The Future of Engineering Education
2024 Annual Conference & Exposition

Oregon Convention Center
Portland, OR . June 23 - 26, 2024

ASEE

Paper ID #41842

Review of Sense of Belonging Relevant Concepts in STEM Higher Education

Mrs. Xiaoye Yang, University of Massachusetts, Lowell

Xiaoye yang is a Ph.D. student majoring in Research and Evaluation in Education at UMass Lowell. For over a decade, she has been involved in the language and education field holding various roles such as student, teacher, and researcher. She is a research assistant working at the center for program evaluation to conduct research on program evaluation methods as well as to offer evaluation planning, consulting, training, and services for the university, regional, and global community. Her research interest includes STEM education, sense of belonging, and program evaluation. She is working on measuring college students' sense of belonging, especially in the engineering field, facilitating school leaders' and educators' work in promoting engineering students' success and broadening participation in engineering.

Dr. Hsien-Yuan Hsu, University of Massachusetts, Lowell

Dr. Hsien-Yuan Hsu is an Assistant Professor in Research and Evaluation in the College of Education at the University of Massachusetts Lowell. Dr. Hsu received his PhD in Educational Psychology from Texas A&M University and has a background of statistics

Dr. Yanfen Li, University of Massachusetts, Lowell

Yanfen Li is an Assistant Teaching Professor at the University of Massachusetts Lowell. She received her PhD in Bioengineering from the University of Illinois at Urbana Champaign. Her current research is in engineering education with a focus on curriculu

Review of Sense of Belonging Relevant Concepts
in STEM Higher Education

In response to the valuable insights provided by the reviewers, this work-in-progress (WIP) paper has been updated in several key areas. Firstly, we have narrowed the paper's focus to thoroughly explore just the two fully developed concepts—University connectedness and sense of inclusion—ensuring a more in-depth examination. In addition, we have updated the summary tables to present the information in a clearer and more concise way. Secondly, we revised the result section and incorporated comprehensive discussion and conclusion sections, which not only give the paper completeness but also emphasize the study's relevance and potential impact. Lastly, adjustments were made to streamline the content to align with the constraints and expectations for a work-in-progress submission, while removing redundant descriptions of related concepts that were previously covered in our 2023 paper.

Background

This WIP paper reviews concepts relevant to the Sense of Belonging (SB) in STEM higher education. SB is both an affective and psychological factor influencing learning and students' outcomes, encompassing participation in STEM, academic and social accomplishments, as well as persistence and retention. In our previous work centered on instruments measuring SB [1], we discerned that within the college context, SB's nature — whether singular or multifaceted — hinges on the underlying theoretical framework. This nature might intersect with other concepts such as "university connectedness" [2], "sense of inclusion" [3], "sense of social fit" [4], "sense of community" [5], and "perceived cohesion" [6]. However, without comprehensive research to determine if these concepts are synonymous with SB or distinct yet related, our previous study refrained from using these terms as search keywords. Hence, the instruments reviewed were primarily identified using "sense of belonging" or "belongingness". Up until now, there has not been a rigorous study that draws parallels between the definitions of these concepts and SB, or that categorically details the instruments available for measuring each concept. This oversight not only presents challenges for researchers and educators looking to holistically foster student belonging but can also lead to unintended conflation of terms. For instance, without a clear demarcation of these concepts, practitioners might present their research findings interchangeably using different concepts. This ambiguity can impede other researchers attempting to replicate the findings. To the best of our knowledge, there is a dearth of comprehensive studies synthesizing information on SB-associated concepts within STEM higher education.

This paper aims to fill this gap by offering a literature review that clearly summarizes the definitions of concepts linked to SB. We will then compare our findings with the SB definition from our 2023 study. Furthermore, this research will review the available measurement tools used for each SB-associated concept. The findings of this study serve as a foundational reference, ensuring that both researchers and educators operate with a unified and in-depth comprehension of SB and its associated terms. This clarity also establishes a solid groundwork for the future systematic review of SB.

Literature Review

In our prior research focused on tools for measuring SB [1], we found that SB can intersect with other concepts, such as "university connectedness" [2], "sense of inclusion" [3], "sense of social fit" [4], "sense of community" [5], and "perceived cohesion" [6]. In this section, we will briefly summarize the connections between SB and the first two concepts, as well as the primary literature that includes their conceptual and operational definitions.

University Connectedness and Sense of Belonging

University connectedness is a multifaceted concept that encompasses the feeling of belonging, social connectedness, and interpersonal relationships within the university community [7]. This connectedness is heavily correlated with students' involvement in university activities, indicating that daily interactions play a crucial role in fostering a sense of belonging [8]. Furthermore, the perception of specific relationships at the university, particularly relationships with teachers, contributes significantly to students' sense of school connectedness [9]. In the context of racially minoritized faculty at predominantly white institutions, mentoring relationships have been identified as a pathway to fostering a sense of belonging, highlighting the importance of supportive interpersonal connections within the university environment [10]. The concept of university connectedness is closely intertwined with social connectedness, which encompasses social support, social networks, and the absence of perceived social isolation [11]. Furthermore, the feeling of belonging and the creation of bonding relationships are integral components of connectedness within the university community [12]. It is evident that university connectedness plays a pivotal role in shaping students' experiences and well-being, mediating the relationships between various factors such as campus racial hostility, parental support, and psychological adjustment [13, 14]. University connectedness encompasses a broad spectrum of interpersonal, social, and institutional factors that contribute to students' and faculty members' sense of belonging within the higher education environment.

The article by Wilson and Gore [2] investigates the impact of parental and peer attachment on students' sense of connectedness to their university. Conceptually, university connectedness is defined as a student's subjective feeling of fit within the university environment and their perception of being accepted, respected, included, and supported by the university community. Operationally, the study assesses this connectedness involving several scales to assess various dimensions related to students' feelings towards their university. Specifically, the study measures attachment using the Relationships Structures Questionnaire [15], which assesses anxiety and avoidance in relationships. The perceived university environment is evaluated through the Sense of Belonging instrument [16], focusing on peer and faculty support, comfort in the classroom, and feelings of isolation. Additionally, the Psychological Sense of School Membership Scale [17] is adapted to measure students' sense of school connectedness, taking into account feelings of acceptance and respect. The study's findings indicate that secure attachment styles positively correlate with a strong sense of university connectedness. Notably, the research suggests that these attachment styles can predict students' perceptions of peer and faculty support, which in turn influence their overall connectedness to the university. These outcomes highlight the importance of fostering supportive social bonds within educational institutions to enhance students' sense of belonging and well-being.

Sense of Inclusion and Sense of Belonging

In the context of higher education, inclusion refers to the practice of creating an environment where all individuals, regardless of their background, identity, or abilities, feel welcomed, valued, and supported [3]. It involves fostering a sense of belonging, promoting diversity, and ensuring equitable access to resources and opportunities for all members of the academic community [18]. The sense of inclusion in higher education is closely related to the concept of belonging. While belonging refers to the feeling of being accepted and valued within a community, the sense of inclusion extends this concept by emphasizing the importance of valuing individual uniqueness and contributions within the inclusive environment. In the context of higher education, the sense of inclusion encompasses the perception of being part of a community that values diversity, promotes equity, and fosters a supportive and welcoming environment for all individuals [18]. This perception of inclusion is essential for creating an academic environment where all members feel respected, supported, and empowered to contribute to the community's collective goals and values.

The article by Lee et al. [3] develops the Engineering Department Inclusion Level (EDIL) survey to measure underrepresented student perceptions of inclusion within engineering departments and universities. It's grounded in Tinto's Model of Institutional Departure, aiming to explore how gender, race/ethnicity, and academic level influence students' sense of inclusion. Through exploratory factor analysis, the survey identifies three key factors of inclusion: Caring, diversity, and pride, each measured at both departmental and university levels. Initial findings show no significant gender differences but reveal that African American students perceive lower levels of inclusion compared to other racial/ethnic groups.

Methodology

For our current review, we are using the citation pearl growing method. This method involves using a relevant and authoritative article, also known as a pearl, to search for other materials that are also relevant and authoritative. This is done by using a citation index to move forward in time. Our research aims to provide an overview of related concepts and their measurement tools. This is an effective approach to ensure that more relevant literature has been identified.

Information Sources and Search Strategy

We followed the "pearl growing" method to find relevant articles. Below is detailed information on each step.

1. First, we identified five fundamental articles based on our prior research about instruments measuring SB [1] and we manually searched the five articles using Google Scholar.
2. Second, we searched the "cited by" list of these articles to find other relevant papers within Google Scholar. We only looked at papers that have cited the article of interest. In detail, we clicked "Cited by #" and then entered our key search terms, which included the main concepts (e.g. "University connectedness") and the following terms, "higher education" OR "college" OR "university" OR "post-secondary" OR "postsecondary" and "tool" OR "instruments" OR "scale" OR "questionnaire" OR "measurement" OR

"assessment". We clicked "Search within citing articles" and found 50 results after entering our key terms for the concept of "University Connectedness".

Due to time constraints, we did not conduct an iterative process to identify further relevant manuscripts beyond the second step. Table 1 provides a detailed search methodology.

Eligibility Criteria

The eligibility criteria for selecting studies included both inclusion and exclusion criteria. The details of the criteria are listed below for clarification.

Inclusion criteria

For documents to be included in this study, they must meet the following conditions:

1. The full text should be in English. We have chosen to focus on English articles to maintain consistency in data extraction and analysis, ensuring a more uniform evaluation process across all included studies.
2. The study must include instruments measuring the relevant concept, such as self-developed or adapted instruments.
3. The article types include peer-reviewed articles, conference papers, and students' theses or dissertations.

Exclusion criteria

1. News and conference abstracts were excluded as they typically lack details on measurement development. Book chapters were excluded due to difficulty obtaining access to the full text.
2. Studies focusing on non-higher education populations, specifically primary, secondary, and high school students, were excluded to maintain the research scope within the undergraduate and graduate student demographic.

Data Management and Selection Process

We utilized Google Drive for effective data management, enabling our team to organize, share, manage, and preserve records and data collaboratively. We reviewed the titles and abstracts of each article to ensure they met our inclusion standards. Once we identified articles that were potentially relevant, we saved them in a shared folder. The ensuing phase involved extracting data, evaluating the full texts for eligibility, and performing inter-rater reliability checks, for which we utilized Google Sheets. This choice was made because it greatly streamlined the comparison process.

Selection of Sources of Evidence

At the start of our research, we utilized the Google Scholar database to look up our two pearl articles individually, which yielded 148 articles on January 28, 2024. We then narrowed this initial pool to 69 articles by entering the appropriate search terms for each concept relevant to our study. We carefully screened each article by reading its title and abstract based on our eligibility criteria. If an article met our criteria, we saved it in "my library" on the Google Scholar account. We then exported all of the article information into a spreadsheet for further screening. After a thorough full-text screening, we were left with a final selection of three articles. For more detailed information, please refer to Table 1.

Table1

Overview of Scholarly Articles Selection Process for Conceptual Reviews in Higher Education

Concepts	Pearl Article ID Source Title Journal Name	Number of Citation (Database: Google Scholar Search Date: January 28, 2024)	Number of Articles after Searching with Key Terms	Number of Articles after Screening Title & Abstract Based on the Criteria	Number of Articles after Screening Full Text
University Connectedness	ID: **UC** Wilson and Gore (2013) *An Attachment Model of University Connectedness* Journal of Experimental Education	108	50	5	2 Article Types: • Dissertation / Thesis (2)
Sense of Inclusion	ID: **SI** Lee et al. (2014) *Measuring Underrepresented Student Perceptions of Inclusion within Engineering Departments and Universities* International Journal of Engineering Education	40	19	4	1 Article Types: • Peer-reviewed Journal (1)

Note. UC = University Connectedness; SI = Sense of Inclusion.

Table2

Extracted Instruments Used to Measure Relevant Concepts

ID	Source	Concept Definition	Instrument Development Study	Instrument for Relevant Concepts	Instrument Scale Dimensions Number of Items	Reliability in Identified Articles
UC	Wilson and Gore (2013)	Students' subjective sense of overall fit within the university and the perception that they are personally accepted, respected, included, and supported by others at the university (Bollen & Hoyle, 1990; Goodenow, 1993; Hagerty et al., 2002; Hausmann et al., 2007; & Pittman & Richmond, 2007)	No	Adapted from Psychological Sense of School Membership Scale (PSSM) (Goodenow, 1993)	UC was measured by the full scale. (18 items on a 5-point Likert scale)	• ICR: α = .77 to .88 • CV: CFA: Correlation Analyses
UC-1	Kilner, G. (2018)	Social connectedness is the sum of the individual's relational networks and their presence has an impact on the individual's well-being. Social connectedness is realized through the initialization and maintenance of a quantity of relationships and may be influenced by the earlier developed ability to connect (Lee & Robbins, 1998).	No	Adopted from Social Connectedness Scale and Social Assurance Scale (Lee & Robbins, 1995)	UC-1 was measured by subscale with dimensions called: 1. Social Connectedness Scale (8) 2. Social Assurance Scale(6) 3. Social Media Questions(2) (16 items on a 6-point Likert scale)	• ICR: α = .933 • CV: Correlation and Cluster Analyses
UC-2	Finn, C. (2018)	Connectedness is defined as an individual's sense of belonging and acceptance, and general feeling concerning the classroom learning environment (Bolliger & Inan, 2012; Sollitto et al., 2013).	No	Adopted from Online Student Connectedness Survey (OSCS) (Bolliger & Inan, 2012)	UC-2 was measured by the full scale with dimensions called: 1. Comfort (8) 2. Community and social presence (6) 3. Facilitation (6) 4. Interaction and Collaboration (5) (25 items on a 5-point Likert scale)	• ICR: α = .906 • CV: CFA; Bivariate Correlation and ANOVA t-testing
SI	Lee et al. (2014)	Inclusion means feeling welcomed, respected, valued, and supported within a department or university climate (Miller & Kat, 2022).	Yes	Engineering Department Inclusion Level (EDIL) Survey	SI was measured by the full scale with dimensions called: 1. University Caring (15), Diversity (3), and Pride (4). 2. Department Caring (15), Diversity (3), and Pride (4). (44 items on a 6-point Likert scale)	• ICR: α > .85 • CV: EFA • CTV: Literature and Check with Experts.
SI-1	Jensen & Cross (2020)	N/A	No	Adopted EDIL Survey Subscale	SI-1 was measured by the sub-scale with dimensions called: 1. Department Caring (15) 2. Department Diversity (3) 3. Department Pride (3) (21 items on a 6-point Likert scale)	• ICR: α > .78 • CV: EFA; Correlation

Note. α = Cronbach's alpha; ICR means Internal Consistency Reliability; CV means Construct Validity; and CTV means Content Validity

Results

Table 2 delineates the operational definitions and measurement instruments for 'university connectedness' and 'sense of inclusion' as extracted from the Pearl study and additional sources. This table meticulously documents whether each instrument was self-devised, adapted, or directly adopted, along with the instrument's name, its various dimensions, and psychometric properties. More details are provided in Table 2.

Conceptual Clarifications

Our synthesis of concept definitions from Table 2 reveals an interchangeable use of 'connectedness' and 'inclusion' within the literature, often in association with 'belongingness.' Belongingness is subjective, focusing on identity within the university community, while connectedness extends to active engagement within societal frameworks. For instance, the Pearl instrument, UC, mirrors 'belongingness' with an emphasis on the students' subjective fit and communal relationships within the university setting. This overlap suggests a conflation of belonging and connectedness in the context of educational integration. UC-1 and UC-2 expand on this by exploring social networks and the classroom environment, respectively. The concept of inclusion in SI also encapsulates belonging, with a broader remit of fostering diversity and equality within university departments, aligning with Tinto's Model of Institutional Departure.

Operational Insights

The instruments presented are predominantly adaptations or adoptions of existing measures, with a sole instance of a novel instrument: the Engineering Department Inclusion Level (EDIL) Survey. The EDIL Survey delves into departmental and university-wide inclusion. Each instrument aligns with its respective conceptual definition, providing a spectrum from unidimensional to multifaceted representations of connectedness. UCI adopts the PSSM, centering on students' perceived acceptance within the university milieu. This instrument focuses on a unidimensional definition of belonging, specifically highlighting students' subjective sense of fit within the university. In contrast to the unidimensional approach of UCI, the other instruments offer a more multifaceted view of connectedness. For instance, UCI-1 incorporates digital social connectedness, while UCI-2, via the OSCS, acknowledges online educational environments' influence on connectedness. The sense of inclusion is captured primarily through the EDIL Survey, reflecting a comprehensive understanding of inclusion within academic communities. The components from SI suggest that inclusion has a multi-faceted understanding that goes beyond just being present in a group, to include how one is perceived and valued by the institution and its smaller sub-communities. SI-1 also adopted the survey instrument, but they only used part of the survey, which focused solely on the engineering department. The reduction in the number of items compared to SI could imply a more streamlined approach to measuring the sense of inclusion that focuses on specific aspects of inclusion.

Psychometric Integrity

The study utilized a variety of instruments with different dimensions to measure connectedness and inclusion within a university setting. These instruments, comprising scales and subscales ranging from 16 to 44 items each, were implemented on Likert scales of 5 or 6 points to capture the nuances of the constructs. Overall, the reliability of these instruments, indicated by Internal Consistency Reliability (ICR) scores, was found to be robust, with values ranging from acceptable to excellent. This underscores the precision and consistency of the

measurement tools applied to assess the subjective experiences of students in relation to their university environment.

Discussion

The exploration into 'university connectedness' and 'sense of inclusion' has revealed intricate constructs essential for the student experience in higher education, with significant implications for STEM education. The overlaps and distinctions between connectedness and inclusion demonstrate the complexity of fostering a sense of belonging, which is particularly pertinent in the STEM fields where diverse representation and integration are critical.

The constructs of connectedness and inclusion, as indicated by the adapted and adopted instruments, suggest that students' perceptions of their belonging within the university are inherently linked to their active participation in both physical and digital realms. The adaptability of instruments such as UCI-1 and UCI-2 underscores the evolutionary nature of connectedness in an increasingly digitalized society, which is reflective of STEM fields' emphasis on technological engagement. The EDIL Survey's focus on departmental and university-wide inclusion resonates with the call within STEM for creating environments that not only attract but also retain a diverse student body.

The validated reliability of the instruments used in this study suggests that STEM programs can benefit from their implementation to assess and enhance their educational climates. Academic institutions can leverage these tools to identify areas for improvement and to tailor interventions aimed at enhancing student integration and well-being. In addition, insights derived from these instruments can guide STEM departments in developing inclusive pedagogical strategies and supportive networks that are known to be vital for the success of underrepresented groups in these fields.

Limitations and Future Research Directions

While the study presents strong psychometric evidence for the selected instruments, the current study's focus may not capture the full spectrum of experiences unique to STEM students, such as the impact of lab culture, peer collaboration, and mentorship on connectedness and inclusion. Future research should explore the applicability of these instruments to address these elements for a holistic understanding of STEM education dynamics. Subsequent investigations should aim to validate and possibly refine these instruments for the STEM context, ensuring their sensitivity to the unique challenges and opportunities inherent in these disciplines. Studies should investigate how connectedness and inclusion contribute to persistence and achievement in STEM, particularly for underrepresented students. Additionally, research could examine the role of virtual labs and online collaboration tools in fostering connectedness in response to the increasing digitization of STEM education.

Conclusion

The constructs of university connectedness and the sense of inclusion are pivotal in shaping positive student experiences and outcomes, with particular relevance to students' sense of belonging in STEM education. By continuing to refine the understanding and measurement of these constructs, STEM programs can cultivate educational environments that not only support but also empower a diverse range of students to excel and innovate.

References

[1]   X.Yang, H. Hsu, and Y. Li, "A systematic review of instruments measuring college students' sense of belonging," in *American Society for Engineering Education (ASEE) 2023 Conference Proceedings*, 2023.

[2]   S. Wilson and J. Gore, "An attachment model of university connectedness," *The Journal of Experimental Education,* vol. 81, no. 2, pp. 178-198, 2013.

[3]   W. C. Lee, H. M. Matusovich, and P. R. Brown, "Measuring underrepresented student perceptions of inclusion within engineering departments and universities," *International Journal of Engineering Education,* vol. 30, no. 1, pp. 150-165, 2014.

[4]   G. M. Walton and G. L. Cohen, "A question of belonging: race, social fit, and achievement," *Journal of Personality and Social Psychology,* vol. 91, no. 1, p. 82, 2007.

[5]   J. W. Lounsbury, D. DeNeui, J. M. Loveland, and L. W. Gibson, "Collegiate psychological sense of community scale," *An investigation of psychological sense of community in relation to Big Five personality traits,* vol. 31, no. 5, pp. 531-541, 2003.

[6]   K. A. Bollen *et al.*, "Perceived cohesion scale," *STARS: Strategies to Assist Navy Recruits' Success,* vol. 172, no. 9, pp. 942-949, 2007.

[7]   K. Hunt and S. Burns, "Is there an association between social connectedness, social identity, alcohol consumption and mental health among young university students?," *Open Journal of Preventive Medicine,* 2017.

[8]   R. F. Baumeister and M. R. Leary, "The need to belong: Desire for interpersonal attachments as a fundamental human motivation," *Psychological Bulletin,* vol. 117, no. 3, pp. 497-529, 1995.

[9]   G. Dovey-Pearce, T. Rapley, and J. E. McDonagh, "Delivering developmentally appropriate health care: Roles for psychologists as members of the multi-disciplinary health care team," *Clinical Child Psychology & Psychiatry,* vol. 25, no. 3, pp. 579-593, 2020.

[10]   R. Wright-Mair, "Longing to belong : Mentoring relationships as a pathway to fostering a sense of belonging for racially minoritized faculty at predominantly white institutions," *Journal Committed to Social Change on Race and Ethnicity (JCSCORE),* vol. 6, no. 2, pp. 2-31, 2020.

[11]   P. J. Wickramaratne *et al.*, "Social connectedness as a determinant of mental health: A scoping review," *PLoS ONE,* vol. 17, no. 10, p. e0275004, 2022.

[12]   D. A. Jorgenson, L. C. Farrell, J. L. Fudge, and A. Pritchard, "College connectedness: The student perspective," *Journal of the Scholarship of Teaching Learning,* vol. 18, no. 1, pp. 75-95, 2018.

[13]   M. Suhlmann, K. Sassenberg, B. Nagengast, and U. Trautwein, "Belonging mediates effects of student-university fit on well-being, motivation, and dropout intention," *Social Psychology,* 2018.

[14]   L. R. M. Hausmann, F. Ye, J. W. Schofield, and R. L. Woods, "Sense of belonging and persistence in White and African American first-year students," *Research in Higher Education,* vol. 50, no. 7, pp. 649-669, 2009.

[15]   R. C. Fraley *et al.*, "Experiences in close relationships--relationship structures questionnaire," *Patterns of stability in adult attachment: An empirical test of two models of continuity and change,* vol. 101, no. 5, pp. 974-992, 2011.

[16]   M. Hoffman, J. Richmond, J. Morrow, and K. Salomone, "Investigating 'sense of belonging' in first-year college students," *Journal of College Student Retention: Research, Theory and Practice,* vol. 4, no. 3, pp. 227-256, 2002.

[17]   C. Goodenow, "Classroom belonging among early adolescent students: Relationships to motivation and achievement," *The Journal of Early Adolescence,* vol. 13, no. 1, pp. 21-43, 1993.

[18]   M. E. Mor Barak, "Inclusion is the key to diversity management, but what is inclusion?," *Human Service Organizations: Management, Leadership & Governance,* vol. 39, no. 2, pp. 83-88, 2015.