

WIP: Sense of Belonging Research in Engineering Education: Preliminary Results from a Scoping Literature Review

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Abstract—This work in progress research paper presents the preliminary results from a pilot scoping review of sense of belonging literature in engineering education in the last 30 years. We analyzed the publication trends and venues, research methods and study populations, and terminologies used to refer to sense of belonging from the searched literature. Preliminary results provide evidence of a rapidly expanding field of research on sense of belonging in engineering education, while suggesting some promising directions for future research: 1) conceptual discussions on sense of belonging, 2) discourses on the operationalization of sense of belonging in research, and 3) expansion of study populations and research approaches.

Keywords—*Sense of belonging, scoping literature review, engineering education*

I. INTRODUCTION

This work-in-progress research paper presents preliminary findings from a scoping literature review of sense of belonging in engineering education. A surge in research exploring sense of belonging in engineering education reflects growing awareness of its significance among researchers. However, a gap exists between understanding the importance of sense of belonging from research perspectives and the recognition of the need for its clear conceptualization and operationalization. This conceptual ambiguity poses substantial challenges for educators and researchers working to establish a coherent and comprehensive understanding of sense of belonging in engineering education. For example, terms related to sense of belonging are used sporadically and inconsistently across engineering education literature, with terms like "connectedness," "sense of community," and "sense of school membership" often being used interchangeably [1-4].

Furthermore, much of the research on sense of belonging in engineering education fails to consider the construct's dimensionality, specifically, whether sense of belonging is unidimensional or multidimensional [5]. This is in contrast to

the emerging discourse in higher education that emphasizes the importance of viewing sense of belonging as a multifaceted construct comprising social, academic, environmental, and individual components. For instance, a study by Maghsoodi et al. [6] examining an existing Sense of belonging scale with college students revealed a multidimensional structure of the sense of belonging construct, including an academic component, findings consistent with Slaten's [7] empirical study on the conceptual structure of undergraduate students' Sense of belonging. This lack of conceptual clarity has not only caused confusion among researchers but has also hindered progress in systematic reviews by complicating the identification of precise search keywords. Consequently, this has posed challenges in consolidating the research field.

To address these challenges, our research team is currently conducting a scoping review focused on identifying the essential attributes necessary for conceptualizing and operationalizing sense of belonging in research (e.g., terminologies, definitions, dimensionalities, theoretical frameworks, etc.) and examining the landscape of sense of belonging research in broader STEM higher education. This work-in-progress paper aims to report preliminary results from a pilot review focused on the literature within engineering education, examining publication trends (e.g., paper counts by year, publication venues, etc.), conceptual attributes (e.g., terminologies, dimensionalities, etc.), and research scope (e.g., study populations, research methods, etc.).

II. BACKGROUND LITERATURE

Sense of belonging. Sense of belonging refers to the fundamental human need for social bonds and connections [8-9]. In education, a substantial body of literature has highlighted the positive influences of sense of belonging on various facets of students' experiences and outcomes, including retention and persistence, academic achievement, and social and psychological well-being [10], across diverse educational levels and disciplines. Particularly in STEM higher education where

certain demographic groups, such as historically underrepresented racial or ethnic minorities, are more likely to experience feelings of isolation or unwelcome [11], researchers have increasingly focused on the concept of sense of belonging, as evidenced by a growing body of literature.

Scoping Review. A scoping review is a form of synthesis research designed to systematically map the existing literature within a specific field [12-13]. A scoping review is the preferred methodology for exploring newly emerging evidence, particularly when specific questions suitable for a more targeted systematic review are yet to be determined. The goals of a scoping review include identifying available evidence in a field, clarifying definitions and key concepts, pinpointing knowledge gaps, and acting as a precursor to a systematic review [14], which align closely with the objectives of our project. Consequently, a scoping review was considered a more suitable methodology for our project given the relatively unexplored nature of our focus, sense of belonging in STEM higher education, and the need for a more refined foundational and comprehensive understanding of the subject. Methodologically, a scoping review shares several processes with other systematic reviews, as both methodologies employ systematic, transparent, and reproducible procedures to select relevant evidence that addresses review questions and extracts necessary information from the gathered evidence [15-16].

III. RESEARCH QUESTIONS

This work-in-progress paper is part of a bigger synthesis research project focused on sense of belonging in the broader STEM higher education literature. The project follows the JBI Manual for Evidence Synthesis developed by The Joanna Briggs Institute [14], a research group renowned in the field of systematic synthesis research, which is congruent with the PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) checklist [17]. The JBI Manual includes six stages: 1) Objectives and research questions, 2) Information sources and search strategy, 3) Inclusion criteria, 4) Data management and selection process, 5) Data collection, item, and synthesis, and 6) Outcomes, and the current work-in-progress paper utilized the data collected in stage 5, as a pilot test of the item identification and synthesis. The objectives and research questions of the current pilot scoping review are presented below.

Objectives. Identifying and synthesizing existing evidence on sense of belonging research in engineering education, focusing on publication trends, research scope, and conceptual attributes.

- **RQ1.** What is the publication trend of sense of belonging research in engineering education in terms of paper counts by year, publication venues, and publication trends?
- **RQ2.** What are the attributes of sense of belonging relevant to its conceptualization and/or operationalization (e.g., terminology, definition, dimensionality, etc.)?
- **RQ3.** What is the scope of sense of belonging research in engineering education in terms of study populations, research methods, and research topics.

The following sections will present the search strategies (e.g., search string, search databases, and inclusion criteria) for

both the project and the current pilot study (visit *Methods*), preliminary results (visit *Preliminary Results*), and our future plans (visit *Future Works*).

IV. METHODS

Considering that our team's effort in developing and refining search strategies (e.g., search string, search databases, and inclusion criteria) was reported in Lawrence & Lee [5], the following sections will present its summary (visit *Search String and Database for the Project and Search Results for the Project*) with details on the search process for the current work-in-progress pilot review (visit *Search Strategy for the Pilot Review*).

Search String and Database for the Project. The search strategy for the project is designed to collect peer-reviewed literature on sense of belonging from various fields of STEM disciplinary-based education research published within the last 30 years [5]. A comprehensive literature search was conducted using selected databases that index empirical and conceptual research on the phenomenon or construct of sense of belonging, or its relevant concepts (e.g., belongingness, connectedness, sense of school membership, etc.) in the context of or among the study populations within engineering education other STEM discipline-based education fields [5]. The databases include general database (Scopus, Web of Science, Academic Search Complete), educational and social science databases (Education Resources Information Center/ERIC), psychological database (APA PsycINFO) and engineering database (Engineering Village).

The search string was developed by the collaborative effort of the research team and an Engineering librarian to include terms related to the identified fields, i.e., STEM discipline-based education research (DBER) fields (e.g., Engineering, Biology, Chemistry, Math, Physics, Geoscience, and Computer science education) primarily based on the definition of DBED by the National Research Council [18], and examples of study populations in each field. (Figure 1).

(belonging OR belongingness OR connectedness OR relatedness OR "sense of inclusion" OR "sense of school membership" OR "sense of social fit") AND ("engineer* educat*" OR "STEM educat*" OR "biology educat*" OR "chemistry educat*" OR "math educat*" OR "physics educat*" OR "geoscience educat*" OR "computer science educat*" OR "engineering student*" OR "STEM student*" OR "biology student*" OR "chemistry student*" OR "math student*" OR "physics student*" OR "geoscience student*" OR "computer science student*" OR "engineering undergraduate stud*" OR "STEM undergraduate stud*" OR "biology undergraduate stud*" OR "chemistry undergraduate stud*" OR "math undergraduate stud*" OR "physics undergraduate stud*" OR "geoscience undergraduate stud*" OR "computer science undergraduate stud*" OR "engineering graduate stud*" OR "STEM graduate stud*" OR "biology graduate stud*" OR "chemistry graduate stud*" OR "math graduate stud*" OR "physics graduate stud*" OR "geoscience graduate stud*" OR "computer science graduate stud*" OR "engineering facult*" OR "STEM facult*" OR "biology facult*" OR "chemistry facult*" OR "math facult*" OR "physics facult*" OR "geoscience facult*" OR "computer science facult*" OR "engineering communit*" OR "STEM communit*" OR "biology communit*" OR "chemistry communit*" OR "math communit*" OR "physics communit*" OR "geoscience communit*" OR "computer science communit*")

Fig. 1. Search string for the project

Search Results for the Project. Following the data retrieval conducted in February, 2024, the abstract review for the project was conducted using Rayyan (<https://www.rayyan.ai>), a collaborative literature review software for systematically organizing, sharing, managing, and preserving records and data. A total of 3,905 articles were searched, and after removing duplicates, 2392 articles remained (Figure 2). For this project, we are in the process of completing the remaining phases, evaluating the full-text articles for eligibility using the developed inclusion and exclusion criteria.

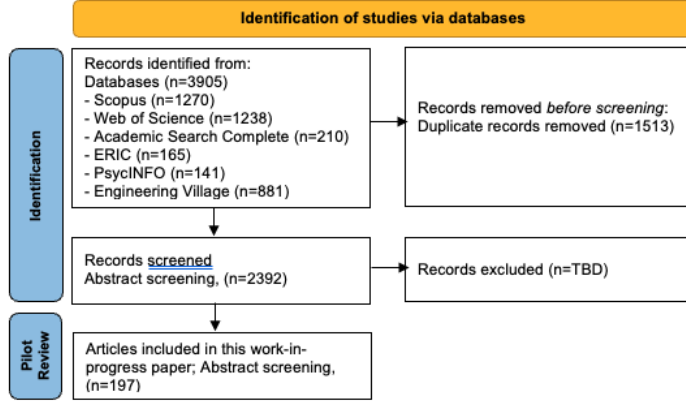


Fig. 2. PRISMA diagram of the current scoping review

Search Strategies for the Pilot Review. For the current pilot review, aiming to test the appropriateness of the identified items, practice synthesis, and gain an early look at a scoping review of sense of belonging literature in engineering education, we followed the pilot review process presented in Reed et al.'s (2020) scoping review with similar purposes. First, we conducted an additional search among the 2,392 articles retrieved for the project. We searched the publication titles, abstracts, and keywords of these articles using the term "engineer*" to find those relevant to engineering education or including different groups of people in engineering as study populations. The * symbol was utilized to search diverse forms of a word simultaneously. Among the searched articles, we searched the publication titles for terms related to, or exchangeably used with sense of belonging, such as "belong*," "relate*," "connect*," "Inclu*," and "fit," to identify sense of belonging-related literature in engineering education. This search process resulted in a total of 288 articles that have both terms related to engineering, either in the publication titles, abstract, or keywords) and sense of belonging (only in the publication titles). Next, we conducted abstract review of the searched articles with the same inclusion criteria developed for the project (Table 1), and a total of 197 articles were utilized for the pilot synthesis that focused on publication trends, research scope, and conceptual attributes. We will refer to the resulting 288 articles as the "sense of belonging in engineering education" articles for the current work-in-progress paper, and the preliminary results of the synthesis will be presented in the following section.

Table 1. Inclusion criteria and their working definitions

Inclusion Criteria	Working Definitions
Central	

Sense of belonging	Include empirical and conceptual studies investigating the phenomenon or the construct of sense of belonging or its relevant concepts
Engineering education	Include publications in engineering higher education
Additional	
Peer-reviewed	Include publications with the peer-review process
Written in English	Include publications available in English regardless of their contexts (e.g., non-/US contexts)
Data range (last 30 years)	Include publications in the last 30 years

Limitation. This work-in-progress paper presents the preliminary findings from a pilot review that aims to develop strategies for the abstract and full paper review process for the main scoping review project, and to gain an early look at the main scoping review. Due to the preliminary nature of this pilot review and its search process, it should be noted that some of the papers in the "sense of belonging in engineering education" may not be related to our topics of interest, while some relevant papers may not have been adequately searched. However, every lesson learned from this pilot review will help the research team to properly scope the main scoping review and identify items for synthesis, contributing to generating more insightful findings from the main project.

V. PRELIMINARY FINDINGS

Publication Trends. We synthesized the retrieved article focused on paper counts by year, publication venues, and publication trends. First of all, the publication years of the "sense of belonging in engineering education" articles range from ##### to current (Fig. 3). A steep increase of the articles is noticed before and after 2020, from the average of 4 to 40 articles per year, which can be potentially explained by the increased attention toward the construct of sense of belonging within engineering education during the global pandemic.

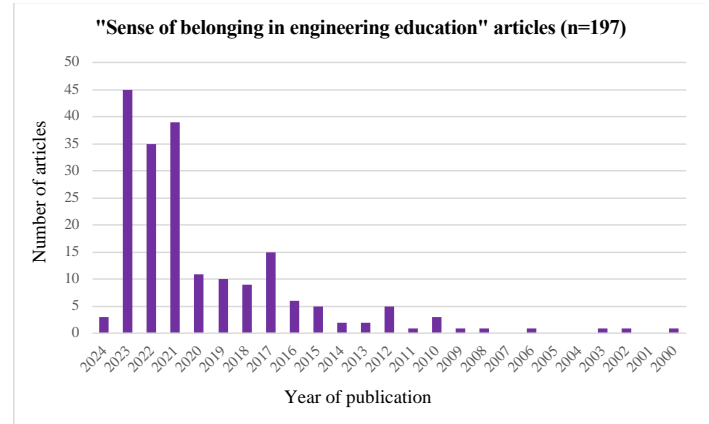


Fig. 3. Publication Trends

Regarding the publication venue (Table 2), engineering or STEM DBED-related conference proceedings or journal articles are the most common venues for publication (84%), with other venues of publication in personality and social psychology, gender studies, etc. (16%). The majority of articles were published as conference proceedings at the American Society of

Engineering Education and IEEE Frontiers in Education conferences (69.5%), with a recent increase in the number of journal articles (30.5%). This trend aligns with findings on publication trends, with the hypothesis that conference proceedings often serve as a step toward publishing journal articles providing potential evidence for the growth of sense of belonging research in the field of engineering education.

Table 2. Publication venues

Publication Venue	# of Articles
ASEE Conference Proceedings	90
IEEE FIE Conference Proceedings	21
Journal of Engineering Education	9
CoNECD Conference Proceedings	7
SEFI Conference Proceedings	5
International Journal of Engineering Education	4
IEEE Global Engineering Education Conference	2
Annual Conference on Innovation and Technology in Computer Science Education	2
IEEE Transactions on Education	2
International Journal on STEM Education	2
European Journal of Engineering Education	2
International Journal of Community Wellbeing	2
Frontiers In Psychology	2
Journal of Diversity in Higher Education	1
IEEE international professional communication Conference	1
IEEE IFEEES World Engineering Education	1
Journal of STEM Education	1
Communications in Computer and information Science	1
CBE Life Science Education	1
Contemporary Educational Psychology	1
IIE Annual Conference and Expository	1
International Journal of Environmental Research and Public Health	1
Others	38
Total	197

Research Scope. We analyzed several research-related characteristics, including research approaches and study population, to gain a better understanding of the scope of the research on sense of belonging in engineering education. To develop an overview of research approaches used in the literature, we categorized the articles as empirical or conceptual studies. As shown in Table 3, most literature is quantitative empirical (46%), qualitative empirical (25%), mixed-methods empirical (13%), or multi-method empirical (3%), with some conceptual synthesis research (2%). The analysis separately counted intervention studies (10%) and instrument development studies (1%). While a full analysis of the research topic through comprehensive paper reviews is needed for a clearer explanation, our initial findings indicate some suggestive trends. Quantitative empirical research is highly represented in our initial sample, suggesting that most of the literature focuses primarily on quantitatively assessing the sense of belonging in relation to other psychological constructs, or as a factor influencing or being influenced by an intervention within a specific context. This trend, coupled with relatively fewer attempts to understand what it means to belong or how the construct of belonging is contextualized in the specific context of engineering education through qualitative or conceptual

research methods, suggests a need for more conceptual discourse to further consolidate the field.

Table 3. Research Methods

Research Methods	# of Articles
Empirical Research	
Quantitative	91
Qualitative	50
Mixed-methods	25
Multi-methods	5
Conceptual Research	
Synthesis	4
Others	
Intervention	19
Instrument development	1
Others (Workshop, etc)	2
Total	197

In terms of study population (Table 4), most of the "sense of belonging in engineering education" articles investigated sense of belonging among students (84%), with a primary focus on undergraduate students. These studies often targeted different student groups, such as underrepresented groups (31%), specific program participants (13%), and first-year students (5%). Other study populations included graduate engineering students (7%), faculty in engineering (7%), and women in engineering (6%).

Table 3. Study Population

Study Populations	# of Articles
Undergraduate Students ($n=153$)	
Underrepresented Students	61
Engineering or STEM Students	55
Participants of Specific Programs	25
First-Year Students	9
Teaching Assistants	3
Graduate Students	13
Faculty	13
Women	12
N/A	6
Total	197

Conceptual Attributes. Lastly, we analyzed the terminologies referring to the construct of sense of belonging.

Table 5. Terminologies

Terminologies	# of Articles
Sense of belonging	113
Belonging	52
Belongingness	21
Connectedness	13
Relatedness	11
Sense of community	3
Sense of Inclusion	1
Total	214

As seen in Table 5, 'sense of belonging' (57%) is the term most frequently used by authors, while 'belonging' (26%) and 'belongingness' (11%) are often used interchangeably with 'sense of belonging,' sometimes even within the same article.

Other terms used include 'connectedness' (7%), 'relatedness' (6%), 'sense of community' (2%), and 'sense of inclusion' (1%). Our initial findings indicate an inconsistent use of terminologies, suggesting the need for further analysis of how these terms are defined and whether the dimensionality of sense of belonging is considered in individual articles to generate a clearer picture of the current operationalization of sense of belonging in engineering education.

VI. DISCUSSIONS AND FUTURE WORK

This work-in-progress paper presents preliminary results from a pilot scoping review of the sense of belonging literature in engineering education. Although additional work is required to properly address the research questions, these preliminary findings provide evidence of a rapidly expanding field of research on sense of belonging in engineering education. The findings also suggest some promising directions for future research, including: 1) more conceptual or theoretical research on sense of belonging, 2) discourses on how to operationalize sense of belonging in research, considering the current inconsistent use of terminologies, and 3) expansion of study populations and research approaches. These pilot review results will also support the development of the scope and strategies for the main scoping review project.

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