

## **[Work-in-Progress] Sense of Belonging in STEM Higher Education: Developing a Scoping Review Protocol and Strategy**

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## Introduction

In STEM higher education, there has been a recent surge in research on sense of belonging. This growth has not only resulted in a wealth of literature but has also presented challenges that more established fields have encountered over time. First, there has been sporadic and inconsistent use of terminologies related to sense of belonging in STEM higher education (Lee et al. 2021; St-Amand et al., 2017; Wilson & VanAntwerp, 2021), with multiple terminologies being used interchangeably (e.g., connectedness, sense of community, etc.). Also, much of the research on sense of belonging in STEM higher education has failed to consider the construct's conceptual structure, such as whether the construct is unidimensional or multidimensional. This lack of conceptual clarity has posed challenges in consolidating the research field, causing confusion among researchers and acting as a barrier to a more comprehensive understanding of sense of belonging in STEM higher education, hindering progress in systematic reviews.

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 the sense of belonging research in STEM higher education. There have been previous efforts to synthesize findings on sense of belonging in STEM higher education, providing valuable insights through accurate summaries of studies and checking for consistencies or relationships. However, most synthesis research is situated within more specific contexts rather than focusing on conceptual understandings across the broader scope of the literature in the field. For example, studies have explored women's sense of belonging in engineering (Wilson & VanAntwerp, 2021), physics (Lewis et al., 2016), or biology education (Otto et al., 2023), gender differences in sense of belonging in STEM (Lewis et al., 2017), and sense of belonging in the context of online engineering classes (Lyles et al., 2021), indicating an opportunity for the current study. Given that the quality of scoping reviews depends on the methods used, this work-in-progress paper aims to elaborate on the research team's ongoing efforts to develop a scoping review protocol for our scoping review, focusing on developing an effective search strategy. A brief background of sense of belonging and scoping review is provided prior to discussing the scoping review design, pilot review, lessons learned and the search strategy, along with future works.

## Background

*Sense of belonging* Sense of belonging refers to the fundamental human need for social bonds and connections (Baumeister & Leary, 1995; Maslow, 1954). 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 (Gopalan & Brady, 2019), 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 (Stayhorn, 2023), 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 (Levac et al., 2010; Daudt et al., 2013). 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 (Munn et al., 2018), 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 (Borrego et al., 2014; Pham et al., 2014).

### **Scoping Review Design**

This scoping literature review was designed to identify and synthesize existing evidence on sense of belonging research in STEM higher education, with a focus on the conceptual attributes (e.g., terminologies, definitions, dimensionalities, theoretical frameworks, etc.) and research scope. This study follows the JBI Manual for Evidence Synthesis developed by The Joanna Briggs Institute (Munn et al., 2018), a distinguished 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 (Tricco et al., 2018). Our review followed the six stages presented by the JBI Manual: 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. The current work-in-progress paper focuses on stages 2) and 3), highlighting the significance of developing an effective search protocol and strategy and its impact on the quantity and quality of the identified literature. The objectives and research questions of the scoping review are presented below.

**Objectives.** Identifying and synthesizing existing evidence on sense of belonging research, focusing on research scope, conceptual attributes, and factors that influence or are influenced by sense of belonging.

- **RQ1.** What is the status of sense of belonging research in STEM higher 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 are and factor that influence of being influenced by sense of belonging for different populations?

The following sections will present the preliminary search strategies (e.g., search string, search databases, and inclusion criteria) for and the search results from a pilot review (see *Pilot Review*), how the lessons learned gained from the pilot review were incorporated into refining the search strategy (see *Lessons Learned and Search Strategy*), and our future plans (see *Future works*).

## **Pilot Review**

Due to the absence of a relevant *a priori* protocol registered with the Open Science Framework for the current scoping review, a pilot scoping review was conducted to develop one. This pilot review also aims to establish a systematic search strategy (e.g., a search string, search database, inclusion criteria) to identify a broad range of primary literature, aligning with the goals of our scoping review (Arksey & O'Malley, 2005). This process also served to enhance the research team's expertise with scoping review procedures and estimate the approximate volume of relevant literature needed for project management. The initial pilot review was conducted in July 2023.

**Search String** First, an example search string was developed through collaboration with an engineering librarian at our institution, who possesses expertise in synthesis research. The initial search string aimed to properly combine terms for the main subjects of the current scoping review (e.g., sense of belonging, STEM higher education, and different study populations for sense of belonging research in the context of STEM higher education) using Boolean operators. This initial search string was refined by the engineering librarian, reviewed by the research team, and the final search string for the pilot search is presented in Fig. 1.

|   |
|---|
| ("belonging" OR "belongingness" OR "connectedness" OR "relatedness") AND ("engineer* educat*" OR "STEM educat*" OR "engineering stud*" OR "engineering undergraduate stud*" OR "engineering graduate stud*" OR "engineering facult*" OR "engineering communit*"). |
|---|

**Figure 1: Initial search string for a pilot review**

**Search Database** We adopted an inclusive approach to comprehensively identify databases relevant to a broad range of literature on sense of belonging, following the suggestion from Arksey and O'Malley (2005). In collaboration with the engineering librarian, the pilot search was

conducted using general databases (Scopus, Web of Science, Academic Search Complete), educational and social science databases (Education Resources Information Center/ERIC), a psychological database (APA PsycINFO), an engineering database (Engineering Village), databases specialized in theses (Dissertations & Theses Global), and a medical database (PubMed). The search fields included title, abstract, and authors' keywords.

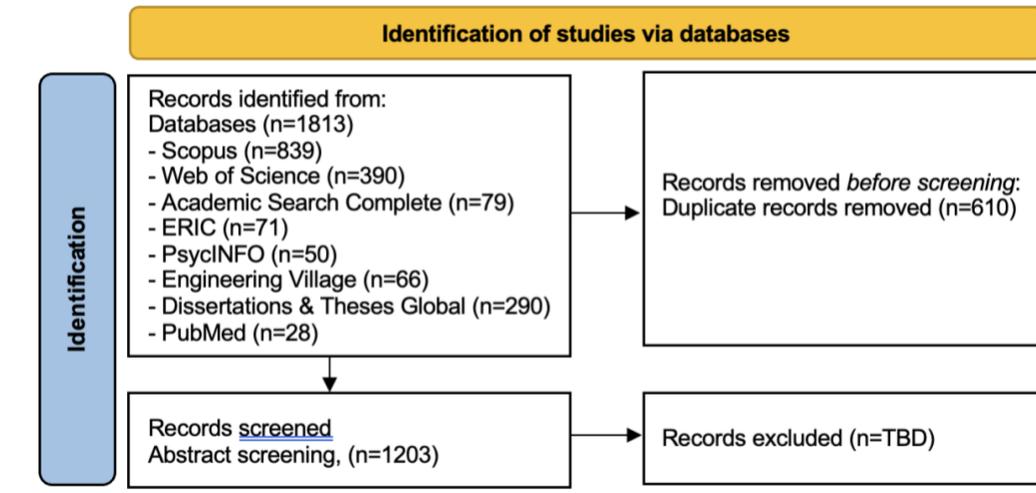
**Inclusion Criteria** To assist in identifying literature relevant to answering the research question in the abstract review, the research team refined the list of central inclusion criteria identified during the objectives and research questions development phase (See *Objectives and Research Questions*). Table 1 presents the central and additional inclusion criteria for the pilot study.

**Table 1. Initial inclusion criteria and their working definitions**

|                   | <b>Inclusion Criteria</b>  | <b>Working Definitions</b>  |
|-------------------|----------------------------|---|
| <b>Central</b>    | Sense of belonging         | Include empirical and conceptual studies investigating the phenomenon or the construct of sense of belonging or its relevant concepts |
|                   | STEM higher education      | Include publications in the context of STEM higher education  |
| <b>Additional</b> | No peer-review restriction | Include publications with and without the peer-review process   |
|                   | Written in English         | Include publications available in English   |
|                   | US context                 | Include publications in the context of US   |
|                   | No data range              | Include all publications until the date of the literature search  |

**Abstract Review** To test the initial inclusion criteria, a pilot abstract review was conducted. This abstract review was conducted using Rayyan (<https://www.rayyan.ai>), a collaborative systematic literature review software for organizing, sharing, managing, and preserving records and data. Following Polanin et al.'s (2022) best practice guidelines, only 10% of the retrieved literature was reviewed for the pilot study. The objectives were two-fold: 1) Search strategy refinement, aiming to further refine the inclusion criteria and their working definitions, and 2) Project management, to estimate an approximate number or percentage of records that remained after the abstract review.

**Search Results** The initial search of the databases resulted in 1,813 records, and 1,203 records remained after removing duplicates (Fig. 2). The abstract review was conducted by two researchers for the randomly selected 120 records, which represent 10% of the literature. For this pilot abstract review, only literature that clearly did not meet more than one of the inclusion criteria was excluded. The results showed that 64 records were included, 48 records were excluded by both reviewers, and eight records remained either as disagreements between the reviewers or for further discussions.



**Figure 2. PRISMA diagram on the flow of the pilot review identification**

### Lessons Learned and Search Strategy

Our pilot review enabled the research team to identify some early failures in the initial search strategy, providing valuable lessons for the development of a more successful strategy. The emergent early failures include: 1) Search strings failed to retrieve sense of belonging literature in diverse STEM discipline-based education fields other than engineering education, 2) Some of the selected search databases retrieved a limited number of relevant literature, and 3) Inclusion criteria failed to identify sense of belonging literature written in English but situated in a non-US context

**Search String** The most significant lesson learned from our pilot review was that the initial search string lacked specificity in retrieving sense of belonging literature across a broad range of STEM discipline-based education fields. This observation surfaced during the abstract review process, as the research team noted a substantial amount of highly relevant literature published outside of engineering education but within various STEM discipline-based education fields, with information on the journal, study population, and context, etc. This proved challenging to retrieve without subject terms specific to those fields in the search string (Fig. 3).

This early failure in search string design guided the research team to experiment with revising the search string. First, we specified 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 (Singer et al., 2012). Then, the initial search string was updated to include terms related to the identified fields and examples of study populations in each field. Although two research questions focus specifically on the conceptual attributes of sense of belonging (e.g., terminology, definition, dimensionality, etc.) (RQ2) and factors influencing and being influenced by sense of belonging (RQ3), the research team did not include related terms to primarily answer RQ1, which aims to identify the landscape of sense of belonging research in STEM higher education. The research team then compared the

volume of literature retrieved with and without specific terms in consultation with the engineering librarian, and the finalized search string is shown in Figure 3. We are currently further refining the search string by taking a more systematic approach to identify terms related to the sense of belonging, based on the previous suggestions by Phillips et al.'s (2017) reflection on a systematic literature review.

(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\*")

**Figure 3. Revised scoping review search string**

**Search Database** Another early failure involved the inclusion of some databases (e.g., PUBMED, eBook Central, Dissertations and Theses Global) that index a limited amount of literature relevant to the focus of this scoping review, sense of belonging. This resulted in a significant number of less relevant literature being retrieved. Although a broader range of search databases was utilized for the pilot search, following Arksey and O'Malley's (2005) recommendation on the purpose of scoping reviews that includes visualizing the range of 'available' materials as possible, this lesson learned led the research team to refine the range of search databases.

Consequently, we identified more appropriate databases that index empirical and conceptual research on the phenomenon or construct of sense of belonging, or its relevant concepts (e.g., belongingness, connectedness, relatedness, sense of inclusion, sense of school membership, and sense of social fit) in the context of or among the study populations within Other STEM discipline-based education fields by reviewing the pilot search results from individual databases. The updated search databases include general databases (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 pilot search results also helped us to scope our review, focusing on peer-reviewed literature (e.g., journal papers and conference proceedings). Although evaluating literature quality is not part of scoping review methodology due to the nature of scoping reviews, which are often conducted

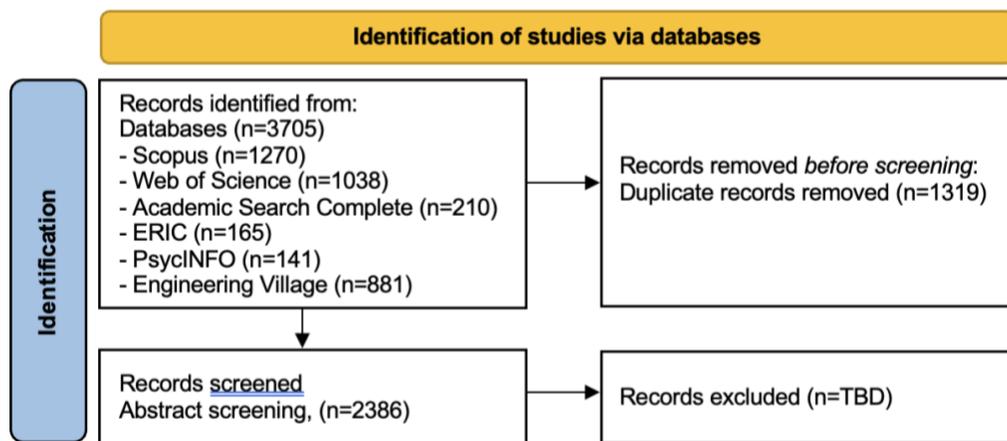
on under-investigated subjects with a small number of retrieved literature, we decided to exclude databases on theses or dissertations considering the high volume of literature searched (n=290) in the pilot review. This also led us to modify the initial inclusion criteria.

**Inclusion Criteria** In addition to the above lessons learned, the overall experiences of the pilot review helped the reviewers understand what had not been considered when developing the initial inclusion criteria. For example, some highly relevant literature was excluded because it did not meet one of the criteria, "US context," despite being written in English. We also set a data range for the scoping review considering the limited number of publications prior to 30 years and their high irrelevance. Lastly, a working definition for each of the criteria was refined to facilitate the collaborative abstract review process, based on the lessons learned (Table 2).

**Table 2. Refined inclusion criteria and their working definitions**

|                   | <b>Inclusion Criteria</b>  | <b>Working Definitions</b>  |
|-------------------|----------------------------|---|
| <b>Central</b>    | Sense of belonging         | Include empirical and conceptual studies investigating the phenomenon or the construct of sense of belonging or its relevant concepts |
|                   | STEM higher education      | Include publications in STEM-discipline based higher education  |
| <b>Additional</b> | Peer-reviewed              | Include publications <b>without the peer-review process</b>   |
|                   | 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   |

**Search Results** With the revised search strategy, the second data retrieval and abstract review were conducted in October, 2023. A total of 3,705 records were searched, and after removing duplicates, 2,386 records remained (Fig. 4). The number of remaining records for the abstract review increased despite reducing the number of search databases, indicating the enhanced effectiveness of the refined search strategy.



**Figure 4. PRISMA diagram on the flow of the scoping review identification**

## Discussion and Future Works

Literature identification is a crucial step in conducting a scoping review. With the vast amount of published data available across numerous databases, searching, identifying, and selecting appropriate literature to properly address the scoping review's research questions is an art that requires a systematic approach. This work-in-progress paper provides evidence supporting the importance of systematically developed search strategies in improving the process and outcome of the literature identification stage, which will ultimately contribute to the overall quality of the scoping review.

The abstract review of this scoping review is currently in progress. Once completed, the project will once again conduct a preliminary synthesis using a portion of the remaining literature to develop a synthesis strategy based on lessons learned from the current work on search strategy development. With the refined search strategy, we will extract and synthesize data from the remaining literature, completing the scoping review. The findings of the current project, including the identified scope of the research and the gained knowledge on the conceptual attributes, will contribute to the consolidation of the field of research on sense of belonging in the context of STEM higher education.

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