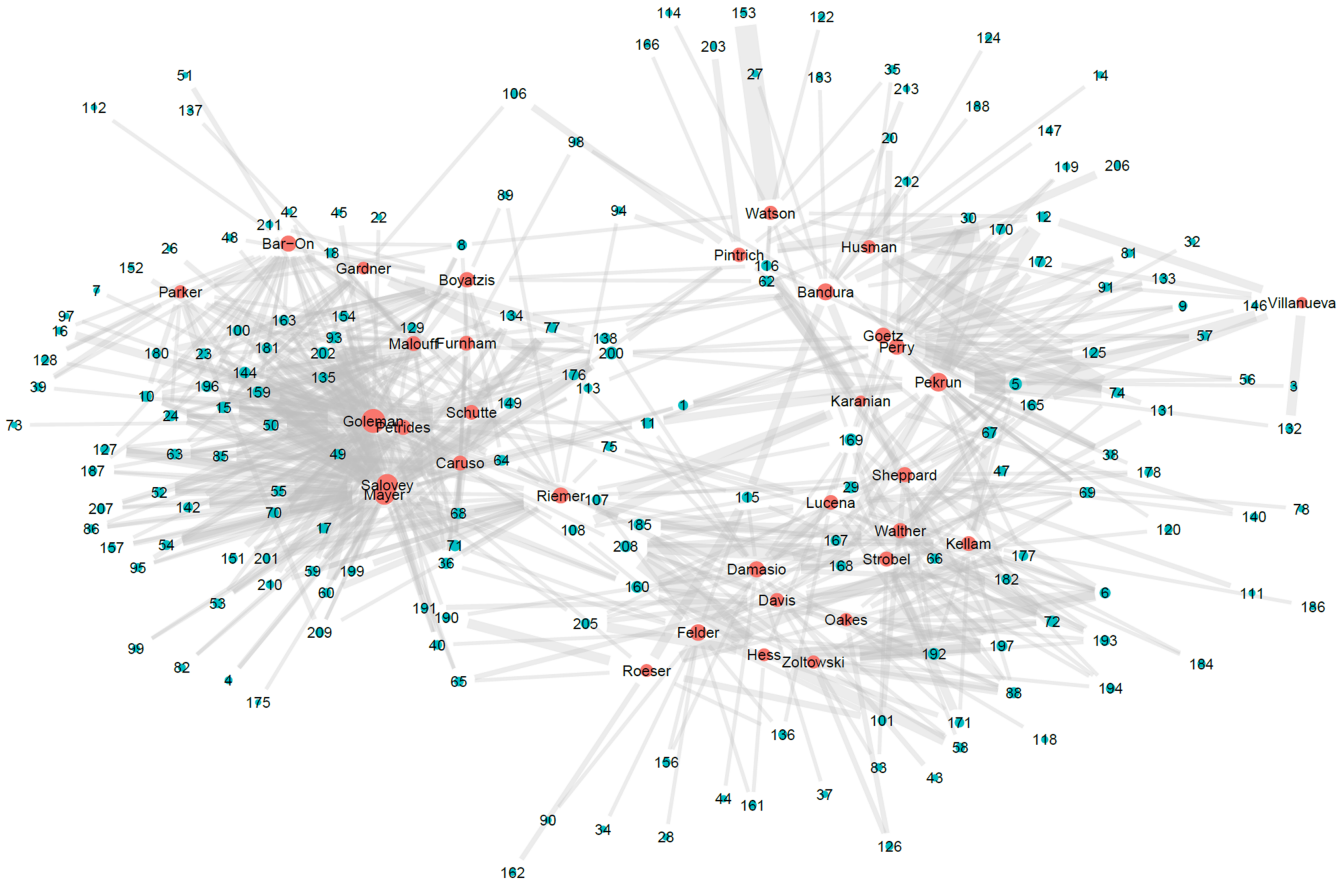


**FIGURE 5** Co-citation network graph illustrating three clusters of frequently co-cited authors (orange nodes) and how they relate to the 213 reviewed publications (turquoise dots).

by the linked publication. Thicker lines indicate higher numbers of citations. The network graph clearly shows three clusters of authors who were frequently co-cited in the reviewed publications: (i) scholars who have written about emotional intelligence (Goleman, Mayer, Salovey, Bar-On, Petrides, Malouff) on the left; (ii) scholars who have written about academic emotions (Pekrun, Goetz, Perry, Husman) on the top right; and (iii) scholars who have primarily worked in engineering education (Kellam, Strobel, Walther, Hess, Lucena, Zoltowski) on the bottom right part of the graph. The clusters are separated from each other, indicating that publications referencing scholars from one cluster tended not to reference scholars from the other clusters. For example, publications citing emotional intelligence scholars almost never cited academic emotions scholars, and vice versa. These findings suggest a lack of integration between EEE research on socio-

emotional competencies (e.g., emotional intelligence), the impacts of emotions on learning (e.g., the roles of academic emotions in learning), and emotions in engineering (e.g., empathy in engineering ethics).

### 6.3.4 | Alignment of conceptualizations of emotion with research purposes

Mirroring findings from the analysis of functions performed by conceptualizations of emotions, more than half of the 150 publications engaging with conceptualizations were coded for purposes related to quantitative research, such as *exploring relationships between variables* (39%) or *assessing constructs* (12%; Table 7). Similarly, pedagogical development perspectives were again relatively prominent, and they were coded for the purposes of *pedagogical development* (9%) and *testing the impact of pedagogical development* (10%). Other common purposes were *developing theoretical/conceptual understanding* (16%), *comparing groups of participants* (9%), and *non-empirical research* (8%). Comparing these purposes with conceptualizations of emotion used in each paper, we found that purposes and conceptualizations were well aligned in a majority (83%) of the 150 publications (Table 8).

### 6.3.5 | Alignment of conceptualizations of emotion with research methods

One hundred and fourteen publications engaged with conceptualizations of emotion and described empirical studies. In a large majority (96%; Table 8) of these publications, we found that conceptualizations of emotion were well aligned

**TABLE 7** Number of publications coded for various research purposes.

| Research purpose | Number of publications | Examples |
|---|---|---|
| Explore relations between variables | 58 | Explore correlation between personality traits and soft skills (Silva et al., 2020) |
| Assess construct(s) | 18 | Explore characteristics of math anxiety among engineering students (Ecciux Wellmann & Barragán, 2016) |
| Test impact of instructional approaches | 15 | Explore students' reactions to different instructional formats (Villanueva et al., 2018) |
| Instructional development | 14 | Describe an approach to increasing student engagement with engineering ethics (Sunderland et al., 2014) |
| Compare groups of participants | 14 | Compare emotional intelligence of professors at different departments (Duşe et al., 2010) |
| Non-empirical research | 12 | Argue for inclusion of emotional reflection into engineering (Roeser, 2012) |
| Develop a model | 8 | Develop a model of empathy in engineering (Walther et al., 2017) |
| Position paper on the importance of emotions | 8 | Argue for the importance of emotions in engineering decision making (M. Davis, 2015) |
| Literature review | 4 | Summarize how empathy is described in engineering education research (Hess & Fila, 2016) |
| Validate psychometric instruments | 2 | Validate scales for interpersonal self-efficacy and emotion regulation (Hess et al., 2018) |

**TABLE 8** Degree of alignment between conceptualizations of emotion, research purposes, and research methods.

| Degree of alignment | Alignment with research purposes ($n = 150$) | Alignment with research methods ($n = 114$) |
|---|---|---|
| Not aligned | 6 (4%) | 2 (2%) |
| Somewhat aligned | 19 (13%) | 3 (3%) |
| Well-aligned | 125 (83%) | 109 (96%) |

with research methods. However, our analysis was performed at a very general level, and it may therefore obscure more subtle issues of misalignment. For example, our analysis suggested that EEE scholars often approached emotional intelligence as an ability rather than a personality trait, but psychometric instruments may be of limited value in assessing emotional intelligence abilities because they primarily measure more stable personality aspects of emotional intelligence (Keefer et al., 2018). Moreover, psychometric instruments rely on self-report measures and fail to capture the interactional dimensions of emotional intelligence (e.g., relationship management). Future studies should conduct more detailed analyses of alignment in the EEE literature.

#### 6.3.6 | RQ 2: Summary

The results for RQ 2 show that many authors used conceptualizations of emotion for quantitative purposes. This confirms the findings from the scoping review and the analysis for RQ 1, showing that it was most common for EEE literature to report on quantitative research and research on socio-emotional competencies (which are typically studied employing quantitative psychometric instruments). Conceptualizations of emotion were also employed to inform or evaluate research processes, argue for the importance of emotions/socio-emotional competencies in engineering education, and inform pedagogical work.

The results further corroborate those for RQ 1 in that authors who were frequently cited in the EEE literature were based in psychology, engineering, philosophy, or engineering education, while sociologists of emotion were hardly cited at all. A cluster of authors associated with work on emotional intelligence was cited particularly often, further corroborating previous findings on the prominence of emotional intelligence research in the EEE literature (RQ 1; cf. Lönngren, Bellocchi, et al., 2021). Two additional clusters were relatively prominent and included authors associated with research on academic emotions and engineering education, respectively. EEE publications referencing theorists from one cluster tended to not reference theorists from other clusters, which also is in line with earlier findings describing the EEE literature as highly dispersed (Lönngren, Bellocchi, et al., 2021).

The most common research purposes in publications engaging with conceptualizations of emotion were related to quantitative measures, but purposes related to instructional development were also relatively common. In terms of alignment, the results suggest high degrees of alignment between conceptualizations of emotion with research purposes as well as methods, at least when alignment is assessed at a very general level.

## 7 | DISCUSSION

There is growing interest in EEE research and scholarship. However, a relatively high percentage of conference publications and few established emotion researchers and national/international research groups indicate that the field is still in an early phase of development. In this paper, we have reported on a systematic meta-synthesis of the EEE literature in which we analyzed how EEE authors engaged with conceptualizations of emotion and what roles these conceptualizations played in study design and research methods. In RQ 1, we have explored *how emotions have been conceptualized in the EEE literature*, showing that many EEE publications did not engage with emotion theory and that the range of emotion theories and concepts applied was limited. In RQ 2, we focused on *how conceptualizations of emotion were used in the EEE literature*, finding that the limited number of conceptualizations of emotion (RQ 1) were introduced by citing a limited number of emotion scholars and disciplinary traditions and that they were used to explore a similarly limited range of research purposes. Based on these results, we provide the following suggestions for scholars to consider in their future EEE studies and for the further development of the field.

### 7.1 | Develop research in which the focus on emotions is intentionally chosen

An important finding from our analysis for RQ 1 was that *almost half of the reviewed publications did not apply any emotion concepts and 30% did not even cite literature describing such concepts*. Moreover, *only 10 publications (7%) engaged with any type of emotion theories*. Some authors may have intentionally chosen to use everyday meanings of the term "emotion" rather than theoretically grounded definitions, and such an approach is adequate for certain types of studies (our review is an example—we intentionally refrained from narrowly defining "emotions" as we were interested in the

ways EEE authors themselves conceptualized the term). However, we believe that many more studies could benefit from a more theoretically grounded approach.

One possible explanation for our findings could be that emotions are everyday phenomena that most people relate to intuitively, much like "education." When researchers first begin to explore emotional phenomena, they may not yet be familiar with the wide range of concepts and theories that are available in the emotion research literature, and they may falsely assume that everyone holds the same assumptions about what emotions are and how they should be studied (Lönngren, Bellocchi, et al., 2021). Elsewhere, we have provided a broad overview of theoretical and methodological approaches to researching EEE (Lönngren et al., 2023), which can help newcomers in the field to orient themselves in the complex EEE research landscape and to find collaborators with similar research interests. Other useful resources are international handbooks for research on emotions in education (e.g., Loughran & Hamilton, 2016; Pekrun & Linnenbrink-Garcia, 2014b; Zembylas & Schutz, 2016).

An important finding from our scoping review analysis was that many of the reviewed studies initially focused on other constructs (e.g., engineering ethics, student performance, or professional identity) and that emotions often arose as a phenomenon of interest first during data analysis. Consequently, research framing and data collection in those studies were not based on pre-defined conceptualizations of emotion, and authors may have had limited time and resources to adjust their conceptual frameworks. We also found that these types of studies tended to lack clarity around the nature of emotions and how they were analyzed, which often limited the clarity and depth of the findings related to emotions. Therefore, we expect that more research adopting an intentional, a priori focus on emotions will be crucial in further developing the field—not only because it is likely to increase the quality of published studies but also because intentional design involves getting acquainted with a broader range of conceptualizations of emotion. The latter can allow EEE scholars to explore a broader range of research questions and extend the scope of EEE.

## 7.2 | Extend the scope of EEE research and scholarship

Considering the number of publications included in our review, we expected to find publications employing a wide range of emotion theories, concepts, and research methods. Instead, we found that the scope of EEE research and scholarship, so far, has been rather limited. First, EEE research *has engaged with a limited number of conceptualizations of emotion* compared to the wide range of options available in the educational and social sciences literature. Our analysis for RQ 1 showed that the few publications applying emotion theories engaged exclusively with cognitive appraisal theories (multi-componential theory and control-value theory). Sociological, critical, and feminist theories of emotion were seldom mentioned and never thoroughly applied in the reviewed publications. Similarly, 91% of all reviewed publications engaged with at least one of the nine most used emotion concepts, with one-third of all publications focusing on emotional intelligence. Sociological concepts, such as emotional labor, emotional capital, feeling rules, affective economies, emotional climate, or emotional geographies, were largely absent, limiting possibilities to explore social dimensions of emotion that may play crucial roles in being and becoming engineers. The results obtained for RQ 2 further corroborated these findings, showing that authors cited in the EEE literature most commonly were based in psychology (many of whom primarily work on emotional intelligence), engineering (education), or philosophy, while sociologists of emotion were rarely cited.

To expand the scope of EEE, researchers and scholars can draw on a wide range of emotion theories and concepts from different disciplines. Examples from psychology include constructionist (e.g., Feldman Barrett, 2017) or social-psychological emotion theories (e.g., van Kleef, 2016). Sociological research offers, among others, macro-sociological theories (e.g., Barbalet, 2001); dramaturgical, symbolic interactionist, and interaction ritual theories; and theories focusing on power relations (Stets & Turner, 2006, 2014). Those interested in feminist perspectives and cultural practices can consider Ahmed's (2014) work on the cultural politics of emotions. Given the strong role that language plays in how we think about emotions in daily life and academic scholarship, linguistic perspectives can also contribute to broadening the scope of EEE research (e.g., Kövecses, 2008).

Second, the EEE literature *has been limited in terms of methods used in empirical research and scholarship*. The results for RQ 2 corroborate and extend findings from the scoping review showing that the greatest portion of the literature focuses on quantitative research (43%). The literature also appears to employ a limited range of quantitative approaches: conceptualizations of emotion were most frequently used in research aiming to quantify emotions (e.g., measuring students' levels of mathematics anxiety; Ecciux Wellmann & Barragán, 2016), quantify socio-emotional competencies (e.g., measure levels of emotional intelligence; Luisa Casado et al., 2016), or explore correlations between variables

(e.g., between anxiety and levels of danger awareness; Güneş & Özsoy-Güneş, 2016; or between emotional intelligence and academic performance; Skipper & Brandenburg, 2013). All these purposes are primarily *descriptive* and may be of limited value for explaining and predicting complex emotional phenomena and the roles emotions can play in engineering education. The literature contains a few examples of studies with *explanatory* or *predictive* purposes (e.g., employing multiple regression analysis to evaluate whether emotional intelligence can predict success; Bélanger et al., 2007; or structural equation modeling to determine the effects of psychological factors on academic performance; Yeh et al., 2014). We see great potential for more research employing advanced statistical methods to move beyond descriptive analyses.

However, we also see a need for more EEE research engaging advanced qualitative methods. To better understand the diverse roles emotions can play in engineering education, we need to move beyond analyses describing *who* experiences *which* emotions. While such analyses are important, we also need to understand *how* and *why* emotions are expressed and experienced in engineering education and how they can impact social interaction, power relations, diversity, equity, and inclusion. Zembylas and Schutz's (2016) *Handbook on Methodological Advances in Research on Emotion and Education* provides a particularly useful resource for EEE scholars wanting to expand their methodological repertoire, and recent examples from the EEE literature can inspire scholars wishing to explore how qualitative methods can be applied in EEE (Lönngren et al., 2023). For example, *in-depth interviews* have been used to develop a better understanding of the diverse ways in which individual students and educators experienced emotions and the effects those experiences could have on, for example, identity development, diversity, and inclusion in engineering education (Huff et al., 2021; Kellam et al., 2018). *Observational methods* have been used to study how emotions were expressed through gestures, facial expressions, and movement in educational spaces. For example, video-recorded interaction has been analyzed to explore how emotions were expressed, how they changed over time, and how different emotional practices influenced teaching, learning, and social relationships in engineering education (e.g., Tanu et al., 2017). Video analysis has also been used to explore how emotion norms were negotiated in engineering education and how they impacted power relations among educational stakeholders (Lönngren, Adawi, & Berge, 2021). Finally, EEE researchers have started to use *physiological measurements* (e.g., participants' heart rates, blood pressure, sweating, or cortisol levels) to study emotions in real time, rather than (solely) relying on participants' descriptions of how they experienced emotions at an earlier point in time (e.g., Villanueva et al., 2018). In addition to increasing the use of more advanced quantitative and qualitative approaches, it would be valuable to increase the number of mixed- and multi-method studies, comparing and/or integrating understandings of emotion across methods and research traditions (Schutz et al., 2016).

Third, the results for RQ 2 showed that the EEE literature, in terms of co-citation patterns, *was divided into three clusters*: emotional intelligence, academic emotions, and engineering education. EEE authors referencing emotion scholars from one cluster tended not to reference scholars from other clusters. Some degree of clustering is to be expected and even necessary in maturing research fields, as has been demonstrated in research on teacher education (Özçınar, 2015) and higher education (Tight, 2008). However, the clusters identified in our analysis mirror—and may even reinforce—the relatively narrow scope of EEE research and scholarship in terms of theories, concepts, and methods. As most EEE authors cite literature from only one of the three clusters, new EEE researchers may get the impression that that cluster represents the only way of researching EEE. A first step to extending the scope of EEE is for researchers and scholars to explore research cited in all three existing clusters. EEE researchers who wish to move beyond the clusters can consult the broader educational literature (e.g., Loughran & Hamilton, 2016; Pekrun & Linnenbrink-Garcia, 2014b; Zembylas & Schutz, 2016) to find inspiration and guidance for developing new clusters. They can also increase national and international collaboration across and beyond the existing clusters and explore emotion research in disciplines beyond education, such as psychology (e.g., Feldman Barrett, 2017), social psychology (e.g., Feldman Barrett, 2017), sociology (e.g., Barbalet, 2001; Stets & Turner, 2006, 2014), feminist (Ahmed, 2014), and linguistic (e.g., Kövecses, 2008) studies. Due to the almost complete absence of sociological perspectives in the reviewed literature (RQ 1), we expect that more research engaging such perspectives will be particularly important for developing the field.

## 7.3 | Stimulate and monitor research quality in EEE

The results for RQ 2 tentatively indicated a high degree of alignment between conceptualizations of emotion with research purposes and methods, which could indicate that a basic criterion for research quality has been met in most of the reviewed publications. However, our results are only tentative, and they should be expanded through in-depth analyses exploring the alignment of purposes/methods with overall theoretical frameworks and underlying onto-

epistemological, methodological, and axiological stances. Such analyses are especially important in engineering education research, where qualitative and postmodern research approaches have emerged relatively recently and where paradigmatic tensions are common (e.g., researchers may employ a postmodern perspective but still apologize for a lack of generalizability; Kellam & Jennings, 2021). Further, it was not clear from our analysis whether the high degree of alignment was a result of conscious research design or an incidental effect of the narrow range of phenomena explored, possibly combined with the availability of free, validated, and relatively easy-to-use instruments to study these phenomena (e.g., the Achievement Emotions Questionnaire; Pekrun et al., 2005; and the Trait Emotional Intelligence Questionnaire; Petrides et al., 2007). When EEE researchers and scholars explore a broader range of phenomena, intentional research design will be especially important for maintaining high levels of alignment between emotion concepts, theories, research designs, and research methods (Schutz & Zembylas, 2016) because no ready-made instruments may be available for exploring those phenomena.

Our results indicate other potential threats to research quality that should be investigated and monitored over time. For example, many publications on emotional intelligence have drawn on popularized (e.g., Goleman, 1995) rather than research-based emotion concepts (e.g., Bar-On, 2000; Schutte et al., 1998), which could lead researchers to design sub-optimal studies, draw questionable conclusions, and hinder integration with other studies. In addition, emotion was often described (solely) in cognitive terms, which may result in inadvertently strengthening the false dualism between emotion and cognition in engineering (education). Sociological and critical theories of emotion have often been used to challenge prominent dualisms (e.g., Cottingham, 2016) and they may therefore be particularly useful in developing a more integrative understanding of how engineering students and educators think, feel, act, relate, and become in educational settings.

Our review has focused on EEE, but it also adds to a growing number of systematic reviews in various sub-fields of educational emotion research (e.g., Loderer et al., 2020; Tan et al., 2021; Wang et al., 2019; Zhang et al., 2020). To do justice to the complexity of emotions and their multi-faceted roles in teaching and learning, we expect that further systematic reviews—within and across sub-fields—will be needed. For example, we see a need for *culture-specific and cross-cultural reviews* investigating the cultural appropriateness of research questions, theories, and methods in EEE. Such reviews have been argued to contribute to broadening the range of cultural perspectives employed in education research (DeCuir-Gunby & Williams-Johnson, 2014). Educational emotion research is today dominated by Western conceptualizations of emotion (Uitto et al., 2015), which is problematic because emotions in education are experienced and expressed differently across racial/ethnic identities and cultural backgrounds (DeCuir-Gunby & Williams-Johnson, 2014). *Cross-disciplinary reviews* could begin to shed light on whether and/or how emotions are experienced, expressed, or interpreted differently across educational domains. They could also facilitate the integration of educational emotion research from different disciplines, which has been identified as an important avenue for future research on emotions in education (Pekrun & Linnenbrink-Garcia, 2014a). More specifically, we suspect that emotion research in different educational disciplines has developed different hot spots, such that topics and theories explored in one discipline may help to illuminate blind spots in another. For example, as engineering often involves high-stakes decision making (due to the profound effects technological development can have on individuals, societies, ecosystems, and species; e.g. Cozzens & Thakur, 2014; Roeser, 2012), the role of emotions in decision making may have emerged as particularly salient in engineering education and can thus shed light on the role of emotions in decision-making processes in other professional fields. On a broader level, it would be interesting to explore similarities and differences in the roles of emotions in diverse disciplinary fields, as such explorations could help researchers and educators to judge the transferability of research findings from one educational context to another.

Finally, EEE is a rapidly growing field with many new studies published each year. We expect that EEE researchers will soon have developed a much stronger, empirical research base for the field, which then would make it possible to synthesize findings across individual studies through meta-syntheses and meta-analyses. Such analyses could contribute to further consolidating the field, increasing interdisciplinary collaborations, and strengthening cumulative knowledge development.

## 8 | LIMITATIONS

Several methodological challenges and limitations emerged during our project. First, we encountered difficulties in standardizing complex coding procedures across our large multi-national group of authors. To reduce uncertainty and inconsistencies in coding, we used detailed codebooks, conducted training sessions with all analysts, and duplicated all

screening procedures. While we cannot rule out remaining inconsistencies, these are outweighed by the overwhelming consistency of the results across our different analyses.

Second, we did not perform a quality assessment of the included publications (beyond rating alignment for RQ 2), primarily because research quality is understood differently in different research traditions; we did not want to impose a single interpretation of quality on the highly interdisciplinary field of EEE. In addition, it is common for engineering education researchers to present preliminary results as conference publications, without necessarily making the preliminary status of the results explicit. Many conference publications are followed up with a journal article, but others are not, and it can be difficult to determine which EEE publications report on final outcomes and which do not. Finally, the purpose of our configurative meta-synthesis review was not to assess the quality of EEE research; nor was it to summarize the main findings in the field. Rather, we set out to explore the current state of the field in terms of how emotions were conceptualized and how conceptualizations of emotions were used to frame and conduct EEE research and scholarship.

Third, while we have diverse disciplinary backgrounds, our analyses and interpretations were framed in terms of engineering education research and practice. Education researchers from other disciplines should keep this framing in mind when comparing or translating our findings to their own contexts. Also, while our team includes researchers with cultural backgrounds in South America, Asia, Australia, Europe, and North America, we were not positioned to include perspectives from African regions and research traditions or perspectives from indigenous communities.

Fourth, in categorizing the extent to which authors engaged with conceptualization of emotions (RQ 1), we noticed that the requirements for the highest level (development of new theory) were unlikely to be met by many studies even in more mature fields. Level 2, on the other hand, covered a broad range of ways in which publications could engage with conceptualizations, which may have rendered more subtle differences indiscernible. In hindsight, it would have been better to divide level 2 into at least two categories, for example, distinguishing between pure application and minor adaptation of theoretical concepts. Raters also experienced difficulties in distinguishing between levels 0 and 1 and we therefore suggest that the differentiation between these two levels should be regarded as initial indicators of trends in the literature—to be confirmed or revised through further research. Finally, some publications engaged with conceptualizations of multiple phenomena. The level of conceptualization reported in response to RQ 1 refers to the *highest level of conceptualization found in a publication*, while conceptualizations rated at lower levels in the same publication were ignored. In other words, the ratings for levels of conceptualization do not necessarily refer to all conceptualizations of emotion used in a publication.

Fifth, the coding for alignment of conceptualizations with research purposes and methods (RQ 2) should be seen as tentative indicators because coders acknowledged that information extracted from some of the publications (in Stage I of the analysis) was not sufficiently detailed to draw fully reliable conclusions. More specifically, we suspect that a more detailed analysis, based on the full text of each publication rather than pre-extracted information, could have resulted in slightly lower alignment scores. We also noted confounding variables that could have influenced the coding. For example, a paper could demonstrate methods that were strongly aligned with the research purpose, but the purpose itself could be tangentially related to emotions. In those cases, alignment of conceptualization with research purpose/methods was rated on the lower end, despite strong alignment between purpose and methods. Further, the categorization of methods, conducted as part of the scoping review (cf. Lönngren, Bellocchi, et al., 2021), included all methods described in the publications, but some of those methods may have been used to explore phenomena other than emotions.

Despite these limitations, our results are valid thanks to strict adherence to authoritative guidelines for searching and screening (Cooke et al., 2012) and for reporting on methods and results (Page et al., 2021). In our large international and interdisciplinary research team, we worked with hundreds of publications through multiple analytic cycles, developing a deep, shared understanding of the EEE literature. Further, throughout our work with this review, other engineering education researchers provided informal peer review, confirming the validity of our methods and preliminary findings (Huff et al., 2020; Lönngren, Bellocchi, et al., 2021; Lönngren et al., 2020). Finally, the trends we found in analyzing the status of the EEE literature are strikingly clear and consistent across all our analyses. Thus, the review achieves the purpose of providing the field with clear guidance for future research and suggestions for addressing current limitations.

## 9 | CONCLUSIONS

This review has provided a much-needed overview of the status of EEE research and scholarship and identified opportunities for broadening and strengthening EEE and educational emotion research more broadly. We have shown that a large part of the EEE literature has not yet engaged with conceptualizations of emotion and that a large majority of

publications doing so have focused on emotion concepts rather than emotion theories. Further, the focus on emotion seems to have been secondary and unintentional in many publications. We have also shown that EEE publications have engaged with a limited number of emotion concepts (especially emotional intelligence) and emotion theories (the few publications referring to emotion theories relied on cognitive appraisal theories) and that EEE authors have primarily cited publications from psychology, philosophy, and engineering (education). Sociological research has rarely been cited, and EEE authors have rarely used theories or concepts from sociological and critical traditions. The most common research purposes in the reviewed publications related to quantitative research, and these purposes were often addressed by employing self-reported psychometric instruments to measure emotional intelligence or academic emotions. Our co-citation analysis revealed a clear divide between three clusters of EEE publications, focusing on emotional intelligence, academic emotions, and engineering education, respectively. In other words, EEE research and scholarship has begun to explore a few isolated islands in the vast ocean of potentially relevant and fruitful theories, concepts, methods, and research questions that could inform future research on socio-emotional and professional aspects of engineering and engineering education. As the field evolves, it will be critical for EEE researchers and scholars to engage more deeply with a broader range of methods, concepts, and theories. Otherwise, important research questions will remain unexplored, and incomplete understandings of the multifaceted roles of emotions in teaching and learning may stimulate ineffective or even detrimental changes in educational practices. Perhaps most importantly, expanding the depth and scope of EEE research and scholarship is crucial for understanding how we can prepare future engineers to collaboratively address the immensely complex and contested societal, ethical, and environmental challenges we are facing today and, unfortunately, will continue to face in the 21st century and beyond.

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## APPENDIX

### LIST OF ALL 213 REVIEWED PUBLICATIONS

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