Conceptualization and situating of sense of belonging among international engineering doctoral students: In light of the previous literature

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Conceptualization and Situating of Sense of Belonging Among International Engineering Doctoral Students: In Light of the Previous Literature

Introduction
This work aims to conceptualize and situate the concept of ‘sense of belonging’ among international engineering doctoral students. This conceptual paper builds on our earlier study [1], which developed a conceptual model of belongingness among international engineering doctoral students based on their interactions with faculty, peers, and staff. A literature review informed this conceptualization and revealed a lack of consistency in the conceptual structure of belongingness in both higher education and engineering education. This work will include the following: 1) a brief review on the varied characteristics of sense of belonging (e.g., definitions and constructs/defining components) in different context (e.g., K-12 education, undergraduate education, graduate education, and community) among different populations (e.g., adolescents, undergraduate students, underrepresented students, and adults), 2) a detailed description on the unique belongingness constructs/defining components depending on the characteristics of the student (e.g., undergraduate, graduate, underrepresented minority (URM), international student) focusing on the context of engineering education, and 3) a conceptualization that situates our previous study [1]. This work will expand our knowledge about sense of belonging as an independent and theoretical concept to move closer to a consensus understanding of its evolving conceptual structure.

Study Context: Diversity in Students’ Citizenship in Engineering Doctoral Education
According to the recent report ‘Science & Engineering Indicators’ [2], the US positions itself as the destination for the largest number of international students worldwide in the fields of science and engineering. International students who possess citizenships from 225 countries earned more than half of doctoral degrees in engineering in 2017, underscoring the diversity in citizenship among the student population [2]. Recently published national reports also support the existence of diversity in citizenship in STEM graduate education. For example, citizenship was included in diversity indices along with the traditional measures in the recent report ‘Graduate STEM Education for the 21st Century’ [3]. This paper answers the call to study this population in an effort to ensure that our engineering programs are inclusive of this important and understudied population [4].

Research on Sense of Belonging in Engineering Education
Belongingness, the fundamental human need for social connection, is a construct that has garnered interest in studies of inclusion [5], [6]. Sense of belonging was introduced to education as a precursor of students’ integration within their academic unit [7],[8] and serves as a measure of the perceived degree of inclusion within that unit. The concept is still evolving because of its transitory characteristics that can change according to the specific context. This means that the
sense of belonging for an individual student changes based on their current context, and thus a student with a high sense of belonging in a certain educational context can have a low sense of belonging if they move into a different educational context. This has resulted in a call to view the concept of belonging as complex, multi-faceted, and as impacted by extra-institutional factors [9]. Moreover, additional researchers have begun to take account of disciplinary-specific characteristics, such as student demographic characteristics and departmental culture [10]-[12].

Most research investigating belongingness in engineering education has focused on undergraduate students with demographic characteristics limited to gender and race/ethnicity. Aspects of student interactions with peers and faculty derived from the diversity in students’ citizenship and the subsequent differences in language and culture [1],[13]-[15] are absent from this work. Among the sparse research that does include students’ citizenship as a variable, differences in sense of belonging were also reported between domestic and international STEM doctoral students [10],[13], in turn underscoring the need for increased understanding sense of belonging from the international student perspective, particularly in the context of engineering doctoral education.

Our earlier work [1] related to understanding international doctoral students’ sense of belonging is a first step in responding to this identified need. We investigated students’ perception of their interpersonal interactions with peers and faculty and the associated relationships on their sense of belonging. The findings include a conceptual model that demonstrates the different constructs of belongingness, (e.g., engineering self-efficacy, academic sense of belonging, sociocultural sense of belonging, authentic-self, problem behavior, and perceived institutional support) and the influence of students’ interpersonal interactions with different groups of people (e.g., faculty, peers, and staff) on those constructs [1].

**New Questions: Have we Conceptualized Sense of Belonging as a Theoretical Construct?**

New questions have arisen while situating our research in the broader literature related to sense of belonging. Definitions and conceptual structures of sense of belonging are sporadic and inconsistent across the belongingness literature in engineering education. The questions (i.e., have we conceptualized sense of belonging as a theoretical construct?) were supported by a cumulative argument in higher education that has claimed the lack of sense of belonging research that specified it as an independent construct [16]-[19]. This is surprising considering arguments made by research in both higher and engineering education regarding the significance of the concept on students’ academic outcomes and perceived inclusiveness. The disparities in researchers’ understandings on the conceptual constructs and the potential confusion driven by inconsistent definition use and terminology among researchers have led to recent concerns in higher education [19],[20].
We proceeded to review the sense of belonging literature in higher and engineering education not only for conceptualizing and situating of our own previous research [1], but also for diagnosing current understanding on the conceptual structure of sense of belonging within the engineering education research community. Correspondingly, this paper has three primary goals:

1. Examine the varied characteristics of sense of belonging as a theoretical concept (e.g., definitions, constructs/or defining components, and measures) in different contexts (e.g., K-12 education, undergraduate education, graduate education, and community) among different study populations (e.g., adolescents, undergraduate students, underrepresented students, and adults) by reviewing literature in higher education.
2. Synthesize unique features of belongingness constructs/defining components across the higher and engineering education literature depending on the demographic characteristics of the study’s sample (e.g., undergraduate, graduate, underrepresented (URM), international students).
3. Conceptualize and situate the constructs of international engineering doctoral students’ sense of belonging based on a literature review.

Methods
The approach to the literature review is broken up into two parts: 1) inconsistencies in definitions and constructs/defining components, and 2) constructs/defining components in different student groups. Part 1 provides a brief review of the sense of belonging literature in education. Literature that developed a measure of belonging while studying the concept as a theoretical construct and providing conceptual structures or constructs/defining components were selected to be included in this review. Reported constructs or defining components from the previous literature were then categorized into four different groups – academic, social, general, and institutional – to indicate the characteristics of each. Both theory-based and empirical research were reviewed. Part 2 reviews the constructs or defining components of belongingness in different groups of students (e.g., undergraduate students, domestic graduate students, other underrepresented students, and international students). In particular, constructs/defining components that were unique to different student groups were reviewed and synthesized. Findings from the literature review are used to conceptualize and situate constructs of international engineering doctoral students’ sense of belonging. The working definitions of the constructs and future research plan will be provided.

Limitations
Although this work provides a basic understanding of the belongingness constructs, the reviewed literature in the current work is limited to the selected seminal papers for the purpose of conceptualizing and situating our previous work [1]. To gain a clear and in-depth understanding of the conceptual structure of a sense of belonging, far more literature should be reviewed with a systematic process with specific search, inclusion, and exclusion criteria.
Literature Review

**Sense of belonging in higher education: Inconsistencies in definitions and constructs**

Sense of belonging is one of a number of ways to refer to the fundamental human need for social connection in psychology [5],[6]. The concept of belongingness has been extensively researched at the K-12 education level and its theoretical constructs and importance on students’ academic and psychological outcomes have been demonstrated by a vast amount of research [19],[20]. Figure 1 presents a summary of the literature review and includes the constructs or defining components of sense of belonging in different contexts – K-12, undergraduate, graduate, and community – among different groups – non-URM/URM students, international students, and adults. Hagerty et al. [21] (Fig. 1, left), which developed a widely used instrument in mental health (the Sense of belonging Instrument/ SOBI), is included in Fig. 1 as an example of a broader scale to measure a sense of belonging to the general community among adults. Our previous study [1] is also included in Fig. 1 to enhance the understanding of how we conceptualized and situated the international engineering doctoral students’ belongingness in line with the sense of belonging literature.

![Figure 1. A summary of the literature review on the belonging constructs/defining components](image)

In spite of the emergent inconsistencies in conceptual structures across the literature, some common features exist in the belonging constructs among students in education. First, academic
and/or institutional groups of constructs/defining components emerged in the sense of belonging literature across levels of education. Compared to Hagerty et al. [21], which weighed mostly on the individuals’ perception of person-environment fit and value through their interactions with an environment, academic and institutional facets have been shown in the sense of belonging literature among students (Fig. 1). Second, reference groups are varied depending on the level of education (e.g., classroom, institution, academic unit, etc.). These features imply the more dynamic and multifaceted characteristics of belonging in education where not only the individuals’ perception on the environment but also the diverse external referents in the educational environments play roles as determinants of belongingness. The following section will provide a literature review of the belongingness constructs/defining components at a different level of education.

Allen et al. [20] conducted a meta-analysis of the sense of belonging literature in K-12 education. Their analysis regarding the definition, constructs, factors related to, and outcomes of the students’ perceived belonging revealed three constructs across the literature, 1) student-teacher relationships, 2) school-based relationships and experiences (with peers), and 3) students’ general feeling about school as a whole (Fig. 1). The definition from Goodenow [22], “the extent to which students feel personally accepted, respected, included, and supported by others in the school social environment [22, p.80]” was reported as most consistently used [20].

Sense of belonging was introduced to higher education as a precursor of students’ social and academic integration by Spady [7] and Tinto [8], but the concept has been understudied as an independent, theoretical concept [16]-[20],[23],[24]. Consequently, definitions and theoretical constructs in the context of higher education have been unclear or lacking in the higher education sense of belonging literature. Some research has conceptualized sense of belonging in higher education, but most were informed by theories in psychology or sociology pertaining to the person-environment fit rather than empirical data from students’ experience [18],[19]. The conception of belonging in the majority of research in higher education is grounded by Spady and/or Tinto’s models of social and academic integration [7],[8]. These models explain the concept of belongingness as a component of social integration impacting student persistence and retention, while having mutual influences on academic integration. Sense of belonging in higher education is consequentially “often implied as the result of social and academic integration, rather than specified and measured as an independent construct [17, p.806]”. The majority of engineering education research on sense of belonging has been informed by the literature in higher education which explains the inconsistencies in definitions and constructs.

Hoffman [23] empirically studied sense of belonging as a theoretical concept by exploring first-year college students’ experiences regarding their belongingness. The study used a focus group and developed a measure of belongingness. Exploratory factor analysis (EFA) results suggested the addition of a construct regarding students’ general sense of belonging to the classroom and
institution, i.e., *perceived classroom comfort* and *perceived isolation*. The remaining constructs included *faculty support, empathetic faculty understanding, and peer support*, which are relevant to the peer and faculty interaction components in Tinto’s model [8]. The study is significantly meaningful in its investigation of the theoretical constructs of belongingness, but failed to provide validity evidence beyond EFA. However, the follow-up study [25] providing additional validity evidence using confirmatory factor analysis (CFA) revealed an entirely different factor structure, which brings into question the original study’s results on the belonging constructs.

Pittman & Richmond [26] conducted a theory-based study suggesting a construct relating to the individual student’s perceived academic competency, i.e., *scholastic competence*, among undergraduate students. They developed an instrument called the ‘Psychological Sense of School Membership Scale (PSSM)’, which adopted items for the student belonging construct from Goodenow’s [22] measure developed for middle school students. A belonging measure for underrepresented undergraduate students was also developed by Ingram [9] based on a theory-based conceptualization of inclusion. A construct regarding the students’ perceived institutional effort towards diversity and inclusion, i.e., *perceived institutional support*, was suggested to be included and remained after CFA.

Inconsistencies in conceptual structure exist across the studies of undergraduate students presented in Figure 1 [9],[18],[24],[25] despite all being informed by Tinto’s model [8]. The constructs were selectively chosen according to the needs of the authors resulting in none of the conceptual structures or measures encompassing all variables. Confusion in the interpretation of results using varied instruments creates a consistency problem when considering the prevalent use of these instruments with different constructs in the current belongingness literature. Similar claims have arisen in higher education [19],[27] bringing about questions on the appropriateness of these measures due to inconsistent results.

These claims accompanied arguments made about the underlying assumptions that led researchers to use or adopt scales developed in K-12 education, or develop ad-hoc scales without concern for the conceptual structure. Assumptions varied in whether emergent belongingness constructs in K-12 research were identical in undergraduate contexts. The previous research also provides insights on the belongingness constructs in the context of higher education, but note that “It is possible that the concept of sense of belonging is more complex than we assumed” [27, p. 543]. Slaten’s conceptual constructs also support the increasing complexities in the structure of belongingness relative to the advance in educational level (Fig. 1) and argues the needs for developing a conceptual model based on empirical data that takes account of the context-specific variables. This paper argues that researchers should acknowledge that sense of belonging can have different meanings when studied with different groups of students and that the meaning should be identified or considered as a theoretical concept in advance of measurement selection or analysis of the results.
Sense of belonging: Constructs/defining components in different student groups

The constructs or defining components varied within the engineering discipline based on educational level, student group, and students’ citizenship. Characteristics of each student group’s belongingness constructs will be synthesized and categorized into the identified facets of belonging - academic, social, general, and institutional (Fig. 1). The meaning of some terminologies used in different contexts will be clarified in each context.

1. Undergraduate student sense of belonging

The majority of research in student belonging in both higher education and engineering education has focused on undergraduate students in connection with diversity and inclusion efforts [28]-[29]. Most of the literature has identified the entire campus community or institutions as reference groups, but peer groups and classrooms have also been identified as reference groups depending on the literature. Such shift in reference groups from classrooms in K-12 to the entire institution in higher education explains the addition of constructs/defining components on the students’ connectedness to the institution to the social facet of belonging. The examples include Extracurricular activities [8] and valued group membership [19] in Figure 1, which describe the students’ engagement through a student organization or a residential environment. Regarding the academic facet of belonging, the emergence of intrapersonal components such as Academic achievement [8] and Scholastic competence [26] was shown in the literature (Fig. 1).

2. Graduate student sense of belonging

Sense of belonging research in graduate education is scarce but is currently growing [1]. Graduate students’ sense of belonging is regarded to be developed through their involvement in their academic units, such as a specific graduate program or department. Such changes in the students’ reference groups of belonging are likely associated with the primary goals of graduate education where professional development within the area of academic specialty has greater importance [30]. Accordingly, the defining components relevant to the institutional engagement activities in the social facet of belongingness among undergraduate students are replaced by the students’ academic and professional engagement in their field of academic specialty (e.g., academic conference, research meeting, etc.) [1].

Regarding the academic facet of sense of belonging, student belongingness research is closely related to graduate student socialization in graduate education [4],[13]. Socialization in graduate education refers to the process of becoming a member of the academic community through learning the knowledge, skills, and values of the academic unit [31]. It has been regarded to be important in graduate education literature due to its impact on student persistence and retention in the academic field after graduation [13],[32]. The recent attention toward students’ sense of belonging in graduate education has derived from the mutual influence between student
belongingness and socialization. According to Weidman’s graduate socialization model, the mechanisms of socialization were explained as the interplay among interactions with others (e.g., faculty and peers), sense of integration or belonging, and learning of knowledge. The model indicates the significance of belonging for student socialization. On the other hand, Stayhorn [33] interpreted the socialization process as the passage of individuals to belong to the academic community and argued the impact of socialization experienced on the individuals’ connectedness to academia.

3. Underrepresented minority (URM) students’ sense of belonging
The sense of belonging research in engineering education has shown inseparable relationships with URM students in engineering who are marginalized in gender, race, and ethnicity. Students from stigmatized groups have been known to have higher uncertainty about their belonging and potential than majority students [34]. An emphasis on understanding the URM students’ belongingness is a natural consequence of inclusion efforts to embrace the diversified student population in engineering.

One of the defining features of URM students regardless of educational level is the emergence of institutional facet of sense of belonging, such as Perceived institutional support and Environmental factors in Fig. 1 [1],[9],[24],[32],[35]. Distinctive features have been found in the literature in terms of the characteristics of the institutional support components between undergraduate and graduate students. Among undergraduate students, institutional support components focus on their perceptions toward the institutional level support or commitment (e.g., the campus racial climate, positive institutional climate for diversity, etc.) (e.g., Perceived institutional support [9] and Environment factors [19] in Fig. 1). On the contrary, among graduate students, Perceived institutional support [1] focuses more on the individual level support provided by institutions or people from the institution regarding the students’ academic and social issues (e.g., structured PhD program, institutional support, etc.) [1],[32]. Considering the overall paucity of research on the graduate students’ sense of belonging, such divergent perceptions of support suggest the need for further investigation of graduate student belongingness within the URM student population.

Regarding students’ interactions with peers and faculty that are integrated within the social and academic facets of sense of belonging, differences have appeared in the belonging literature among URM students. Figure 1 shows belongingness constructs pertaining to the interpersonal interactions or relationships, such as Peer interaction (informal & formal), Faculty interaction (informal & formal) [8], Peer support, Empathetic understanding, Faculty support [23], Social acceptance [26], Social sense of belonging, Academic sense of belonging [9]. Meaningful personal relationship [19], and Socio-cultural sense of belonging (Faculty & Peer), and Academic sense of belonging (Faculty and Peer) [1]. Although these components are also known as determinants of belonging regardless of a group presentation, students’ relationships with
faculty have been highlighted as salient features connected to student belonging and engineering identity, particularly among URM students [9],[36]-[38]. Relationships with peers from underrepresented backgrounds have also been reported to contribute to URM students’ ability to find a deeper sense of belonging through the community by creating opportunities to share their experiences and barriers [16],[39].

4. International students’ sense of belonging
Although the majority of research on URM students’ belongingness in engineering education has focused on women, racial and ethnic URM students who have been traditionally known as marginalized groups of students, recent attention has been paid to international students, particularly at the level of doctoral education [1],[13],[38]. Some aspects of URM students’ belongingness have also emerged for international students, such as the importance of faculty in student belonging, lending support to consider international students in engineering doctoral education as being marginalized based on citizenship, even though their number quantitatively outpaces their US counterparts. In addition to such commonalities, some distinct features also have emerged for the international student population.

One noticeable feature among international students is the emergence of cultural aspects across all the identified facets of belongingness (i.e., general, social, academic, and institutional in Fig 1.). Regarding the general facet of belonging, the differences in the students’ cultural background and/or language associated with the diversity in the students’ citizenships have emerged as influencers of students’ perceived acceptance, isolation, or discrimination (e.g., Authentic self and Problem behaviors constructs [1] in Fig. 1). Similarly, the institutional facet of belonging among international students include the support from the academic unit of the institution during the students’ academic, social, cultural, and life transitions (e.g., assistance with administrative work such as Visas, SSN, housing).

Regarding social and academic facets, international students have reported different patterns in peer and faculty interaction and the cultural differences have been frequently reported as the biggest reason. For example, lower interactions with both faculty and peers have been reported among international students compared to other groups (e.g., majority and the racial/ethnic URM students) in spite of the significant role faculty interactions play in the URM student perceived belongingness [40]-[44]. International students’ perceived frequency of social and personal interactions with faculty was significantly lower than others (e.g., majority and the racial/ethnic URM students) although all the groups reported the similar frequency of academic interactions [40]. Also, racial/ethnic URM status did not show a significant association with the frequency of interaction with peers and faculty [40]. This synthesis implies the greater impact of international student status and the associated differences in cultures and social norms on the peer and faculty interaction patterns compared to other marginalized statuses [27],[40],[45],[46].
A Conceptualization of International Engineering Doctoral Students’ Sense of Belonging

This section will provide a conceptualization of sense of belonging among international engineering doctoral students based on our previous work [1] and the literature review on the constructs/defining components of belonging in education. Our previous work [1] explored students’ lived experiences on belongingness in connection with their interpersonal interactions with people in their academic units. The results include a conceptual model of sense of belonging among international doctoral students with three constructs - Perceived institutional support construct, Academic sense of belonging, and Sociocultural sense of belonging. In this section, the initial conceptual model was informed by the findings of the literature review and revised. Table 1 presents the six constructs of the revised version of conceptual model among international engineering doctoral students’ belongingness, with their names and definitions. The constructs are also categorized into the four identified groups of constructs/defining components that resulted from the literature review - academic, social, general, and institutional (Fig. 1).

Table 1. The sense of belonging constructs among international engineering doctoral students.

<table>
<thead>
<tr>
<th>Name</th>
<th>Definition</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Authentic self</td>
<td>The extent to which students perceive that they are viewed and accepted as their authentic self regardless of their personal background (e.g., citizenship, culture, language, etc.)</td>
<td>General</td>
</tr>
<tr>
<td>Problem behavior</td>
<td>The extent to which students experience problem behaviors (e.g., discrimination, oppression, disadvantage, etc.) relating to and/or caused by their personal background</td>
<td></td>
</tr>
<tr>
<td>Engineering self-efficacy</td>
<td>Students’ belief about their capabilities to perform tasks (e.g., coursework, research) needed to successfully complete their doctoral degrees in the US as international students</td>
<td>Academic</td>
</tr>
<tr>
<td>Academic sense of belonging</td>
<td>The extent to which students feel that they are academically and professionally included in their academic units through their academic interactions (or socialization) with faculty and peers</td>
<td></td>
</tr>
<tr>
<td>Sociocultural sense of belonging</td>
<td>The extent to which students feel that they are socially included in and culturally accepted by the group of faculty and peers in their academic units through personal interactions (or socialization) with them</td>
<td>Social</td>
</tr>
<tr>
<td>Perceived institutional support</td>
<td>The extent to which students feel that they are supported from their academic units regarding their academic, social, and cultural issues, through staff interactions</td>
<td>Institutional</td>
</tr>
</tbody>
</table>

The initial conceptual structure in our previous work (Academic sense of belonging, Sociocultural sense of belonging, and Perceived institutional support) [1] were mostly informed by the empirical results but also guided by the prevailing notion of the belongingness that are mostly grounded on Tinto and Spady’s models [7],[8]. Although the findings of our previous work [1] included the analyzed themes relevant to the newly added constructs in this paper (Authentic-self, Problem behavior, and Engineering self-efficacy), they were included as a part of the former three constructs to make consistency with the previous literature. However, the broadened understanding on the conceptual structure of sense of belonging obtained from the literature review convinced the research team to reconsider the conceptualization. The lesson
learned from the literature review include the prevalently conceived constructs of belongingness in higher and engineering education may not be applicable to every context. Instead, there is a need for conceptualizing sense of belonging depending on the educational level and/or group of students, and there has been a recent claim to develop a conceptual model grounded on the empirical data with the students’ lived experience relevant to sense of belonging. The revised conceptual model will be presented in the following sections with the reasons behind the decisions.

First, *Authentic self* and *Problem behavior* were added as individual constructs after being separated from *Sociocultural sense of belonging*. They were previously regarded as themes included in *Sociocultural sense of belonging* [1] due to the relatively smaller amount of students’ experiences pertinent to each construct and the inconsistency with the belongingness constructs in the belonging literature among URM students. However, the greater impact of directly feeling accepted or rejected as ‘who I am’ on the students’ belongingness, compared to other indirect ways of feeling belonged, was considered as important. Reviewing a broader range of the sense of belonging literature and its findings, which include the constructs on the general facet of belonging (Fig. 1) also supported our decision.

Second, the former *Academic sense of belonging* construct in our previous work [1] was broken down into two constructs, *Engineering self-efficacy* and *Academic sense of belonging*. What supported this decision was the significant amount of students’ experiences relevant to the construct in our original data and the uniqueness of the construct among international students. The constructs on the students’ academic capacity have been shown in the literature among undergraduate students (*Academic achievement* and *Scholastic competence* in Fig. 1). However, *Engineering self-efficacy* was differentiated by encompassing the students’ feeling of confidence in studying in the US by speaking English that was attributed by the international student status.

Consequently, the rest of the constructs - *Academic sense of belonging*, *Sociocultural sense of belonging*, and *Perceived institutional support* - resulted in focusing on the students’ feeling of belonging in different aspects, particularly through interpersonal interactions with peers, faculty, and staff. The updated conceptual structure is comprised of intrapersonal constructs (*Authentic-self, Problem behavior, and Engineering self-efficacy*) that are influenced by interpersonal constructs (*Academic sense of belonging, Sociocultural sense of belonging, and Perceived institutional support*).

**Implications and Conclusion**

This work will be useful for practitioners, including faculty, administrators, and researchers in the engineering education community. The developed conceptualization will provide faculty members and administrators the information needed to develop appropriate, and thus, effective support that can enhance the international engineering doctoral students’ perceived
belongingness. The literature review on the conceptual structure of belongingness will advance the current knowledge about a sense of belonging in engineering education, and the findings of the review indicate the need for understanding sense of belonging as an independent and theoretical concept.

Reference


