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Emotions in Engineering Education

Preliminary Results from a Scoping Review

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Emotions in Engineering Education: Preliminary Results from a Scoping Review

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ABSTRACT

CONTEXT

There is today a broad consensus that emotions influence all forms of teaching and learning, and scholarship on *Emotions in Engineering Education* (EEE) is an emerging and rapidly growing field. However, this nascent research is currently very dispersed and not well consolidated. There is also a lack of knowledge about the state of the art, strengths, and limitations of the existing literature in the field, gaps, and future avenues for research.

PURPOSE

We have conducted a scoping review of EEE research, aiming to provide a first overview of the EEE scholarship landscape. We report here on preliminary findings related to (1) the status of the field, (2) geographical representation of authors, and (3) emerging hot spots and blind spots in terms of research approaches, contexts, and topics.

METHODS

The scoping review is part of a larger, systematic review of the EEE literature. Using an inclusive search strategy, we retrieved 2,175 items mentioning emotions and engineering education, including common synonyms. Through abstract screening and full text sifting, we identified 184 items that *significantly* focus on engineering education *and* emotion. From these items, we extracted and synthesized basic quantitative and qualitative information on publication outlets, author origins, keywords, research approaches, and research contexts.

PRELIMINARY RESULTS

Surprised by the large number of EEE publications, we found that EEE is a rapidly expanding, but internationally dispersed field. Preliminary results also suggest a dominance of research on higher education, often exploring students' academic emotions or emotional competences. Research on emotional intelligence and anxiety is particularly common while studies focusing on cultural and sociological aspects of EEE are largely absent.

CONCLUSIONS

The EEE literature is expanding exponentially. However, the field is not well consolidated, and many blind spots remain to be explored in terms of research approaches, contexts, and foci. To accelerate the development of the field, we invite current and prospective EEE researchers to join our emerging, international community of EEE researchers.

KEYWORDS

Emotions, engineering education, systematic review, scoping review

Introduction

Engineers often identify their work as rational, beyond emotion, and engineering is often characterized as purely scientific, involving technical solutions to real world problems (Cech, 2018). However, many real-world problems, such as the 17 United Nations Sustainable Development Goals and the emergence of the Industry 4.0 era, require attention to human factors, including emotions, since technical issues are only part of the problem (World Economic Forum, 2021).

During the past two decades, engineering programs, professional societies, and accrediting bodies have increasingly acknowledged the importance of emotions in engineering education and practice—which is supported by research on, for example, engineering ethics, social justice, risk management, problem solving, student development, and retention (Hess et al., 2020; Kellam et al., 2018; Roeser, 2012), as well as the wider educational literature (Pekrun & Linnenbrink-Garcia, 2014). In fact, research interest in EEE is increasing rapidly (Lönngren et al., 2020) and in April 2020, the authors gathered at an international symposium to formulate a research agenda for this emerging field. However, we realized that we first needed a comprehensive overview over *existing* research, which did not exist yet. Thus, we decided to undertake a scoping review and a systematic review of the EEE literature. Here, we report on preliminary results from the scoping review.

Purpose

The purpose of this scoping review is to provide a first overview of the existing landscape of EEE scholarship. In this paper, we report on preliminary findings related to (1) the status of the field, (2) geographical representation of authors, and (3) emerging hot spots and blind spots in terms of research approaches, contexts, and topics.

Research team positionality

The disciplinary backgrounds of our review team include engineering education, science education, psychology, and professional development for university faculty, and we employ a wide range of theoretical and methodological approaches. Our cultural understandings are colored by our backgrounds in Australia, Denmark, France, Germany, Ireland, Malaysia, Portugal, Sweden, Switzerland, the United Kingdom, the United States, and Venezuela. We acknowledge that we are not able to represent African, Eastern European, and Middle Eastern perspectives.

Background

Emotions are commonly distinguished from *affect*, which is an omnibus construct that encompasses emotions, feelings, moods, and non-emotional constructs, such as motivation, interest, and attitudes (Pekrun & Linnenbrink-Garcia, 2014). Emotions are studied in many different disciplines, leading to a wide range of definitions (Bellocchi, 2019). Many scholars subscribe to *componential theories* (Scherer, 2005), which outline four dimensions of emotions: they (1) are represented by linguistic labels, (2) are *about* something, (3) involve physiological changes, and (4) may involve expressive gestures (Turner, 2007). We restrict our discussion to this componential approach because it is consistent with perspectives used in many of the items in our review. In making this choice, we acknowledge the broader range of theories and perspectives (e.g., social constructionist, feminist) that are not considered here.

Methods

In this paper, we report on preliminary results from a *scoping review* (Grant & Booth, 2009), which is part of a larger systematic review project and we therefore follow “transparent, methodical, and reproducible procedures” (Borrego et al., 2014, p. 46). More specifically, we

follow Siddaway et al.'s (2019) description of six stages in conducting systematic reviews: scoping, planning, searching, abstract screening, full text sifting, extracting and synthesizing information.

Scoping

The scoping stage focuses on formulating research questions, considering the breadth and depth of the review, and becoming familiar with the literature that is to be reviewed. Since there was no previous review of the EEE literature, we did not know in advance what we would find in the literature. We therefore decided to start off with a broad scope and narrow our focus in an iterative manner. To get familiar with the literature, we conducted several pilot searches in different databases and with a variety of search term combinations. Based on those searches, we formulated the following research questions:

1. What is the status of EEE research in terms of numbers of publications, publication outlets, and publication trends?
2. Who publishes EEE research and how do authors collaborate internationally?
3. What are some emerging hot spots and blind spots in terms of research approaches, contexts, and topics in the EEE literature?

Planning

The planning stage involves operationalizing the research questions by formulating search terms and in-/exclusion criteria. We formulated, tested, and refined our search terms until we were confident to achieve an adequate "balance between sensitivity (finding as many articles as possible that may be relevant) and specificity (making sure those articles are indeed relevant)" (Siddaway et al., 2019, p. 757). As recommended by Siddaway et al. (ibid.), we initially prioritized sensitivity to ensure that we would not miss anything important. For example, we included the broader terms "affect" and "feeling" in our database searches since we suspected that some authors may unintendedly use these terms as synonyms of "emotion". By including these terms, we also assumed that we would retrieve items that focus on specific emotions, such as "anxiety" or "shame", even if the term "emotion" is not used.

To formulate preliminary in-/exclusion criteria, we took inspiration from two frameworks that are widely used to develop search strategies for systematic reviews: the primarily quantitatively oriented *PICO framework* (Population, Intervention, Comparison, Outcome) and the more qualitatively oriented *SPIDER framework* (Sample, Phenomenon of Interest, Design, Evaluation, Research type) (Borrego et al., 2014; Cooke et al., 2012). Since our review covers quantitative, qualitative, mixed-methods, and non-empirical literature, we combined elements from both frameworks and added criteria for non-empirical scholarship.

Searching

We searched a broad range of databases to capture as many EEE publications as practically feasible. We included general databases (*Scopus*, *Web of Science*, *Academic Search Complete*), educational/social science databases (*ERIC*, *IBSS*), a psychological database (*APA PsycInfo*), an engineering database (*Engineering Village*), and databases specialized on eBooks and theses (*eBook Central*, *Dissertations & Theses Global*, *Open Thesis*). Prioritizing sensitivity, we included synonyms and related terms. We also used truncation symbols to capture different word forms. The search string used—adapted to the syntax of each database—was:

```
((emoti* OR affective OR feeling*) AND ("engineer* educat*" OR "technology educat*" OR "engineering stud*" OR "engineering instruct*" OR "engineering facult*")).
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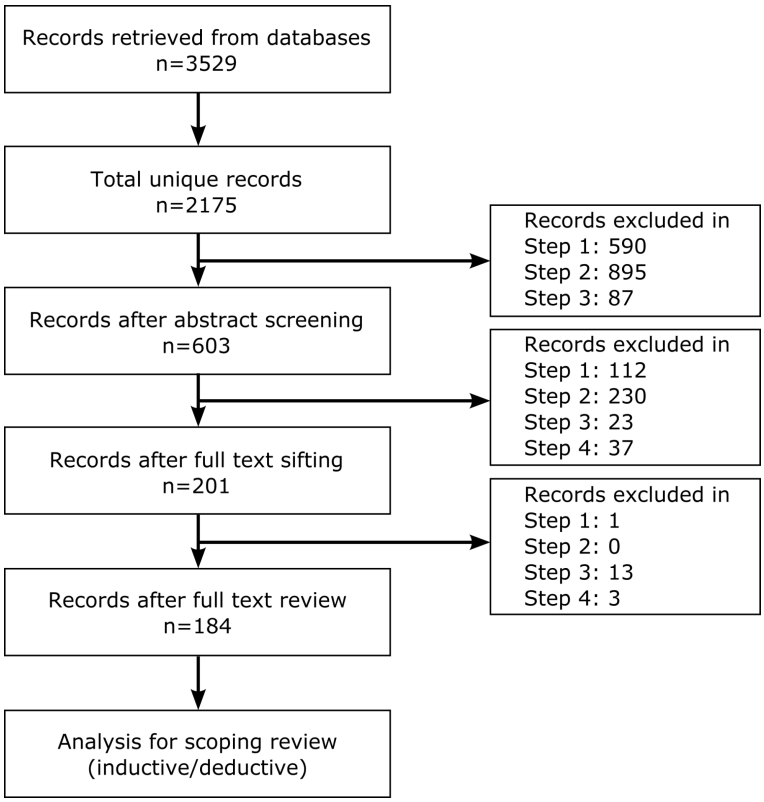
Where possible, the fields searched were "Title", "Abstract", and "Author Keywords", and the search was limited to peer-reviewed items.

Each database was searched independently by two reviewers and the results cross-checked. The searches were completed in late August 2020, yielding 3,529 items. The items were added to the reference management software *Zotero*. We also used Zotero to remove



duplicates, leaving 2,175 unique records for abstract screening (see Figure 1).

Figure 1. Overview of the selection process for the review.

Abstract screening

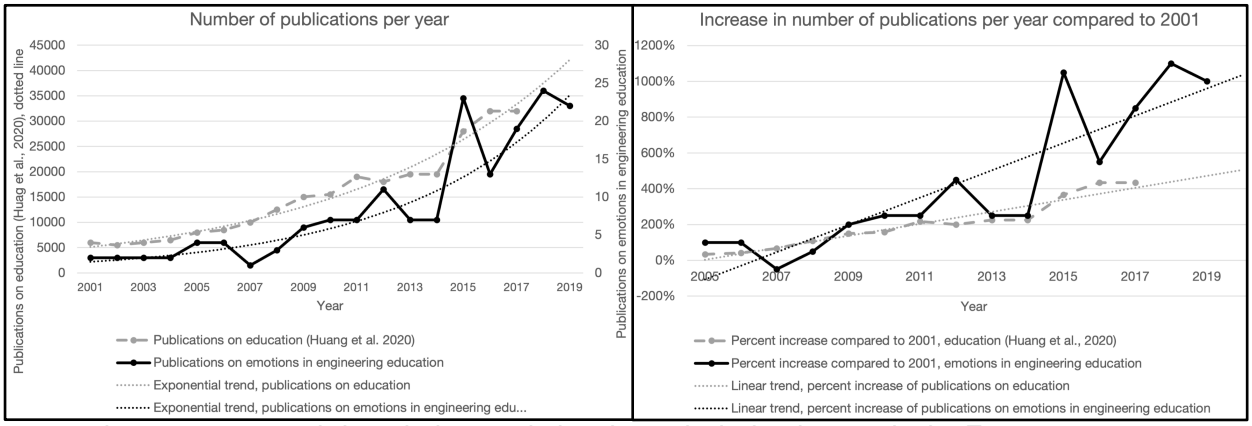
For abstract screening, we developed a detailed code book based on our preliminary in/exclusion criteria. It included 41 criteria, applied in three steps: (1) sample and/or setting must be *related to engineering, technology, and/or computer education*; (2) phenomenon of interest and/or outcomes must be *related to emotions*; and (3) must be a *scientific publication*. All reviewers participated in a training session and all items were screened independently by two researchers (inter-rater agreement 75%) and disagreement was resolved by a third researcher. 590 items were excluded in step 1, 895 in step 2, and 87 in step 3, leaving 603 items for full text sifting.

Full text sifting

During full text sifting, Siddaway et al. suggest that the focus should “shift from sensitivity to specificity”, aiming to “see if each [item] is indeed appropriate for inclusion” (2019, p. 764). Therefore, we adapted our code book to increase specificity. The revised code book included 37 items, applied in four steps: (1) content must be *relevant for engineering, technology, and/or computer education*, (2) must have a *substantive focus on emotions*, (3) must be a *scientific publication*, (4) *full text must be accessible* through our library resources and written in a language that at least one member of our international research team can read. Again, all reviewers participated in a training session, all items were sifted independently by two researchers (inter-rater agreement 74%), and disagreement resolved by a third researcher. 112 items were excluded in step 1, 230 in step 2, 23 in step 3, and 37 in step 4, leaving 201.

Extracting and synthesizing relevant information

From the remaining 201 items, we extracted information about publication outlets, authors' origins and keywords, use of common emotion-related concepts, research approaches (types of research, research methodologies, data collection methods), and contexts (e.g., educational context, pedagogical approaches used). Each item was read by one reviewer, who also entered the extracted information in a shared spreadsheet. As we read the items more closely in this stage, we identified 17 additional items that did not meet the inclusion criteria for full text sifting, one in step 1, 13 in step 3 and four in step 4, leaving 184 items for analysis in this preliminary scoping review (for the final results, we will include additional items after hand searching reference lists and journals). For items with predefined



categories, we extracted descriptive statistics through deductive analysis. Free text answers were analyzed inductively through thematic clustering and creating new categories as needed. Authors' keywords were analyzed deductively, categorizing keywords according to terms included in the EER taxonomy (Finelli, 2020).

Figure 2a. Number of publications per year. Figure 2b. Increase in number of publications per year, compared to 2001. Statistics for publications on education from Huang et al. (2020).

Preliminary Results & Discussion

EEE is an emerging and rapidly expanding field

When we decided to do this review, we expected to find a relatively low number of publications (n<50). This expectation was based on our observation that many EEE publications (including some of our own) start with a claim that there is a lack of EEE research. Thus, we were surprised by the overwhelmingly large number of publications retained in our review. Our surprise indicates that the field is not well consolidated since authors often do not seem to know about others' EEE research. At a later stage, we will perform a citation analysis to explore the extent to which authors draw on others' work.

Despite this apparent lack of consolidation, the EEE literature seems to have grown exponentially in the past two decades. Only three items were published before 2001, while 22 papers were published in 2019 alone. At a first glance, this growth seems to mirror the development of the broader educational literature (Huang et al., 2020; Figure 2a). However, the *percentage growth*, compared to the number of publications in 2001, seems to indicate a faster growth rate for the EEE literature (Figure 2b).

Although the number of publications is increasing, many items are published as conference papers (45%) rather than journal articles (40%), books (0,5%), or book chapters (3%), indicating that EEE is still an emerging and developing field (Figure 3a). We also found a relatively large number of theses (23%), which may be explained by the growing interest in the field. It may also indicate that EEE research is easier to perform in long-term projects that allow researchers to explore the complexities involved in theorizing, measuring, and

analyzing emotions. Compared to funded projects, most thesis projects are relatively open, allowing students to focus on what they find most interesting rather than what is most easily funded. Thus, the large number of theses in our review may also point to difficulties in obtaining funding for EEE research.

Finally, we analyzed how central emotions are to the items in our review. Despite our full text sifting criteria to only include publications with a *substantive* focus on emotions, we found that many publications (33%) did not have emotions as their *primary* focus. This suggests that emotions are a topic that often emerges in, or is added to, research focused on other topics: emotions are often only a secondary focus.

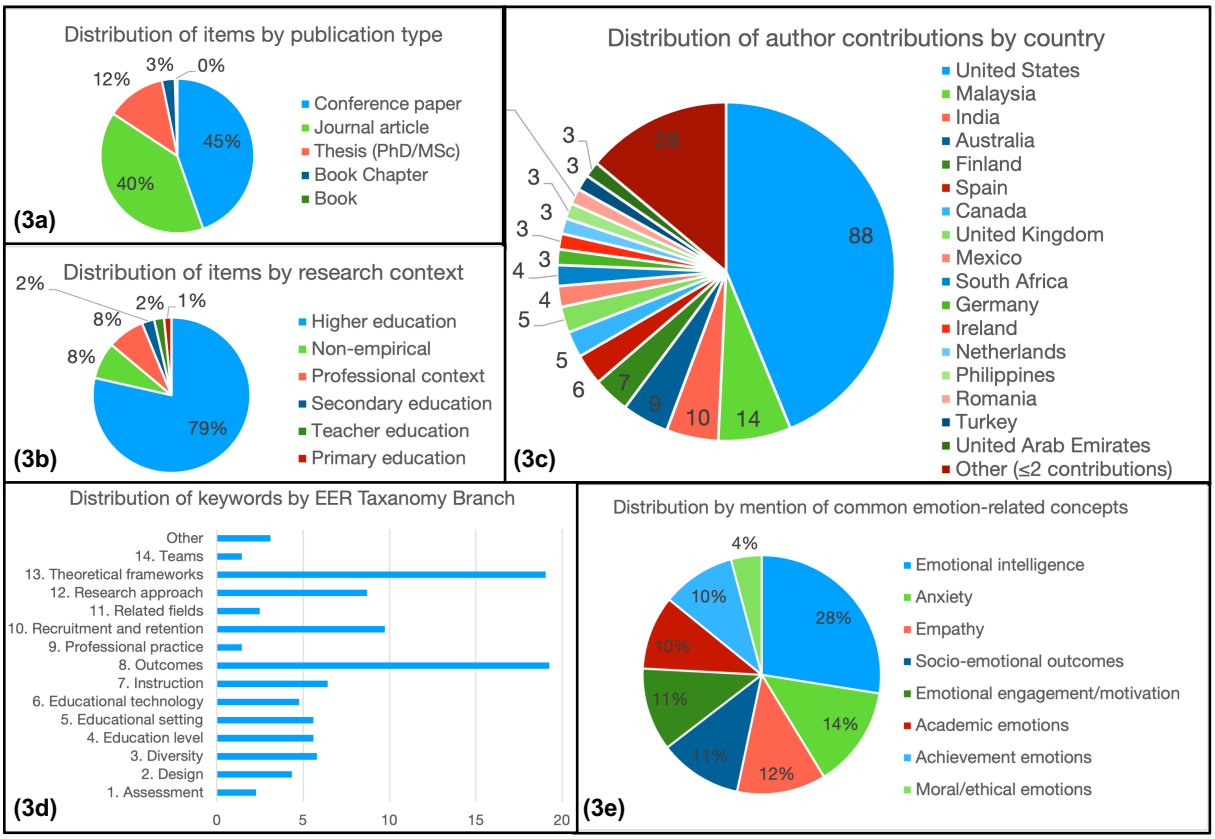


Figure 3a. Distribution of items by publication type. Figure 3b. Distribution of items by research context for empirical data collection. Figure 3c. Distribution of countries where authors are based. Countries are counted only once per item, even if several authors from a country contributed to it. Figure 3d. Frequency of keywords by EER Taxonomy branch. Figure 3e. Percentage of publications that mention common emotion-related concepts.

EEE is an internationally dispersed field

445 authors from 39 different countries contributed to the 184 papers in our review. There is a strong dominance of authors based in the United States, contributing to 88 papers. However, we also found substantial contributions from authors based in Malaysia (14 papers) and India (10 papers). Figure 3c provides an overview of countries from which authors have contributed to at least three papers.

International collaborations are relatively rare. While authors from 17 countries have collaborated with at least one other author internationally, only 13 items (7%) were written in international collaborations and they were all co-authored by at least one author from the United States (n=7) or the United Kingdom (n=6).

The authors who contributed to most publications are Walther (n=7), Karanian (n=5), Kellam (n=5), and Villanueva (n=5) from the United States; Muhamad (n=5), Sahari (n=5), and Saibani (n=5) from Malaysia; and Riemer (n=5) from Australia. We only found two groups of

authors that frequently publish together (Walther, Kellam & Villanueva in the United States; Muhamad, Sahari & Saibani in Malaysia). 396 authors (89%) only contributed to one item in our review, indicating that the field is highly dispersed and that many researchers explore emotions as a side topic—rather than making emotions their primary research focus.

Emerging hot spots and blind spots in EEE research

Research approaches

To develop an overview of research approaches used in the literature, we categorized the publications as conceptual (e.g., essays, literature reviews, conceptual discussions, and scholarship of teaching; n=35), quantitative empirical (n=78), qualitative empirical (n=28), mixed-methods empirical (explicitly adopting a mixed-methods design, with reference to mixed-methods literature; n=23), or multi-method empirical (utilizing multiple methods, but without reference to mixed-methods literature; n=10). As shown in Table 1, quantitative studies clearly dominate our sample.

We also categorized the 149 empirical studies according to research methods, distinguishing between *artifacts* (e.g., written documents; n=12), *observations* (n=10), *physiological measures* (n=8), and s*elf-reports* (reporting on one's own emotions in, e.g., questionnaires or interviews; n=78). 20 publications reported using a combination of methods. Self-report methods are used most often. Self-report methods are also regularly used in single-methods studies, while the other method types typically are combined with self-report methods.

Table 1. Article categories in the corpus and methods used in empirical studies

	Article Type					
Methods	*Conceptual*	*Mixed Methods*	*Multimethod*	*Qualitative*	*Quantitative*	Total
Artifact		4	0	7	1	12
Observation		3	2	4	1	10
Physiological		0	7	0	1	8
Self-Report		23	10	28	78	149
Combination		5	9	4	2	20
Total	35	25	10	35	79	184

The dominance of self-report methods is not surprising since these methods are consistent with cognitive and psychological perspectives on emotions—which have dominated the educational emotion literature for several decades (cf. Bellocchi, 2019; Pekrun & Linnebrink-Garcia, 2014). In short, self-report methods are well suited for research based on an understanding of *emotions as mental constructs* that are made available to researchers through participants' own descriptions. Research using physiological measures (which has emerged more recently and is not yet widely used) is based on an understanding of *emotions as internal to individual's bodies or minds*. Observational studies, on the contrary, are often based on an understanding of *emotions as social and relational phenomena*. The low number of such studies suggests that social/relational perspectives are underrepresented in EEE. We suggest that future research should engage with a broader range of emotion theories, including socio-cultural, feminist, critical, cultural theory, and distributed perspectives. For example, critical discourse analysis could be used to uncover the role of emotions in maintaining—or challenging—unequal power relations in engineering education (c.f. Zembylas, 2007).

Our analysis of the use of *artifacts* is preliminary. We currently use it as an umbrella term for different types of artifacts, ranging from reflective writing, to teaching plans or meeting notes. We acknowledge that this category is broad and that some artifacts could be counted as self-report measures instead. We will further explore this category in our ongoing analysis.

Research contexts

We also coded all items according to the contexts in which the research was undertaken. Each item could be coded with multiple research contexts. By far the most common research context was *higher education* (79%), followed by engineering learning in professional

contexts (8%). Primary (1%) and secondary (2%) education accounted for very few research contexts. Although this probably reflects the fact that engineering education is primarily carried out in higher education, our search string included the term *technology education*, which is commonly used to describe engineering education in schools. The comparatively weak focus on research on emotions in primary and secondary education seems at odds with the broader research on emotions in engineering (Uitto et al., 2015).

In 40% of the publications, the research was carried out in the context of teaching interventions, utilizing a wide range of pedagogical approaches. The most common approaches were problem-/project-based learning (15%), labs/workshops/exercises (6%), seminars/group discussions (5%), written assignments (5%), lectures (4%), case studies (3%), online education (3%), assessment (3%), and language learning (3%). Given that lectures and assessment are widely used in engineering education, their relatively low representation in our review suggests that emotions may be considered more relevant and/or problematic in active learning situations, such as problem-based learning, than in traditional lecture-based education. This is unfortunate since research has shown that emotions are important even in those formats (e.g., Quinlan, 2019; Tormey, 2021).

Research foci

To develop an overview of foci in EEE scholarship, we analyzed authors' keywords. We found 382 unique keywords (after removing obvious terms, such as 'engineering education', 'emotion', 'engineering', and 'education'), which we coded using the Engineering Education Research (EER) Taxonomy (Finelli, 2020). The taxonomy has 14 thematic branches, each of which is further divided into subcategories. Figure 3d shows the frequency of keywords by EER Taxonomy Branch. Only 40 keywords were used in more than one publication and 90 publications lacked keywords.

Our preliminary analysis suggests a dominance of research on *emotional intelligence* (n=46), which was used as a theoretical framework (branch 13) and/or in data collection instruments (branch 12). Mental health-related keywords, particularly *anxiety*, were also dominant (branch 10, n=31), mirroring a trend in the broader research on emotions in education (Pekrun & Linnenbrink-Garcia, 2014). Many of the keywords coded as educational *outcomes* (branch 8) were related to *communication*, *ethics*, and *entrepreneurship*, indicating that emotions are considered more relevant/problematic in teaching targeting these types of outcomes than in teaching of purely technical content. Our analysis further suggests a dominance of research on *academic emotions*, while non-academic emotions (e.g., *humor*) were rarely explored. Keywords related to *faculty* and *instructors* were also rarely used, suggesting a lack of research on teachers' emotions. Finally, the initial analysis suggests a lack of research based on sociological and cultural conceptualizations of emotions, as keywords such as *emotional culture*, *emotion rules*, or *emotional capital* were lacking.

We also coded all publications for eight emotion-related concepts that we expected to be used frequently. The results from that analysis (Figure 3e) confirm preliminary findings from the keyword analysis: *emotional intelligence* (28%), *anxiety* (14%), and *socio-emotional outcomes* (11%) are frequently used. The results further suggest that *empathy* (12%), *emotional engagement/motivation* (11%), *academic emotions* (10%), and *achievement emotions* (10%) are frequently mentioned in publications, but seldom chosen as keywords.

Conclusions

We have presented preliminary results from a scoping review of the EEE literature, finding that EEE is an emerging and rapidly expanding, but internationally dispersed field that could benefit from more international exchange and collaborations. We also found that most EEE research so far is conducted in higher education contexts, employs quantitative research approaches, self-report methods, and a limited range of theoretical conceptualizations of emotions. The blind spots we identified indicate many promising and important directions for future research. Finally, we invite current and future EEE researchers to join our international

EEE community, which aims to create spaces for international and interdisciplinary scholarly conversations about emotions in engineering education.

References

Bellocchi, A. (2019). Emotions and teacher education. In G. Noblit (Ed.), *The Oxford Research Encyclopedia of Education*. Oxford University Press.

Borrego, M., Foster, M. J., & Froyd, J. E. (2014). Systematic Literature Reviews in Engineering Education and Other Developing Interdisciplinary Fields. *Journal of Engineering Ed*, *103*(1), 45–76.

Cech, E. A. (2018). The (Mis)Framing of Social Justice: Why Ideologies of Depoliticization and Meritocracy Hinder Engineers' Ability to Think About Social Injustices. In J. C. Lucena (Ed.), *Engineering Education for Social Justice* (pp. 67–84). Springer.

Cooke, A., Smith, D., & Booth, A. (2012). Beyond PICO: The SPIDER Tool for Qualitative Evidence Synthesis. *Qualitative Health Research*, *22*(10), 1435–1443.

Finelli, C. J. (2020). *A taxonomy for the field of engineering education research* (Version 1.2). University of Michigan. http://taxonomy.engin.umich.edu/taxonomy/eer-taxonomy-version-1-2/

Grant, M. J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*, *26*, 91–108.

Hess, J. L., Miller, S., Higbee, S., Fore, G. A., & Wallace, J. (2020). Empathy and ethical becoming in biomedical engineering education: A mixed methods study of an animal tissue harvesting laboratory. *Australasian Journal of Engineering Education*.

Huang, C., Yang, C., Wang, S., Wu, W., Su, J., & Liang, C. (2020). Evolution of topics in education research: A systematic review using bibliometric analysis. *Educational Review*, *72*(3), 281–297.

Kellam, N., Gerow, K., Wilson, G., Walther, J., & Cruz, J. (2018). Exploring Emotional Trajectories of Engineering Students: A Narrative Research Approach. *International Journal of Engineering Education*, *34*(6), 1726–1740.

Lönngren, J., Adawi, T., Berge, M., Huff, J. L., Murzi, H., Direito, I., Tormey, R., & Sultan, U. (2020). *Emotions in engineering education: Towards a research agenda*. Frontiers in Education, Uppsala.

Pekrun, R., & Linnenbrink-Garcia, L. (2014). Introduction. In R. Pekrun & L. Linnenbrink-Garcia (Eds.), *Inter. handbook of emotions in education* (pp. 1–10). Routledge.

Quinlan, K. M. (2019). What triggers students' interest during higher education lectures? Personal and situational variables associated with situational interest. *Studies in Higher Ed*, *44*(10), 1781–1792.

Roeser, S. (2012). Emotional Engineers: Toward Morally Responsible Design. *Science and Engineering Ethics*, *18*, 103–115.

Scherer, K. R. (2005). What are emotions? And how can they be measured? *Social Science Information*, *44*, 695–729.

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to Do a Systematic Review: A Best Practice Guide for Conducting and Reporting Narrative Reviews, Meta-Analyses, and Meta-Syntheses. *Annual Review of Psychology*, *70*(1), 747–770.

Tormey, R. (2021). Rethinking student-teacher relationships in higher education: A multidimensional approach. *Higher Education*.

Turner, J. H. (2007). *Human emotions: A sociological theory*. Routledge.

Uitto, M., Jokikokko, K., & Estola, E. (2015). Virtual special issue on teachers and emotions in Teaching and teacher education (TATE) in 1985–2014. *Teaching and Teacher Ed*, *50*, 124–135.

World Economic Forum. (2021*). Fourth Industrial Revolution*.

Zembylas, M. (2007). The Power and Politics of Emotions in Teaching. In P. A. Schutz & R. Pekrun (Eds.), *Emotion in Education* (pp. 293–309). Academic Press.

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