Learning Communities Research and Practice

Volume 8 | Issue 1 Article 3

Development and Validation of a Survey to Assess Belonging, Academic Engagement, and Self-Efficacy in STEM RLCs

Justin B. Leibowitz
University of Louisville, jbleib01@louisville.edu

Charity Flener Lovitt
University of Washington Bothell, lovittc@uw.edu

Craig S. Seager
University of Central Arkansas, cseager@uca.edu

Recommended Citation
Leibowitz, J. B. , Lovitt, C. F. , Seager, C. S. (). Development and Validation of a Survey to Assess Belonging, Academic Engagement, and Self-Efficacy in STEM RLCs. *Learning Communities Research and Practice*, 8(1), Article 3.
Available at: https://washingtoncenter.evergreen.edu/lcrpjournal/vol8/iss1/3

Development and Validation of a Survey to Assess Belonging, Academic Engagement, and Self-Efficacy in STEM RLCs

Abstract

This study examines how to investigate traditionally underrepresented students' sense of belonging, self-efficacy, and academic engagement in science, technology, engineering, and mathematics (STEM) residential learning communities (RLCs). A 28-item survey was developed that included items from three previously validated instruments to measure three constructs: academic engagement; self-efficacy; and sense of belonging to the academic major, institution, and residential community. The survey was administered to first-year residential students pursuing a STEM major at three universities. This article discusses the development and administration of a survey to measure these constructs and the resulting validity scores. Samples included students living in STEM RLCs and STEM students not living in RLCs. An exploratory factor analysis examined validity, and Cronbach's alpha was computed for internal consistency. Belonging to the university, belonging to academic major, and belonging to residential learning community emerged as separate factors, indicating that students appear to conceptualize these different types of belonging during their college experiences. These constructs can be used to explore differences between student populations. Despite the small sample sizes, there were observations suggesting that differences in sense of belonging, academic engagement, and self-efficacy exist between traditionally represented and underrepresented students. However, further research is needed to explore these questions.

Cover Page Footnote

This project was supported by the 2017-2019 Research Seminar on Residential Learning Communities as a High-Impact Practice, a multi-institutional research initiative hosted by Elon University's Center for Engaged Learning (www.CenterForEngagedLearning.org).

In 2012, the President's Council of Advisors on Science and Technology issued the *Engage to Excel* report, which declared the need for one million more professionals in Science, Technology, Engineering, and Mathematics (STEM) fields in order for the US to maintain competitiveness in research and innovation (President's Council of Advisors on Science and Technology, 2012). Over 40% of STEM students exit STEM majors in the first and second years of study, a trend that is amplified for under-represented populations, particularly for people of color and women (Espinosa, 2011; Johnson, 2012). The National Science Foundation (NSF) considers female, African American, Latino/a, Native American, and low SES populations an untapped resource for diversifying the existing field of U.S. STEM professionals (NSF, 2013). One of the ways to increase STEM professionals is to improve retention during these first two years especially for these underrepresented students.

Students are more likely to continue studying science if they feel like they are part of a scientific community (Maltese & Tai, 2011). The amount a student views that "he or she feels included in the college community" is defined as the psychological sense of belonging (Hurtado & Carter, 1997, p. 327). A psychological sense of belonging (SB) is positively correlated with a sense of community and positively correlated with academic engagement (AE) and self-efficacy (SE) in STEM (Wilson, 2015). Students who experience high academic engagement and self-efficacy are more likely to persist in higher education (Soria & Stebleton, 2012). Therefore, there is a need to identify practices that foster this sense of community for STEM students.

Residential learning communities (RLCs) have been proposed as one such practice. RLCs involve collaborations between housing offices and their student and academic affairs divisions. RLCs often include a series of linked courses or social activities that engage students across classes, subjects, and interests. (Gabelnick et al., 1990; Inkelas, 2011). Students may live together in academically themed housing and take similar courses together (Inkelas et al., 2018). RLC programs may include programming and staffing which allows students the opportunity to make more connections between academic and social contexts (Hurtado & Carter, 1997). RLCs can be STEM-themed (STEM RLCs), where students in the residential community plan to major in STEM fields of engineering, natural science, mathematics, or biological sciences. STEM RLCs may include STEM specific programming, where students will take STEM courses and live together in student housing.

RLCs are associated with greater academic success and student engagement (Mayhew et al., 2016). Pascarella et al. (1994) found that students participating in RLCs persisted longer, performed better academically, and engaged in more intellectually stimulating environments than students in traditional residence experiences. RLCs made interactions with faculty members much more comfortable and stimulating for students as well as provided plenty of opportunities for social acclimation and development (Seager, 2015). This impact can be important for students pursuing STEM majors. For example, STEM RLC students report more conversations with peers, positive faculty interactions with mentoring, and socially supportive residence halls, which lead to STEM persistence (Soldner, 2012). Given these positive outcomes, programs like STEM RLCs could support academic and professional success in STEM among underrepresented populations and improve the low inclusion of these populations in the field. Given the positive outcomes associated with STEM RLCs, it is important to determine how they affect participants, and measure if that translates to academic success.

Few studies focus exclusively on STEM RLCs, but available data suggest positive effects for retention and persistence, especially for under-represented groups. Women in STEM RLCs reported smoother social transitions to college than STEM women not in RLCs (Inkelas, 2011). Preliminary research suggests that women who participate in STEM RLCs are more likely to pursue PhDs (Inkelas, 2011). The structure of the RLC matters; women in coed STEM RLCs reported a smoother academic transition (Inkelas, 2011) than women in gender-specific RLCs. RLCs can also support academic transitions for first-generation students (Inkelas, 2007), suggesting that STEM RLCs can increase persistence for first-generation students.

Students in RLCs experience higher sense of belonging and self-efficacy than non-RLC students. STEM communities dedicated to underrepresented groups, like black men in engineering or engineering RLCs at women-only schools (Kendricks & Arment, 2011) reported positive outcomes for students in the particular group. However, the typical gender and racial diversity of STEM RLCs may mean that women and underrepresented students do not experience belonging the same way, as described in prior studies (Dasgupta et al., 2015; Johnson, 2012;). For example, Dasgupta et al. (2015) reported that the proportion of women in a group affected first-year female students' anxiety, and female students in female-majority groups were more likely to participate verbally. This research indicates that even RLCs may not be a panacea for some of the challenges underrepresented students experience in the STEM environment. Given the contradictory data, it is important to understand the effect the RLCs have on student belonging, self-efficacy, and academic engagement, especially with students from under-represented groups.

The purpose of this article is to detail the development, administration, and validation of a survey to examine students' sense of belonging, academic engagement, and self-efficacy in STEM RLCs. Practitioners can use such a tool to track program effectiveness and as a tool for examining student outcomes. This article discusses the theoretical constructs used to develop and validate this survey. The study, which was carried out at three public universities with STEM RLCs, obtained preliminary results which can be used to suggest pathways for future research for intentional modifications, interventions, and policies that maximize program effectiveness.

Theoretical Background, Definitions, and Constructs

The theoretical foundation of this survey is similar to the model of Wilson et al. (2015), which highlights the relationships among STEM students' self-efficacy, belonging, and academic engagement. The logic model for this research is displayed in Figure 1. The theoretical background for each construct is described along with the survey tool used to assess it.

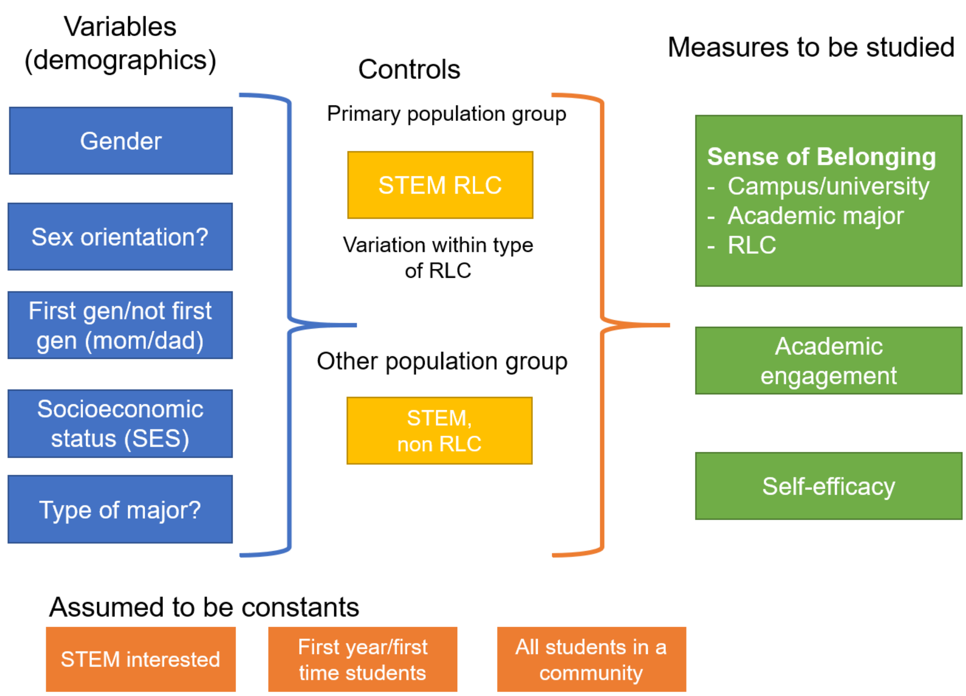

Figure 1. Conceptual model for the study

Sense of belonging represents a student's perception that they belong in a community, such as a campus, residence hall, or major (Hurtado & Carter, 1997). Examining sense of belonging captures students' perception of their inclusion in the community, rather than a metric that potentially implies a student's deficiency (Hurtado & Carter, 1997). Wilson et al. (2015) separated students' sense of belonging into three components: in their university, in their classes, and in their major. This study modified Wilson et al.'s (2015) framework, replacing sense of belonging in class with sense of belonging in residential community to account for the RLC experience. The sense of belonging component was split into three subcategories to reflect three places of integration: belonging on campus (SB-U), in the major (SB-AM), and in the residential community (SB-RC).

Rendón (1994) related sense of belonging to academic engagement; if students do not feel connected to the campus community, they are unlikely to develop into engaged leaders. Pascarella and Terenzini (2005) described student engagement as the energy and time students dedicate to academic success. Over time, the definition of engagement shifted, becoming more inclusive of non-academic work. Kuh (2009) described it as "the time and effort students devote to activities that are empirically linked to desired outcomes of college and what institutions do to induce students to participate in these activities" (p. 683). Astin (1984) discussed student development around their involvement, and examined policies and interventions based on their ability to increase such involvement. Kuh (2009) related engagement to equality of effort and time on task, including the institution's effort to yield those behaviors. In this study, academic engagement focuses on the concept used by Kuh (2009), time spent on activities linked to desired academic outcomes. Yorke (2016) drew upon belongingness and academic engagement literature to develop an instrument, parts of which were used in the current study.

Self-efficacy, one's belief in their ability to accomplish a task, is an important factor in students' higher education outcomes (Bandura, 1977). Lent and Larkin (1984) provided evidence that engineering and science students with greater self-efficacy performed better. Bandura explained this by saying that people are more likely to invest in themselves to overcome obstacles and challenges when they believe that they can succeed (Bandura et al., 2001). MacPhee et al. (2013) assert that academic self-efficacy and performance of underrepresented groups in STEM are important to examine; self-perceived competence is a crucial factor in an individual's development and career choice. Self-efficacy is linked to belonging; even if they had high self-efficacy, many students, particularly historically underrepresented students, had lower academic engagement and outcomes without validation on campus (Rendón, 1994).

The authors constructed a survey from these three components; belonging, academic engagement, and self-efficacy. This article focuses on the validation and initial results of the survey, which examines three questions. First, do the scores factor according to the structure that was initially designed? These questions were examined using principal component analysis (PCA) with orthogonal rotation. Second, to what extent are the scores valid and reliable? This was examined with Cronbach's alpha (Cronbach, 1951), content validity, and construct validity. Finally, what effects do race, sex, first-generation status, and living in an RLC have on a linear combination of the scale's factors? This was examined using a multivariate analysis of variance (MANOVA).

Methods

Survey Development

The scale utilizes items from three studies to measure sense of belonging (Johnson et al., 2007), academic engagement (Yorke, 2016), and self-efficacy (Chen et al., 2001). Each item used a five-point Likert scale, and responses ranged from strongly disagree to strongly agree. For sense of belonging, five items were adopted from Johnson et al. (2007). The same group of questions was utilized for sense of belonging in the institution, in the academic major, and in the residential community. The academic engagement component used five items from Yorke's (2016) belongingness survey. The self-efficacy component utilized eight items from Chen et al.'s (2001) work.

In total, there were 28 items on the survey, yielding five scales: campus sense of belonging, academic major sense of belonging, residential community sense of belonging, self-efficacy, and academic engagement. Construct validity (Messick, 1995) was examined by drawing items from scales that had previously been used in studies with successful score validation. The comprehensive list of questions can be found in the Table 1. Participants also had the opportunity to respond to demographic questions, although they were optional.

Table 1

List of survey items

Item Number	Item Content
SB-U1	I feel a sense of belonging to my university.
SB-U2:	I feel that I am a member of my university's community.
SB-U3	I feel comfortable on my campus.
SB-U4	If given the choice, I would choose the same university over again.
SB-U5	My institution is supportive of me.
SB-AM1	I feel comfortable in my academic major's community.
SB-AM2	If given the opportunity, I would choose my academic major again.
SB-AM3	My academic major's community is supportive of me.
SB-AM4	I feel that I am a member of my academic major's community.
SB-AM-5	I feel a sense of belonging to my academic major's community.
AE1	I am motivated towards my studies.
AE2	I expect to do well in my classes.
AE3	I try to make connections between what I learn from different parts of my classes.
AE4	I put a lot of effort into the work I do.

AE5	I use feedback on my work to help me improve what I do.
SE1	I will be able to achieve most of the goals that I have set for myself.
SE2	When facing difficult tasks, I am certain that I will accomplish them.
SE3	In general, I think that I can obtain outcomes that are important to me.
SE4	I believe I can succeed at any endeavor to which I set my mind.
SE5	I will be able to successfully overcome many challenges.
SE6:	I am confident that I can perform effectively on many different tasks.
SE7	Compared to other people, I can do most tasks very well.
SE8	Even when things are tough, I can perform quite well.
SB-RC1*	I feel a sense of belonging to my STEM residential community.
SB-RC2*	I feel that I am a member of my STEM residential community.
SB-RC3*	I feel comfortable in my STEM residential community.
SB-RC4*	I would choose to live in my STEM residential community again.
SB-RC5*	My STEM residential community is supportive of me.

* Students not living in STEM RLCs have "STEM residential community" replaced with "residential community."

Participants

The research studied first-year students majoring in or intending to major in a STEM field. "Intending to major" includes students who were accepted to the university but were not accepted to the STEM major of their choice, either due to prerequisites or pre-entry requirements. Participants were selected from three public universities in the United States with STEM RLCs. Each STEM RLC included linked courses, offered supplemental faculty engagement via programming and/or a faculty in residence, and required the student to complete an application or interest form. The STEM RLCs groups are described in Table 2. A comparison group was also selected, STEM or STEM-interested students who lived on campus and not in a STEM RLC. Participation in the survey was voluntary, and student assent was obtained. Participants received an incentive to participate in the survey by being placed in a drawing for a $50 gift card.

Table 2

Description of RLCs in study

Institution	Institution 1	Institution 2	Institution 3
Institution type	Medium, Public, Comprehensive	Medium, Public, Research	Large, Public, Research
Size of STEM RLC	32	220	240
Faculty involvement	Faculty teaching & mentoring	Faculty in Residence	Faculty Programming
Peer involvement	Resident Assistants, Peer Instructors	Resident Assistants, Peer Coaches, Peer Mentors	Resident Assistants
Linked Courses	Interdisciplinary core course exclusive to STEM RLC	Cohort in larger class and exclusive STEM course for RLC students	Cohort in larger STEM class
Application Process	Application Essay	Application	Interest Form, Admittance to Major

Procedures

The research team received IRB approval to administer the survey. This survey was administered during the second half of the academic year, allowing the data to reflect students' first few months of college. After receiving the survey at their university email account, students were permitted three weeks to respond and received weekly reminders. Students answered the 28 survey questions and optional demographic questions, including sex, race, first-generation status, and family income.

During the 2017-2018 and 2018-2019 academic years, the survey was distributed to 1,564 students. Students had three weeks to respond to the survey online; 364 responses were returned, out of which 304 were completed entirely, a response rate of 19.4%. This response rate fits the standards used for factor analysis utilizing a subject-to-item ratio of 10:1 (Costello & Osborne, 2005). After the survey closed, the researchers aggregated the three institutions' datasets. For categorical variables with small numbers of responses, the responses were aggregated into larger groupings. For example, Korean and Vietnamese were regrouped into Asian/Pacific Islander. For some comparisons, due to a small number of non-White students, race was recoded into a binary variable for White and non-White. Raw scores were computed for each factor, such as self-efficacy and academic engagement. To assess evidence for supporting the use of the items developed, the following validation procedures were administered: survey item quality, dimensionality, and reliability.

Results

Survey Validation

Dimensionality

The complete dataset had 304 total responses. Exploratory Factor Analysis (EFA) was conducted using Principal Components Analysis (PCA). Communalities can be found in appendix B. The Kaiser-Meyer-Olkin (KMO) statistic used to assess sampling adequacy was 0.893, indicating that sampling adequacy was excellent (Kaiser, 1970). Eigenvalues and explained variance statistics can be found in appendix C. The primary goal of EFA is to retain the minimum number of factors that explain the most variance of the observed variables. Many protocols can be used to assess the number of factors to retain, the most common method being the eigenvalue greater than 1 rule (Henson & Roberts, 2006). EFA extracted five components that accounted for 60.85% of the explained variance, with each of the five component's eigenvalues being greater than 1. The scree plot (Figure 2), another factor retention solution (Cattell, 1966), also supported a five-factor solution.

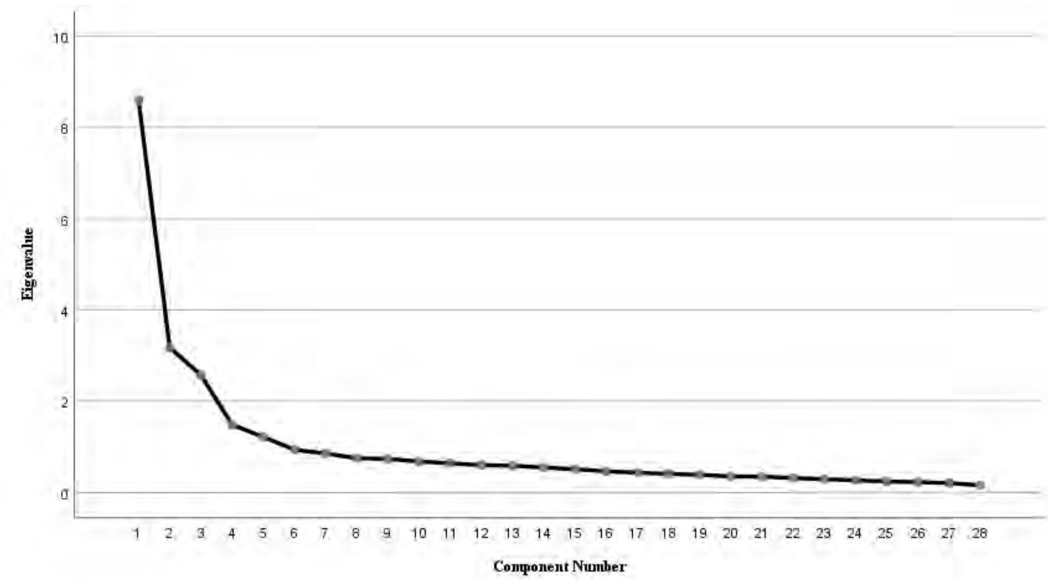

Figure 2. Scree plot generated from factor analysis of survey items

Henson and Roberts (2006) noted that parallel analysis was the most accurate method for factor retention decisions, although typically underutilized. Parallel analysis was utilized as another method for factor retention; its recommendations were compared to those from scree plots and eigenvalues. While scree plots and the traditional eigenvalue rule recommended a five-factor solution, parallel analysis recommended a four-factor solution. The fifth factor, recommended by scree plot and initial eigenvalues, was for academic engagement; it was not recommended to be retained by parallel analysis. The decision to retain academic engagement as part of a five-factor solution requires additional examination in future research. Because academic engagement's factor loadings exceeded the cut-off criterion of 0.4 and the construct theoretically made sense, it was retained.

To determine if the factors were related, a correlation was run on the component scores. No relationship between components was found, which indicated that orthogonal rotation should be used. Factor analysis was rerun with orthogonal rotation, using Varimax, with five factors retained, as indicated from the first run. The rotated factor solution confirmed the constructs sense of belonging to university, sense of belonging to academic major, sense of belonging to residential community, academic engagement, and self-efficacy. The factor loadings (only loadings greater than 0.4 were retained) are reported in Table 3. There was one academic engagement item that loaded weakly to the self-efficacy construct (.444) as well as to the academic engagement construct (.574). The item in question was "I expect to do well in my classes," a phrasing extremely similar to the items in the self-efficacy construct. However, because the item loaded more strongly on academic engagement it was included with the academic engagement construct and not the self-efficacy construct. All other items loaded as expected to their respective constructs.

Table 3

Factor Loadings from Principal Components Analysis with Orthogonal Rotation

Item	Comp 1 (SE)	Comp 2 (SB-AM)	Comp 3 (SB-U)	Comp 4 (SB-RC)	Comp 5 (AE)
SE2	0.783				
SE6	0.764				
SE5	0.749				
SE4	0.734				
SE3	0.731				
SE8	0.726				
SE7	0.704				
SE1	0.633				
SB-AM5		0.828			

SB-AM4		0.815			
SB-AM3		0.797			
SB-AM1		0.774			
SB-AM2		0.520			
SB-U			0.798		
SB-U2			0.774		
SB-U4			0.750		
SB-U3			0.683		
SB-U5			0.577		
SB-RC1				0.820	
SB-RC2				0.784	
SB-RC3				0.707	
SB-RC5				0.698	
SB-RC4				0.664	
AE4					0.764
AE1					0.752
AE2	0.444				0.574
AE5					0.551
AE3					0.484

Comp stands for component. Components correspond to original construct in Figure 1. Loadings greater than 0.40 are listed by component from highest to lowest. Survey items provided in Table 1.

Reliability

The three-step construct validation process outlined by O'Leary-Kelly and Vokurka (1998) was utilized. The first step involves identifying a group of theoretically-based items that are believed to assess the construct, which was addressed in the survey development section. The second step requires that three components be established: unidimensionality, reliability, and validity. Unidimensionality is a matter of establishing that a set of items relates to only one construct. This required using the factor loadings reported in Table 2 to demonstrate that items loaded on one factor and that each factor was interpretable. To determine the reliability of each construct, Cronbach's alpha was calculated for SB-I (α = .837), SB-AM (α = .872), SB-RC (α = .794), SE (α = .902), and AE (α = .781). Typically, an alpha value of .7 is the minimum accepted value (Streiner, 2003). The third step in O'Leary-Kelly and Vokurka's (1998) construct validation process deals with examining nomological validity, another form of construct validity, which determines the degree a construct relates to other constructs in a manner that can be predicted. This step was not utilized in this study because this was the first use of the scale, and the primary focus was on factor structure and item review. Examining nomological validity is recommended for future validation studies.

Preliminary Results of Survey

Descriptive statistics

Survey responses were examined for completeness, descriptive statistics, frequency statistics, and outliers. Table 4 contains descriptive statistics of the raw continuous variables for each of the five factors for all 304 respondents. All items had responses in each category. Examining the factors, one finds that many participants scored themselves highly on all assessments, with the average values for all measures but SB-RC above 4.0. This apparent ceiling effect is a cause for concern when considering future uses of the survey. However, each factor had some students scoring on the lower end of the scale, and these differences are important for additional examination. If, for example, underrepresented students are the individuals reporting low scores, this should be of high concern to the staff involved with the RLCs' administration. Variables were evaluated for skewness and kurtosis concerns; they were within acceptable ranges (West et al., 1995).

Table 4

Descriptive Statistics for Five Measured Factors for All 304 Respondents

Variable	Measures			
	Minimum	Maximum	*M*	*SD*
SB: University (SB-U)	1.20	5.00	4.12	0.75
SB: Academic Major (SB-AM)	1.20	5.00	4.03	0.83
SB: Residential Community (SB-RC)	1.00	5.00	3.25	1.01
Academic Engagement (AE)	1.00	5.00	4.38	0.60
Self-Efficacy (SE)	1.00	5.00	4.29	0.61

Scores are reported as an average for each factor. Average scores for each item are reported in Appendix A. SB is sense of belonging, *M* = Mean, *SD* = Standard deviation. *n* = 304

Survey responses appear robust between institutions, with average item scores reflecting differences between institutions. Average values for each institution are reported in Table 5. Respondents at institution 1 report statistically lower SB-AM, which is expected because the institution does not admit students into a major until their second or third year. At the other institutions, students must be enrolled in the major before they can be admitted to the RLC.

Table 5

Distribution and Averages of Categorical Variables for Each Institution in The Study

	Institution 1		Institution 2		Institution 3	
STEM RLC	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
n	24	14	65	64	105	32
SB-U	4.00	3.73	4.16	4.17	4.15	4.12
SB-AM	*3.49	3.63	4.15	4.05	4.14	3.93
SB-RC	3.28	3.26	3.10	3.23	3.38	3.14
AE	4.44	4.20	4.36	4.56	4.32	4.26
SE	4.19	4.07	4.20	4.37	4.36	4.20

Generally, scores are similar between institutions. The exception (*) is SB-AM at Institution 1. Institution 1 does not admit students to the major until their third year, so the lower SB-AM is expected.

Data were examined for differences in factor scores, including differences across demographic items. Table 6 shows the mean scores for each group. Demographic item responses were condensed to allow meaningful comparison between groups. Results are similar between subgroups, although some observed differences warrant further investigation. For example, STEM RLC students report slightly higher average values in all categories except academic engagement. Students from households with annual income less than $50,000 report lower levels of belonging than students from wealthier households but similar levels of academic engagement and self-efficacy. Of note, the sample had a larger proportion of first-generation students than previous studies. In the current study 37% of participants self-identified as first-generation students compared to earlier studies reported 17% (Inkelas, 2007).

Table 6

Averages of Measured Factors for Various Demographic Groups

Demographic		***n***	**SB-U**	**SB-AM**	**SB-RC**	**AE**	**SE**
STEM RLC Status	STEM RLC	194	4.14	4.06	3.28	4.35	4.29
	Non-RLC	110	4.10	3.96	3.21	4.43	4.29
Gender	Male	143	4.07	4.02	3.38	4.27	4.34
	Female	153	4.21	4.05	3.16	4.50	4.26
	Other / Prefer not to answer	8*	--	--	--	--	--

Annual Household Income	$0 to $49,999	69	4.10	4.01	3.17	4.46	4.31
	$50,000 to $99,999	63	4.17	4.08	3.28	4.27	4.24
	$100,000 or more	78	4.21	4.1	3.14	4.46	4.36
	Do not know	60	4.17	4.01	3.40	4.39	4.26
	Prefer not to answer	32	3.77	3.82	3.43	4.18	4.20
First-Generation Student	First-generation	114	4.10	4.05	3.29	4.38	4.31
	Not first-generation	181	4.15	4.01	3.24	4.40	4.29
	I do not know	7*	--	--	--	--	--
Race	Caucasian	218	4.19	4.10	3.29	4.39	4.31
	African-American	29	3.81	3.55	2.99	4.32	4.18
	Asian or Pacific Islander	27	3.87	3.93	3.37	4.32	4.12
	Two or more races	13	4.22	4.11	2.86	4.54	4.45
	Other/no answer	15	4.07	3.91	3.34	4.30	4.29

Demographic responses were not required to be utilized in scale development.
*Average values not reported when group size less than 10.

Data analysis

A multivariate analysis of variance (MANOVA) was computed to examine the effects of race, sex, first-generation status, and RLC status on the linear combination of sense of belonging to university, sense of belonging to academic major, sense of belonging to residential community, self-efficacy, and academic engagement. The MANOVA also allowed for examining interactions between independent variables, as well as their effects on individual dependent variables, rather than the linear combination of all subscales. A few results were statistically significant. First, sex was significantly associated with the linear combination of the five factors (Pillai's Trace = .012, $F[5, 255] = 3.160$, $p = .009$) with a partial eta squared of .058, indicating that gender explained 5.8% of the variance in the linear combination of factors. Second, the interaction between race and first-generation student status was significant (Pillai's Trace = .053, $F[5, 255] = 2.828$, $p = .017$)

with a partial eta squared of .053, explaining 5.3% of the linear combination of factors' variance.

Additional between-subjects tests revealed additional significant relationships that could warrant future examination. For example, STEM RLC was a significant independent variable for academic engagement ($F[1, 259] = 4.826$, $p = .029$). The interaction between race and STEM RLC status was also significant for academic engagement ($F[1, 259] = 4.375$, $p = .037$). Finally, the interaction between race and first-generation student status was significant for sense of belonging to residential community ($F[1, 259] = 4.183$, $p = .034$). Future research could examine each of these results further to identify actionable takeaways, given the interest in the success of underrepresented populations, such as students of color and first-generation students.

Discussion

The study's primary focus was the creation and administration of the survey, along with validating the resulting scores. Factor analysis was an important component of this process. All five expected factors emerged in the factor analysis, although academic engagement's retention decision was conflicted due to differing recommendations based on eigenvalue, scree plot, and parallel analysis.

Of most interest was the consistency with which the three types of sense of belonging factored. Belonging to the university, belonging to academic major, and belonging to residential learning community emerged as separate factors, indicating that students appear to identify and understand different types of belonging during their college experience. They allocate experiences to one or more types of belonging rather than one aggregate belonging concept. While there is literature that discusses the multiple types of belonging, such as Wilson et al. (2015), the students' ability to identify three separate concepts of belonging requires further examination for use and implications. For practitioners, these separate belongingness scales may require strategic efforts to understand how each affects students' retention, followed by corresponding programming efforts. Conversely, one might wonder if this was the outcome of asking students about three different types of belonging. If a fourth, fifth, and/or sixth type were introduced, could it be that these new types of belonging would also factor equally well? If so, then practitioners and researchers need to examine which types of belonging, if not all, require monitoring to maximize student success.

As illustrated in the survey validation section, there is a need for scale revision on the academic engagement construct. Yorke's (2016) academic engagement items do not completely capture the theoretical components of engagement as outlined by Kuh's (2009) definition, which also signals some room for additional items to be added to the scale. In the principal component analysis, AE2 loads with both self-efficacy and academic engagement. Upon further inspection, the wording of AE2, “I expect to do well in my classes,” is similar to wording of self-efficacy questions like SE6, “I am confident that I can perform effectively on many different tasks.” To further measure academic engagement, it may help to include statements that gauge students’ ability to connect academics to their lives. Perhaps including phrasing like, “When I’m in classes in my major, I participate in class discussions with my classmates and instructors’’ as used by Wilson et al. (2015) would provide stronger connections to student academic engagement while also providing insight into how students in the RLC connect academic to social activities. However, the results of this current measure may still be a helpful measure for some form of engagement, particularly if it yields a predictive relationship with students’ GPA.

The MANOVA results yielded many results that were not statistically significant. Those that were significant tended to indicate that students from overrepresented and/or privileged populations, such as White and male students, benefited from STEM RLC membership. Perhaps underrepresented students having lower scores on belongingness measures reflects the challenges they face in STEM environments, which may be magnified when living in a STEM RLC that is predominantly White and male. The current study’s sample was heavily White, though there was a nearly even split of men and women.

Strengths and Limitations

This study shows that a survey of belonging, self-efficacy, and academic engagement can be used to examine the difference between first-year STEM students living in STEM RLCs and other STEM students living on campus. The study adopted and modified a theoretical framework used by other researchers (Wilson et al., 2015) which allowed students to evaluate their perceived sense of belonging on multiple levels: university, academic major, and residential community. This construct acknowledges that a student’s education experience is not necessarily seen homogeneously. For example, students sometimes will think negatively of a university while thinking very positively about an office or staff member, even though the latter are part of the same university.

A limitation of this study is the relatively small number of responses. Part of the small sample size came from the focus on the STEM first-year residential population. The sample size could be increased by expanding the study population to include more schools and types of RLC programs. In addition, although listed as a strength, the specific population being studied poses some limitations as well. First, it limits the generalizability of conclusions. First-year STEM students are not necessarily comparable to all other student groups. Second, the students’ self-reported scales clustered around the top of the scale, creating ceiling effect challenges. This issue could potentially be reduced by expanding from a five-point to a seven-point scale. However, it is unclear what other consequences might emerge from transforming the scale. Finally, while the sample was relatively diverse it still lacked enough responses to evaluate trends for specific groups beyond large consolidated groups.

Although they were not statistically significant, there were trends identified that could be interesting or warrant further research. These are detailed in the next section. These observations are, at minimum, academically interesting and something that practitioners would likely want to know more about. If increased data continue not to be significant, then practitioners will need to examine RLC programs closely and determine how to make them more effective and/or improve the assessment methods. If there is no clear option for improvement, then resources might be best contributed to other practices with greater impacts.

Future Research

As noted previously, future research should include an expanded dataset that would allow a researcher or practitioner to evaluate the effect of related campus programs on these factors. The MANOVA results encourage further intentional examination of differences between groups. Interviews with selected survey participants are ongoing to investigate this effect. Interviews would invite an opportunity to understand how students understood the scale's questions, as well as gather qualitative feedback about their RLC experiences.

Future administrations of the survey could further validation efforts as well. For example, discriminant and convergent validity were not evaluated in this study. Utilizing other established metrics in conjunction with this one would allow for such evaluation. This would also allow for an opportunity to revise and improve the academic engagement items, which would yield factor loadings. A new administration of the survey would also provide for an opportunity to use confirmatory factor analysis to examine the factor structure.

An area of interest and further examination in this research study is to consider how a student's involvement may affect one component of belonging but not others. For example, which experiences affect STEM students' sense of belonging to major, university, and RLC? How and why do the effects differ for each belongingness component? More importantly, further research is needed to examine how those differences influence a student's academic outcomes; specifically, does a sense of belonging, academic engagement, and self-efficacy correlate with student grades and persistence? If they do correlate, as hypothesized, which factors matter the most and the least? Given the interest and investment in STEM, there are many opportunities to examine such questions to determine the most effective practices to foster student success and responsible resource allocation. These analyses remain available for examination outside of STEM RLCs.

References

Astin, A. W. (1984). Student involvement: A developmental theory for higher education. *Journal of College Student Personnel, 25*(4), 297-308.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self-efficacy beliefs as shapers of children's aspirations and career trajectories. *Child Development, 72*(1), 187–206. doi/10.1111/1467–8624.00273

Cattell, R. B. (1966). The scree plot test for the number of factors. *Multivariate Behavioral Research, 1*(2), 140-161.

Chen, G., Gully, S. M., & Eden, D. (2001). Validation of a new general self-efficacy scale. *Organizational Research Methods, 4*(1), 62-83.

Costello, A. B., & Osborne, J. W. (2005). Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research, & Evaluation, 10*(7), 1-9.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334.

Dasgupta, N., Scircle, M. M., & Hunsinger, M. (2015). Female peers in small work groups enhance women's motivation, verbal participation, and career aspirations in engineering. *Proceedings of National Academy of Sciences*, *112*(16), 4988-4993.

Espinosa, L. (2011). Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence. *Harvard Educational Review, 81*(2), 209-241.

Gabelnick, F., MacGregor, J., Matthews, R. S., & Smith, B. L. (1990). *Learning communities: Creating connections among students, faculty, and disciplines*. Jossey-Bass.

Hausmann, L. R., Ye, F., Schofield, J. W., & Woods, R. L. (2009). Sense of belonging and persistence in White and African American first-year students. *Research in Higher Education, 50*(7), 649-669.

Henson, R. K., & Roberts, J. K. (2006). Use of exploratory factor analysis in published research: Common errors and some comment on improved practice. *Educational and Psychological Measurement, 66*(3), 393-416.

Hurtado, S., & Carter, D. F. (1997). Effects of college transition and perceptions of the campus racial climate on Latino college students' sense of belonging. *Sociology of Education.*324-345.

Inkelas, K. K. (2011). Living-learning programs for women in STEM. In J. Gaston-Gayles (Ed.), *Attracting and retaining women in STEM: New directions for institutional research* (pp. 27-37). Association for Institutional Research.

Inkelas, K. K., Daver, Z. E., Vogt, K. E.; & Leonard, J. B. (2007) Living-learning programs and first-generation college students' academic and social transition to college. *Research in Higher Education*, *48*(4), 403-434.

Inkelas, K. K., Jessup-Anger, J., Benjamin, M., & Wawrzynski, M. R. (2018). *Living-learning communities that work: A research-based model for design, delivery, and assessment.* Stylus.

Johnson, D. R., Soldner, M., Leonard, J. B., Alvarez, P., Inkelas, K. K., Rowan-Kenyon, H. T., & Longerbeam, S. D. (2007). Examining sense of belonging among first-year undergraduates from different racial/ethnic groups. *Journal of College Student Development, 48*(5), 525-542.

Johnson, D. R. (2012). Campus racial climate perceptions and overall sense of belonging among racially diverse women in STEM majors. *Journal of College Student Development, 53*(2), 336-346.

Kaiser, H. F. (1970). A second generation little jiffy. *Psychometrika, 35*(4), 401-415.

Kendricks, K., & Arment, A. (2011). Adopting a K-12 family model with undergraduate research to enhance STEM persistence and achievement in underrepresented minority students. *Journal of College Science Teaching*, *41*(2), 22-27.

Kuh, G. D. (2001). Assessing what really matters to student learning inside the national survey of student engagement. *Change: The Magazine of Higher Learning, 33*(3), 10-17.

Kuh, G. D. (2009). What student affairs professionals need to know about student engagement. *Journal of College Student Development, 50*(6), 683-706.

Kuh, G. D., Schuh, J. H., Whitt, E. J., & Associates (1991). *Involving colleges: Successful approaches to fostering student learning and personal development outside the classroom*. Jossey-Bass.

Lent, R. W., Brown, S. D., & Larkin, K. C. (1984). Relation of self-efficacy expectations to academic achievement and persistence. *Journal of Counseling Psychology, 31*(3), 356-362.

MacPhee, D., Farro, S., & Canetto, S. S. (2013). Academic self-efficacy and performance of underrepresented STEM majors: Gender, ethnic, and social class patterns. *Analyses of Social Issues and Public Policy, 13*(1), 347-369.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among US students. *Science Education*, *95*(5), 877-907.

Mayhew, M. J., Pascarella, E. T., Bowman, N. A., Rockenbach, A. N., Terenzini, P. T., Seifert, T. A., & Wolniak, G. C. (2016). *How college affects students: 21st century evidence that higher education works* (Vol. 3). Jossey Bass.

McKenzie, K., & Schweitzer, R. (2001). Who succeeds at university? Factors predicting academic performance in first year Australian university students. *Higher Education Research & Development, 20*(1), 21-33.

Messick, S. (1995). Validity of psychological assessment: Validation of inferences from persons' responses and performances as scientific inquiry into score meaning. *American Psychologist, 50*(9), 741-749.

National Science Foundation, National Center for Science and Engineering Statistics. (2013). *Women, minorities, and persons with disabilities in science and engineering: 2013. Special report NSF 13–304*. Author. www.nsf.gov/statistics/wmpd/2013/pdf/nsf13304_digest.pdf

O'Leary-Kelly, S. W., & J. Vokurka, R. (1998). The empirical assessment of construct validity. *Journal of Operations Management, 16*(4), 387-405.

Osborne, J. W. (2017). *Regression & linear modeling: Best practices and modern methods*. SAGE.

Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research* (Vol. 2). Jossey-Bass.

President's Council of Advisors on Science and Technology. (2012). *Engage to excel: Producing one million additional college graduates with degrees in science, technology, engineering, and mathematics*. Office of the President.

Rendón, L. I. (1994). Validating culturally diverse students: Toward a new model of learning and student development. *Innovative Higher Education, 19*(1), 33-51.

Seager, C. S. (2015). The development and field-testing of a living-learning program assessment instrument. (Unpublished doctoral dissertation). University of Central Arkansas, Conway, AR.

Soldner, M., Rowan-Kenyon, H., Inkelas, K.K., Garvey, J., & Robbins C. (2012). Supporting students' intentions to persist in STEM disciplines: The role of living-learning programs among other social-cognitive factors. *The Journal of Higher Education*, *83*(3), 311-336.

Soria, K. M., & Stebleton, M. J. (2012). First-generation students' academic engagement and retention. *Teaching in Higher Education, 17*(6), 673-685.

Streiner, D. L. (2003). Starting at the beginning: An introduction to coefficient alpha and internal consistency. *Journal of Personality Assessment, 80*(1), 99-103.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45*(1), 89-125.

West, S. G., Finch, J. F., & Curran, P. J. (1995). Structural equation models with nonnormal variables: Problems and remedies. In R. H. Hoyle (Ed.), *Structural equation modeling: Concepts, issues and applications* (pp. 56-75). Sage.

Wilson, D., Jones, D., Bocell, F., Crawford, J., Kim, M. J., Veilleux, N., Floyd-Smith, T., Bates, R., & Plett, M. (2015). Belonging and academic engagement among undergraduate STEM students: A multi-institutional study. *Research in Higher Education, 56*(7), 750-776.

Yorke, M. (2016). The development and initial use of a survey of student "belongingness", engagement and self-confidence in UK higher education. *Assessment & Evaluation in Higher Education*, *41*(1), 154-166.

Appendix A

Statistical responses for all questions in the survey

Item	*M*	*Mdn*	*SD*	Minimum	Maximum
SB-U1	4.06	4.00	.935	1	5
SB-U2	3.89	4.00	1.009	1	5
SB-U3	4.36	5.00	.856	1	5
SB-U4	4.17	5.00	1.122	1	5
SB-U5	4.13	4.00	.876	1	5
SB-AM1	4.01	4.00	1.040	1	5
SB-AM2	4.28	5.00	1.033	1	5
SB-AM3	4.12	4.00	.928	1	5
SB-AM4	3.85	4.00	1.053	1	5
SB-AM5	3.89	4.00	1.069	1	5
AE1	4.26	4.50	.942	1	5
AE2	4.41	5.00	.870	1	5
AE3	4.37	4.00	.768	1	5
AE4	4.40	5.00	.794	1	5
AE5	4.45	5.00	.747	1	5
SE1	4.31	4.00	.807	1	5
SE2	4.15	4.00	.858	1	5
SE3	4.50	5.00	.675	2	5
SE4	4.35	5.00	.815	1	5
SE5	4.44	5.00	.677	1	5
SE6	4.36	5.00	.788	1	5
SE7	4.08	4.00	.875	1	5
SE8	4.10	4.00	.848	1	5
SB-RC1	3.37	4.00	1.398	1	5
SB-RC2	3.38	3.00	1.305	1	5
SB-RC3	3.16	2.00	1.391	1	5
SB-RC4	2.93	2.00	1.382	1	5
SB-RC5	3.41	4.00	1.357	1	5

Note: n = 304, *M* = Mean, Mdn = Median, *SD* = Standard deviation

Appendix B

Communalities from principal component analysis

Item	Initial	Extraction
SB-U1	1.000	.721
SB-U2	1.000	.695
SB-U3	1.000	.552
SB-U4	1.000	.598
SB-U5	1.000	.518
SB-AM1	1.000	.714
SB-AM2	1.000	.376
SB-AM3	1.000	.731
SB-AM4	1.000	.764
SB-AM5	1.000	.787
AE1	1.000	.723
AE2	1.000	.580
AE3	1.000	.373
AE4	1.000	.642
AE5	1.000	.495
SE1	1.000	.542
SE2	1.000	.666
SE3	1.000	.632
SE4	1.000	.597
SE5	1.000	.644
SE6	1.000	.654
SE7	1.000	.552
SE8	1.000	.588
SB-RC1	1.000	.694
SB-RC2	1.000	.648
SB-RC3	1.000	.565
SB-RC4	1.000	.448
SB-RC5	1.000	.535

Appendix C

Eigenvalues, initial variance explained, and variance explained after rotation generated from principal component analysis and Varimax rotation

Component	Eigenvalue	Initial Variance (%)	Initial Cumulative (%)	Rotated Variance (%)	Rotated Cumulative (%)
1	8.586	30.663	30.663	18.022	18.022
2	3.175	11.338	42.001	12.433	30.455
3	2.572	9.185	51.185	11.489	41.944
4	1.486	5.305	56.491	10.128	52.072
5	1.219	4.354	60.845	8.773	60.845
6	0.938	3.350	64.195		
7	0.855	3.055	67.250		
8	0.752	2.685	69.935		
9	0.736	2.630	72.565		
10	0.680	2.427	74.992		
11	0.641	2.289	77.280		
12	0.601	2.146	79.426		
13	0.586	2.094	81.520		
14	0.549	1.960	83.481		
15	0.511	1.824	85.305		
16	0.467	1.668	86.973		
17	0.435	1.553	88.526		
18	0.410	1.464	89.991		
19	0.389	1.388	91.379		
20	0.354	1.263	92.642		
21	0.347	1.238	93.880		
22	0.318	1.137	95.016		
23	0.292	1.044	96.060		
24	0.267	0.955	97.015		
25	0.242	0.865	97.880		
26	0.227	0.811	98.691		
27	0.209	0.746	99.437		
28	0.158	0.563	100.000		