AC 2012-5111: INVESTIGATION OF BELONGING FOR ENGINEERING AND SCIENCE UNDERGRADUATES BY YEAR IN SCHOOL

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Investigation of Belonging for Engineering and Science Undergraduates by Year in School

Abstract

Belonging is an important factor in STEM education and is a basic human need which is dependent on social relationships for fulfillment. In this work, researchers at five institutions continued a multi-year study of belonging among engineering and science students. For this study, belonging is separated into four separate constructs: belonging to class, belonging to major, belonging to the university as an institution, and belonging to the university as a community. The focus of this work is on self-reported belonging for STEM undergraduates by classification (year in school), and the following hypothesis was tested: belonging will increase monotonically with student classification. From spring 2010 through spring 2011, a combined total of more than 900 students completed surveys at a large Research institution located in the Northwest, a Historically Black College/University (HBCU) in the Southeast, a women's college in the Northeast, a small private faith-based institution in the Northwest, and a large teaching institution in the Midwest. The four types of belonging, or scales, were included in the survey assessing individual characteristics and academic experiences. Belonging scores across all institutions ranged from 14.08 to 18.12 out of 20.00 for four item scales and 9.49 to 12.68 out of 15.00 for the three item scale (belonging to the university as a community). The results of the analysis indicate that, although statistically significant differences in belonging were observed based on student classification at individual institutions, the differences did not support a monotonic increase by classification hypothesized at all schools for all types of belonging. The authors attempt to explain these observations based on cohort effects, institutional contexts and other factors.

Introduction

The articulation and demonstration of student learning outcomes and educational objectives are essential elements of undergraduate education. For STEM education, in particular, efforts to improve student learning outcomes and achieve educational objectives have concentrated on methods of teaching and learning such as student research experiences.[1] However, it is important to realize that STEM educational objectives and outcomes which, over the course of the undergraduate degree, represent all levels of Bloom's taxonomy[2] are overlaid with the student life experience represented by Maslow's hierarchy of needs.[3] Thus, if a student has not experienced a sense of belonging, the third level of Maslow's hierarchy, it may become the bottleneck in the goal to improve learning outcomes and achieve educational objectives.

Maslow's hierarchy of needs presents a theory of human motivation.[3] The hierarchy includes five levels of needs. The lowest level is physiological needs (food and water), and the next level of needs is concerned with safety and security. Once the lower two categories have been fulfilled to a reasonable extent, achieving a sense of belonging becomes the primary motivation for human behavior. Leading scholars of belonging propose that the "…need is for regular social contact with those to whom one feels connected"[4] (p. 501) and that belonging is defined by perceptions of acceptance, fit within the group, and inclusion in a classroom or a larger campus

setting.[5-7] In the present study, we adopt the above definition of belonging and examine the perceptions of belonging in the academic contexts of classroom, academic major, and campus experience. Belonging is also related to other expressions including ambient belonging,[8] relationships,[9] activities,[10-11] community,[12-13] professional role confidence,[14] connnections,[4] and departmental culture[15] which all fall into Maslow's category of belonging needs. Belonging also has multiple domains and, for this study, is separated into four domains or types: belonging to class, belonging to major, belonging to the university as an institution, and belonging to the university as a community.

Previous research at the K-12 level and the university level has demonstrated or supported the importance of belonging to improve student outcomes, academic engagement and retention.[8-13, 15-25] Acknowledging the importance of student belonging in STEM education, researchers at five institutions began a multi-year study of belonging among engineering and science students. The main goal of this larger study is to test the linkage between STEM students' sense of belonging while in school and their engagement in their studies across different types of institutions.[26] One potential outcome of the larger study is a list of interventions or best practices to ensure that students achieve a sense of belonging at their respective institutions.

Because the study is broad, it allows other linkages to be tested.[26-28] This paper focuses on self reported belonging for STEM undergraduates by classification (i.e. year in school). The following hypothesis was tested: belonging will increase monotonically with student classification. The research most closely related to this paper was conducted by Deneui[24] in a study of psychological sense of community (PSC). College freshman were recruited during orientation and the first week of class to participate in a study to determine if PSC increased after the first semester of college. The students were surveyed during or prior to the first week of class and again at the end of the semester. Deneui found that PSC did not increase during the first semester. Notwithstanding, given the longer time period on campus (years versus months as compared to the previous study) for the students in this study, it was anticipated that an increase in belonging would be observed by year in school. Another noteworthy difference between this study and the Deneui work is that the present research is cross sectional whereas the Deneui study was longitudinal. Nevertheless, this study provides insight into the changes in STEM students' ability to meet belonging needs as they progress through school.

Methods

Belonging has been measured in a number of different contexts and communities. In the academic environment, belonging has been most often measured in the context of the classroom and whole school settings where individuals experience significant interpersonal connections. In the K-16 literature, labels for belonging have included belonging to classroom, belonging to school,[29-30] group belonging,[31] school membership[16] and psychological sense of community.[12]

The survey items for this study are subsets of items from the Anderson-Butcher & Conroy[31] measures for belonging and the Lounsbury & DeNeui[12] measures for psychological sense of community. Because all of our items measure aspects of regular social contact and stability consistent with the definition of belonging presented above, we consider that all of our four subscales represent the construct of belonging in different settings. These four settings are the classroom, the major, the university as an institution, and the university as a community. Items

for each of these four measures of belonging in higher education are detailed in Table 1. The students responded to scale items using a Likert scale ranging from "1" (Strongly Disagree) to "5" (Strongly Agree).

Table 1: Four Measures of Belonging in Higher Education

Belonging Context	Items
To Class	I feel accepted in this class. I feel comfortable in this class. I feel supported in this class. I feel that I am a part of this class.
To Major	I feel accepted in my major. I feel comfortable in my major. I feel supported in my major. I feel that I am a part of my major.
To University as Institution	I feel like I really belong at this school. I really enjoy going to school here. I wish I had gone to another school instead of this one.* I wish I were at a different school.*
To University as Community	People at this school are friendly to me. I feel that there is a real sense of community at this school. I feel like there is a strong feeling of togetherness on campus.

*Reverse coded

From spring 2010 through spring 2011, a combined total of more than 900 students completed surveys at a Research institution located in the Northwest, a Historically Black College/University (HBCU) in the Southeast, a women's college in the Northeast, a small private faith-based institution in the Northwest and a large teaching institution in the Midwest. These institutions were chosen to represent a range of institutions with different strengths in undergraduate education. The larger institutions were chosen because of their size, which may detract from undergraduate education, with yet a corresponding infrastructure of opportunities, which overall is likely to contribute to undergraduate education. The smaller institutions were chosen because students are connected by faith, ethnicity or gender.

Analysis of pilot survey data revealed that the internal reliability coefficients for each scale were strong (alphas ranged from .80 to .88). One-way Analyses of Variance (ANOVAs) for each school compared mean levels of the 4 types of belonging across school classifications. Significant effects ($p<.05$) were followed-up with post-hoc tests (Scheffe, $p<.05$) to determine the significant differences between specific classification levels.

Results and Discussion

Five institutions participated in the study. The data are presented by institution because it is assumed that institutions may have different baseline levels of belonging and institutional variance might blur the relationship between belonging and student classification. Because the study was not longitudinal, some of the results may represent cohort effects. In the analysis of the survey data, it is assumed that the results do not represent cohort effects, artifacts that are not

generally applicable but only apply to the particular group of students holding the classification at the institution at that time.

Private Faith-Based University

Participants included 23 females and 51 males from sophomore, junior, and senior classifications. The academic majors reported by the students were primarily electrical engineering (31%), math (20%), and computer science (19%). Sophomores and juniors were the intended study participants. Consequently, students were recruited from courses typically taken by sophomores and juniors in the chosen majors. Although the classes are intended for a particular level, students in various classifications enroll. Thus, data are also available for seniors. Sophomore students were recruited from Electric Circuits I (EE2726), Linear Algebra (MAT 2401), Advanced Physics Lab I (PHY 3311), Applications Programming (CSC 3220) and Organic Chemistry (CHEM 3371). Junior level students were recruited from Engineering Junior Design (EE 3730/EGR 3810), Electrochemistry (CHEM 3228), Modern Algebra (MAT 4403), Advanced Physics Lab III (PHY 3313), and Netcentric Computing (CSC 3221).

The mean levels for the belonging measures are presented in Table 2 for each classification. The one-way ANOVAs were significant for Class Belonging and Major Belonging. Follow-up post hoc analyses revealed that seniors experienced higher levels of belonging in class and major compared to juniors. The sophomore means were not significantly different for either juniors or seniors. The sophomore year is an important one for the STEM majors. That is the year that they generally begin taking courses specific to their major where there are not many students from outside the major in attendance. Furthermore, for engineering students, the beginning of the sophomore year is when they get lockers and toolkits. There is a significant effort to bring these students "into the major" at the beginning of the sophomore year. The most likely reason for the seniors' strong sense of belonging to the class and the major are the required senior capstone courses for all students and senior design for engineering students. In these courses, students work closely together, meet frequently with faculty, and address multiple aspects of their major simultaneously. The juniors are in more of an "in between" stage, some taking sophomore level courses and some taking senior level courses. Thus, it is not surprising that there is a weaker connection to the major and class at the junior level.

Table 2: Mean levels of belonging for students at a private faith-based university

	Sophomores	Juniors	Seniors	
	n = 35	n = 14	n = 25	
Belonging to				Significant Effects
Class	16.20	15.21[a]	17.16[b]	F (2,71) = 3.41, $p < .04$
Major	17.23	15.86[a]	18.12[b]	F (2,71) = 3.85, $p < .03$
University as Institution	17.54	17.14	17.44	
University as Community	12.57	12.36	12.68	

Note: Means with different superscripts are significantly different, $p < .05$

Historically Black College/University

Participants included 44 females and 86 males who ranged from freshmen to senior years. The academic majors reported by the students were primarily mechanical engineering (35%), chemical engineering (24%), electrical engineering (20%), and aerospace engineering (12%). Sophomores and juniors were the intended study participants. Consequently, sophomore (200 level) and junior (300 level) courses were chosen from which to recruit students. Although the classes are intended for a particular level, students in various classifications enroll. Thus, data are available for students at all classifications. Sophomore students were recruited from Calculus courses, Probability and Statistics (MENG 0237), Statics (MENG 0211), Material and Energy Balances (CENG 0210) and Linear Networks and Circuits (EENG 0221). Junior level students were recruited from Ordinary Differential Equations (MATH 0307), Strength of Materials (MENG 0316), Reaction Engineering (CENG 0360) and Electronics I (EENG 0325).

The mean levels for the belonging measures are presented in Table 3 for each classification. The one-way ANOVAs were significant for Belonging to Class and Belonging to University as an Institution. Follow-up post hoc analyses revealed that the seniors reported lower levels of belonging in class compared to sophomores. The decrease in belonging from sophomores to seniors is attributed to the recruitment pool. Seniors were not specifically targeted but were captured in sophomore and junior level classes due to changes in major, transfer status and other factors. Thus, it seems reasonable that a decrease in belonging is observed because the students are not in class with their peers. This hypothesis is supported by pilot data obtained from graduating seniors in spring 2010 who were surveyed in the capstone design course and reported a mean level of belonging of 17.21 which was significantly greater than senior means in Table 2 ($t(46) = 3.79$, $p<.001$).

Although the overall effect of Belonging to the University as an Institution was significant, the post-hoc analyses did not identify any significant differences between the classifications. There were no differences among the classifications for Belonging to Major or Belonging to the University as a Community.

Table 3: Mean levels of belonging for students at a HBCU

	Freshmen	Sophomores	Juniors	Seniors	
	n = 29	n = 54	n = 35	n = 12	
Belonging to					Significant Effects
Class	15.62	16.51 [a]	15.23	14.08 [b]	$F(3,126) = 3.22$, $p < .03$
Major	16.96	16.69	16.66	15.33	
University as Institution	15.21	16.76	17.09	14.71	$F(3,126) = 3.20$ $p < .03$
University as Community	11.15	11.47	11.23	10.67	

Note: Means with different superscripts are significantly different, $p < .05$

Women's College

Participants included 86 females from freshmen to senior classifications. The academic majors reported by the students were primarily biology (33%), chemistry (21%), and biochemistry (20%). Specific courses were targeted to attempt to capture the most sophomores and juniors. Although the initial plans called for surveying sophomores in the fall and juniors in the spring, the Women's College curriculum was not strictly stratified along those lines. In addition, since each major was typically small, the curriculum was also flatter (constructed with a shorter prerequisite structure) than might be found at larger universities. Thus, a course might be equally distributed among all four classes, from first years to seniors. Instead of targeting by class year, math and computer science courses were surveyed in the fall and chemistry classes were surveyed in the spring with the particular courses within the major selected to ensure that the majority of the students enrolled were classified as sophomores or juniors.

The mean levels for the belonging measures are presented in Table 4 for each classification. The analyses revealed few differences between the classifications for students' sense of belonging to class, major, or the university. Even though the main effect for Belonging to the University as a Community was significant, none of the post-hoc analyses confirmed significant differences among the various classifications. Overall, classification was not related to levels of belonging for students at the Women's College. It is unlikely that, given the lack of structure around class year, students of various class years would feel a different sense of belonging.

Table 4: Mean levels of belonging for students at a women's college

	Freshmen	Sophomores	Juniors	Seniors	
	n = 23	n = 19	n = 28	n = 16	
Belonging to					Significant Effects
Class	15.83	15.84	15.17	14.83	
Major	16.26	17.00	16.06	15.75	
University as Institution	15.91	16.63	14.78	15.81	
University as Community	12.07	11.79	10.33	11.13	F (3,82) = 3. 0 6p < .04

Note: Means with different superscripts are significantly different, $p < .05$

Large Teaching University

Participants included 20 females and 158 males from sophomore, junior, and senior classifications. The academic majors reported by the students were primarily automotive engineering technology (27%), civil engineering (23%), mechanical engineering (21%) and electrical engineering (13%). Recruitment began by targeting classes. For first semester sophomores, these were calculus 2, differential equations, physics and a major-specific course in the automotive program. For the second semester juniors, these were junior design in electrical and automotive engineering, hydraulics and hydrology in civil engineering and thermodynamics in mechanical engineering. Recruitment continued with invitations to participate through classroom announcements, emails, and personal conversations. When this produced low turnout, faculty members teaching targeted classes were asked if time could be used at the beginning or

end of classes for students to complete the survey. Giving students time to complete the survey in class was the most effective recruitment tool.

The mean levels for the belonging measures are presented in Table 5 for each classification. There were no significant differences among the classifications for the different types of belonging. Students are more strongly connected to their major at this university, with a slightly lower sense of connection to the university as an institution and as a community. The junior class was also more coherent with a stronger sense of connection to other students within their major. Students are admitted to the major at the end of sophomore year and juniors typically take multiple classes with the other students in their major. Seniors taking the survey were in one of two classifications: taking courses typically taken by sophomores and juniors, or at the end of their final semester when their focus may have been beyond their academic career.

Table 5: Mean levels of belonging for students at a large teaching university

	Sophomores	Juniors	Seniors
	n = 35	n = 94	n = 49
Belonging to			
Class	15.26	15.65	15.33
Major	15.93	16.48	16.32
University as Institution	15.51	15.64	15.52
University as Community	10.77	10.60	10.25

Research University

Participants included 138 females and 302 males from freshmen to senior classifications. The academic majors reported by the students were primarily civil engineering (25%), electrical engineering (22%) and mechanical engineering (11%). Survey participants were recruited during the Spring 2010, Fall 2010 or Spring 2011 quarters. Participation in the study was voluntary and students were assured that their survey responses would be confidential. In Spring 2010, students were recruited from an introductory electrical engineering class that included students from a wide range of engineering majors. In the remaining recruitment quarters, most subjects were recruited from core (required for the major) classes in each discipline. Additional students were recruited as needed (to achieve a representative, statistically significant sample size) by e-mail, using similar recruitment protocols as in core engineering courses. Recruitment rates were 90% or higher in core classes but dropped to less than 20% when using e-mail as a recruitment tool. All surveys for this phase of research were completed using on-paper versions of the survey.

The mean levels for the belonging measures are presented in Table 6 for each classification. The analyses revealed significant differences for each of the variables. The results for Belonging to Major confirmed the general hypothesis that advanced students would report greater belonging than freshmen or sophomores. Freshmen and sophomores are not only early in their program, but are not yet admitted to their major. The significant jump in Belonging to Major coincides

with the time that most students enter their major. Thus, students likely report low Belonging to Major in their freshman and sophomore years because of external (their major department has not yet admitted them, thereby enabling them to belong) influences rather than internal ones. Once in the major, sense of Belonging to Major remains stable through junior and senior years. Interestingly, however, students report a stronger sense of Belonging to Class as freshman than they do as sophomores. Although mean values suggest that Belonging to Class begins to recover as students advance from sophomore to junior to senior levels, these increases are not statistically significant. Thus, the impact of late-stage admissions to the major (during the sophomore year) may be to impair student's sense of belonging in their classes through graduation from the major. As is typical of the other institutions in this study, no significant differences in Belonging to the University as an institution or as a community (both representing a connection to the larger community of the university) emerge as a function of year in school. This could represent stability in the students' sense of connection to the university, or it could be that differences are confounded by the feeling associated with late (sophomore year) admission to the major. Longitudinal data collection planned in future studies should aid with interpretation of the cross-sectional study findings.

Table 6: Mean levels of belonging for students at a research university

	Freshmen	Sophomores	Juniors	Seniors	
	n = 31	n = 141	n = 197	n = 71	
Belonging to					Significant Effects
Class	15.65[a]	14.35[b]	14.96	15.20	F (3,436) = 2.90, $p < .04$
Major	14.31 [a]	14.25 [a]	15.87 [b]	15.96 [b]	F (3,438) = 11.23, $p < .001$
University as Institution	16.34	15.46	16.34	15.25	F (3,436) = 3.46, $p < .02$
University as Community	10.47	9.49	10.35	9.82	F (3,436) = 4.68, $p < .004$

Note: Means with different superscripts are significantly different, $p < .05$

Concluding Remarks

In this study, five institutions participated in a study of belonging in STEM environments. Four types of belonging were investigated: belonging to class, belonging to major, belonging to the university as an institution and belonging to the university as a community. Consistent with a related study,[24] overall, results from this study do not support the hypothesis that belonging increases by student classification. However, belonging in major did increase from junior to senior year at the private, faith-based institution and from lower level (freshman and sophomores) to upper level (juniors and seniors) at the research institution. Interestingly, a decrease was observed in class belonging from freshman to sophomore year at the research institution.

The results presented should be interpreted with caution because they could be confounded by cohort effects. Thus, although the raw belonging scores for individual institutions are intriguing, further discussion is delayed until longitudinal data and additional cohort data are obtained to support the current findings. Another limitation of the study is that, at some institutions, the

small number of participants may have masked effects that would have been statistically significant for a larger number of participants. However, despite the limitations of the data, this paper provides insight into the evolution of belonging by suggesting that, generally, belonging does not increase monotonically by year in school. This finding is important because it suggests that understanding what happens during a student's course of study that causes his/her sense of belonging to change could be as important as efforts to improve a student's initial sense of belonging. Ultimately, understanding what impacts student belonging both negatively and positively should point to interventions to improve belonging and, consequently, the engagement, performance and persistence of STEM undergraduates.

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