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Critical Review of Research on the Role of Social Engagement in Engineering Students' Retention and Academic Success

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Abstract

The authors of this study conducted a critical review of common measures of college student social engagement as well as the research literature on the role of peer-oriented social engagement in predicting retention and academic performance of engineering students. The analyses revealed limited evidence of reliability and validity of social engagement measures. Related to the importance of peer-related social engagement for student success, engineering or STEM-related social engagement was more frequently observed as a significant variable than non-engineering related/general social engagement. The construct of social engagement is also found to be more important among traditionally underrepresented groups in engineering such as women and ethnic minority students. The authors suggest that future research should include the re-development of the social engagement concept to reflect distinguishing characteristics of engineering fields.

Introduction

During the last two decades, the retention and academic success of engineering students has emerged as a major topic for discussion among policy makers and researchers in higher education. However, the current record of engineering student retention and graduation does not suggest a positive outlook. Based on the most recent U.S. Bureau of Labor Statistics projections [1], the demand for qualified engineering graduates will grow 11% between 2008 and 2018, yet the number of engineering graduates remained relatively unchanged between 2005 and 2009[2]. It is now estimated that only about one half of the college students who matriculated into an engineering program will actually earn an engineering degree [3].

For many years, researchers have highlighted the critical role of social engagement in college student retention and academic success. Astin [4] emphasized that the single most influential factor in college student development was the peer group, a factor that links a sense of community with overall satisfaction in college. To increase student retention, Tinto [5] suggested that freshman students should be integrated into social and academic communities early in their freshman year. Several subsequent studies provided empirical evidence that social engagement or social integration is a critical factor in students' persistence in higher education [6]. Researchers have also suggested that some types of social engagement are more critical to the academic success and retention of female and underrepresented ethnic minority students [7,8,9]. However, with the increasing number of research studies in engineering education during the last two decades, researchers have begun to acknowledge that a retention and academic success model for engineering students may differ from those of non-engineering majors. In an analysis of a national data set on student engagement, Lichtenstein et al. [10] noted that engineering students reported spending similar amounts of time on co-curricular activities and volunteer work as non-engineering students; however, time spent involved in these activities did not

contribute to explaining persistence or graduation. Using data from the University of Michigan, Veenstra et al. [11] proposed a model listing seven pre-collegiate predictors that contribute to the academic success of freshman engineering students, including social engagement. While Veenstra et al. acknowledged that the construct of social engagement is measured in many different ways and it is hard to identify a trend in the use of the construct, they concluded that social engagement is a more salient factor in general college education than in engineering education. Contrasting research results regarding the importance of "social engagement" in the academic success and retention of freshman engineering students suggest the way researchers have conceptualized and measured the construct in current research literature may be problematic.

Statement of Research Purpose

This paper provides a critical analysis of the existing literature related to the construct of "social engagement," which has been studied as an important predictor of engineering student retention and academic success. For the purpose of this paper, we include both behavioral and affective dimensions of social engagement and conceptualize the construct as having three categories, a) Participation in co-curricular activities, b) Satisfaction, frequency, and quality of interaction with peers, and c) Feelings of belonging or integration in the institution or academic program. Table 1 displays the analytic categories, constructs, and examples of survey items from studies used in our analysis to illustrate our conceptualization.

Table 1: Examples of Constructs of Social Engagement and Related Survey Items

Analytic categories	Construct	Survey items	Used in
Participation in co-curricular activities	Frequency of involvement in extracurricular activities	Some people desire to be involved in non-engineering activities on or off campus, such as hobbies, civic or church organizations, campus publications, student government, social fraternity or sorority, sports, etc. How often are you involved in the kinds of activities described above?	Eris et al.
Satisfaction, frequency and quality of interaction with peers	Peer group interactions	I have developed close personal relationships with other students. (5-point Likert scale) The student friendships I have developed have been personally satisfying (5-point Likert scale)	French et al.
Feelings of belonging or integration in the institution or academic program	Interpersonal climate	I feel a sense of community in the Engineering College. (5-point Likert scale)	Hartman & Hartman

Our analyses were completed in two phases. First, we examined four survey measures of social engagement that have been frequently utilized by engineering education researchers. The four measures selected for our review were: Cooperative Institutional Research Program (CIRP) Freshman Survey, College Student Experiences Questionnaire (CSEQ), National Survey of Student Engagement College Student Record (NSSE CSR) Survey, and Pittsburgh Freshman Engineering Attitude Survey (PFEAS). Specifically, we reviewed the survey items related to social engagement and examined issues of measurement quality including validity and reliability.

Second, we conducted a comprehensive review of engineering education literature on relationships between peer-oriented social engagement and engineering students' persistence/retention and academic success. Only ten studies met the criteria specified. Additionally, we included three classic retention studies in our review that are consistently referenced in higher education and engineering education literature, for a total of 13 studies (see Table 2: Sample Characteristics and Measures in 13 Empirical Studies). The analytic scheme used for this second analysis includes the three categories presented in Table 1, yet results from the 13 studies were also analyzed based on: a) statistical significance, b) specificity to STEM/engineering areas, and c) types of outcome measures (see Table 3: Summary of Effects of Peer-Oriented Social Engagement by Outcome in Engineering Education Studies). Using these multi-layered analytic categories that elucidate different aspects of the results from the 13 studies, we elicited four critical syntheses on the relationship between peer-oriented social engagement and student success factors (retention/persistence, academic achievement). These four analytic syntheses illuminate the heterogeneity of the construct of social engagement (and individual survey items) that were utilized in each investigation, and how the results of each study are related to the unique characteristics of the study's sample.

Critical Review of Large Scale Survey Studies

The decades between 1970 and 2000 saw the development of theories emphasizing student involvement [4,12], student experiences [13], effective educational practices [14], academic and social integration [15,16], and student engagement [17] for student learning and success in college. Based on these works, researchers have designed large scale surveys to study the American higher education system, and the practices and orientations of its students, faculty, and institutions. Measures of social engagement are emphasized to differing extents in these existing surveys, but nevertheless remain important in understanding student persistence and development. In this review, we summarize three prominent surveys from the field of higher education and one engineering education survey, and note their primary limitations for the measurement of social engagement.

Cooperative Institutional Research Program Surveys

The Cooperative Institutional Research Program (CIRP) was established in 1966 by Astin and colleagues at the Higher Education Research Institute (HERI) as a national longitudinal study of the American higher education system, and is the oldest such study in the nation [18]. The CIRP Freshman Survey is administered to incoming first-year students before they start classes, and is designed as a pre-test instrument for additional CIRP surveys administered at key points during the undergraduate career. Sections of the freshman survey include behaviors established in high school, academic preparation, college expectations, peer and faculty interactions, values and goals, and financial concerns. Social engagement measures are included in questions about frequency of social interactions and activities, e.g., socializing with friends and participation in student clubs during high school, importance of college's reputation for social activities in selection of college, and expectations for participating in extracurricular activities in college.

The CIRP surveys consist of three follow-up assessments designed to be administered to students at the end of the first year, during the sophomore or junior year, and at the end of the senior year to understand student growth and change over time. All of these surveys contain some measures of social engagement. There are items in the first year survey (Your First College Year – YFCY) that measure the frequency and quality of participation in extracurricular activities, social commitments, and membership in campus organizations, along with student satisfaction with campus life. The Diverse Learning Environments (DLE) survey, intended to be administered during the sophomore or junior year, measures social engagement concepts such as sense of belonging, perceptions of climate, co-curricular diversity activities, social action, and civic engagement. The College Senior Survey (CSS) includes items that measure participation in activities, time spent socializing, satisfaction with sense of community and availability of social activities, and perceptions of climate and belonging.

College Student Experiences Questionnaire

The College Student Experiences Questionnaire (CSEQ) was developed and first administered in 1979, based on the work of Pace [13]. The stated purpose of the CSEQ is to measure the a) quality of student effort invested in using educational resources and opportunities, b) student perceptions of the extent to which the campus environment emphasizes diverse educational priorities, and c) how student efforts and perceptions relate to their estimates of progress toward learning outcomes [19] . The fourth and most recent version of the CSEQ [20] is comprised of 13 activities scales, 10 environment scales, and 25 estimates of gains. Items related to social engagement include scales on frequency of participation in art, music, and theatre, attendance at campus events, participation in clubs, personal relationships and acquaintances, and quality of relationships with other students. The CSEQ project will discontinue in 2012.

National Survey of Student Engagement

The launch of the National Survey of Student Engagement (NSSE) project in 2000 is the most recent national project focused on gathering information about collegiate quality. The project utilizes The College Student Report (CSR), a survey that assesses good practices in undergraduate education. Founded by Kuh [17], who had worked with Pace on the CSEQ, the project is based in the Center for Postsecondary Research (CPR) at Indiana University Bloomington. The CSR is administered to first year and senior students, and generates five institutional benchmark scores for effective educational practices: a) Academic Challenge; b) Active and Collaborative Learning; c) Enriching Educational Experiences; d) Student-Faculty Interaction; and e) Supportive Campus Environment. Like the CSEQ, the CSR includes measures of activities, environment, and estimates of learning gains. The launch of NSSE 2.0 is anticipated in 2013, and will include refined measures related to the benchmarks, and new measures related to effective teaching and learning [21]. Compared to previous national surveys, the CSR contains fewer items on social engagement, which are focused on frequency of participation in co-curricular activities, hours spent socializing and relaxing, quality of relationships with other students, and perceived institutional emphasis on helping students thrive socially.

Pittsburgh Freshman Engineering Attitudes Survey

In 1993, engineering education scholars Besterfield-Sacre and colleagues at the University of Pittsburgh [22,23,24] developed a survey targeted at understanding freshman engineering student attitudes called the Pittsburgh Freshman Engineering Attitude Survey (PFEAS). The PFEAS is composed of 50 multiple-choice items on 13 psychological constructs, including students' attitudes and perceptions of confidence in their engineering related knowledge. While the authors cite the work of Tinto and Astin in support of studying student perceptions of institutional culture to understand persistence, they indicate that the PFEAS is based on Seymour & Hewitt's [25] study of reasons why students leave engineering and the sciences [26]. The PFEAS has almost no emphasis on social engagement, except for one item about friends (Most of my friends that I 'hang-out' with are studying engineering).

Limitations of Large Scale Surveys

The four surveys presented all utilize multiple choice items and scales to measure constructs related to student persistence and success. We noted four major limitations of these surveys in relation to quality of measurement of social engagement.

1) Some survey items on participation include more than one type of social activity, affecting the precision of measurement. For example, time spent participating in co-curricular activities is measured with one item in the NSSE CSR, and is followed by a prompt that names organizations, campus publications, student government, fraternities and sororities, and intercollegiate or intramural sports as examples. In the other behavioral measure of social engagement, time spent relaxing and socializing is grouped into one item, with the examples of watching TV and partying.

2) Building on the first limitation, scales developed from the surveys often include more than one construct or varying levels of intensity of involvement, again affecting accuracy (validity) of measurement. For example, the scale on student acquaintances (peer interaction) on the CSEQ includes items focused on both acquaintances and serious discussions, while the scale on participation in clubs and organizations included attending meetings, working on committees, and providing leadership. Furthermore, information about the reliability of scales is not easily accessible.

3) Some studies focus on social engagement during high school, which does not fit with theoretical models of retention which emphasize social integration in college (e.g., Tinto), and in engineering in particular [25]. While the CIRP freshman survey includes several measures of participation in activities and interaction with peers, these past experiences are not theoretically posited to predict first year college outcomes.

4) Overall, survey items focus broadly on engagement in the institution, but do not include measures of social engagement specifically related to the major. While interaction with peers of a different race/ethnicity, and perceptions of campus climate has become an important focus of surveys (e.g., CIRP DLE; NSSE CSR), surveys do not permit opportunities for students to assess interactions with peers in their major, program

climate, or participation in clubs related to their major area of study. These types of measures would be particularly important for understanding the outcomes of underrepresented minorities in STEM and other fields. Only the PFEAS includes an item about socializing with other engineers, but this survey is administered upon beginning studies and may not be a reliable indicator of how many engineering friends a student has at a later point in the first year.

Recently, Porter [27] argued that the typical question on a college student survey has "minimal validity" (p. 45), and cites students' ability to comprehend the phrases used on the surveys and ability to retrieve information as challenges to the validity of the items. Defenders of such surveys [28] suggest they are designed for consequential validity – that is, to produce actionable data, not for content or construct validity. Nevertheless, researchers use data from the surveys to measure engagement constructs and test models of student success; thus, validity and reliability are important considerations in the use of these large data sets and must be considered in the interpretation of study results

Critical Review of Empirical Research

We reviewed a total of 13 studies for the second component of our critical analysis. First, we reviewed classic retention studies by Astin [4,29] and Tinto [30], which have been frequently cited as germinal research linking the construct of social engagement to college student retention and/or academic success. Nora et al.'s study[6] was reviewed as an example of more recent empirical investigations using an extensive national dataset. Next, we analyzed 10 empirical studies that examined relationships between peer-oriented social engagement and measures of college student adjustment/persistence (e.g., retention, GPA, other persistence measures) in engineering education. We specified four criteria for the inclusion of a study in our review: a) Use of survey construct or survey item(s) that measure at least one of the three social engagement categories explained above; b) At least one outcome variable of student successful adjustment or persistence (e.g., retention, enrollment status, GPA, or student intention to persist in the major); c) Clear presentation of the statistical significance of social engagement in relation to an outcome variable(s); and d) Published in a refereed journal during the last ten years. In order to ensure consistency in our analysis, we limited the literature review to quantitative studies using survey and other quantitative measures. As a result, this paper does not include any qualitative research that examined the importance of social engagement based on interview or observation data.

Once 10 studies were identified, we classified all constructs/individual survey items of peer-oriented social engagement into three categories: (a) Participation in co-curricular activities, b) Satisfaction, frequency and quality of interaction with peers, and c) Feelings of belonging or integration in the institution or academic program. Each category was divided into two sub-categories; engineering/STEM-specific social engagement and general, non-engineering/STEM-related social engagement. We also specified the type of outcome measures adopted as the indicator of student retention or student academic success in each study. Finally, we interpolated major institutional and/or demographic characteristics of the participants in each study (e.g., gender, ethnicity, geographical location of sample), and examined possible relationships between the demographic characteristic of the samples and research results.

Table 2: Sample Characteristics and Measures in 13 Empirical Studies

Authors and Reference #	Sample description	Survey	Outcomes examined
Amelink & Creamer[37]	N= 1629 from 9 institutions 70% Men; 79.6% White	Engineering Student Survey using *The Student Persisting in Engineering Survey* (AWE, 2005)	Intention to Persist (Survey item)
Astin[4]	N= 25,000 students from more than 200 institutions (1985-1989) Nationally representative sample; no specific sample breakdown provided.	CIRP Freshman Survey	Persistence (Retention status); Academic Performance (GPA)
Brown et al.[7]	N= 514 from 53 institutions All African Americans No information on gender is provided.	Student Perceptions of Campus Climate (SPSS)	Persistence (Graduation rate)
Eris et al.[32]	N= 160 (141) 61% Men; 42% White	Persistence in Engineering (PIE) Survey including items from PFEAS;CIRP Freshman	Persistence (Enrollment status for 4 years)
Espinosa et al. [38]	N=2,141 Women from 135 institutions 42% White	CIRP Senior Survey	Persistence in 4th year in STEM (survey item on enrollment status)
French et al.[30]	Cohort 1 (N=1,000): 80.7% Men; 87.9% White Cohort 2 (N= 756): 81.9% Men; 90% White	Institutional Integration Scale (IIS)	Persistence (enrollment status in 6th or 8th semester); Academic Performance (GPA)
Hartman & Hartman[35]	N= 352 (319 stayers/ 33 leavers) 80 % Men No information on ethnicity is provided; PWI (78% white)	Department survey	Persistence (enrollment status after one year from the initial survey)
Lichtenstein et al. [10]	N=12,000 69.9% Men (under sampled) 84.7% White	NSSE	Persistence (enrollment status in the senior year)
Meyers et al. [34]	N= 550, 72.5% Men No information on ethnicity is provided. PWI (76% White)	Department survey	Intention to Persist (survey item)
Nora et al. [6]	N=2,740 Analysis itself was conducted by gender and race (majority and minority students)	NCTLA (National Center on Teaching, Learning, and Assessment) Surveys; College Student Experiences Questionnaire (Pace, 1979), and Collegiate Assessment of Academic Proficiency (CAAP)	Persistence (enrollment status after 1 year)
Tinto[5]	N= 287, 48 % Men No information on ethnicity is provided, (urban community college with 49% minority students in 2011)	Pace's (1984) Quality of Student Effort Scales (QSES)	Persistence (enrollment status in subsequent semesters)
Trenor et al.[36]***	N= 160 (survey) 100% Women; 34% White	Developed for study	Intention to Persist (Survey item)
Veenstra et al.[33]	N= 1650 No information about gender and ethnicity is provided (PWI Engineering college with 22 % women; 8% underrepresented minorities)	CIRP Freshman	Academic Performance (GPA)

Classic Studies of Student Engagement

Astin's publication, *"What matters in college?"* explained that the freshman college experience provides rich and critical opportunities for learning and development for teenagers transitioning into young adulthood. He argued that these great opportunities for learning and development come with an increased level of risks (e.g., attrition) and responsibilities because students must adjust to their new campus life separated from families and pre-existing support systems. Through his influential research exploring patterns of student academic and social development, Astin concluded that students' college experiences and academic outcomes are profoundly affected by college environments.

Astin's "Theory of Involvement" [29] highlighted students' social engagement and participation in various clubs and voluntary activities on a college campus as an essential part of their integration into the values of the institution. Astin's theory has been reaffirmed in several subsequent studies, including another oft-cited study by Nora and colleagues [6]. Notable is a study by Astin derived from a comprehensive CIRP survey database including 25,000 students representing more than 200 four-year colleges and universities between 1985 and 1989 [4]. In this publication, Astin explained that all variables showing positive relationships with student retention reflect high involvement with faculty, fellow students, and/or academic work. He contested that, in contrast, the majority of variables having negative relationships with retention indicate isolation or disconnection.

In a similar way, Tinto [30] reported a statistically significant relationship between student involvement with peers and retention/persistence in his longitudinal mixed-method study. Tinto's study adopted two research designs: a panel study using surveys and enrollment data, and a qualitative case study based on interviews. The qualitative case report included students' responses exemplifying the importance of peer relationships and peer support. These two studies have been widely cited in engineering education literature as evidence for a positive relationship between freshman students' social engagement and retention [31,32].

However, a closer examination of the two studies described above provides a more complex look at the construct. The CIRP Freshman Survey utilized in Astin's studies includes multiple survey items that measure a wide range of social engagement, and it is difficult to draw a clear-cut interpretation about results obtained through this measure. In fact, each survey item measuring different aspects of social engagement generated varied relationships with retention and GPA, two common measures of college students' successful adjustment [29]. For example, peer interactions (e.g., hours per week spent socializing with friends and partying) did appear to facilitate student retention, yet some negative associations were also found between other social engagement items (e.g., hours per week spent partying, being a member of a social fraternity or sorority) and student first-year GPA. Therefore, the impacts of peer interactions upon the indicators of college students' successful adjustment (e.g., retention and first year GPA) varied depending on the type of social engagement examined in a specific survey item. As we explained in our critique of the large scale survey studies, many individual survey items on student social engagement in the CIRP Freshman Survey have a strong non-academic component (e.g., time spent partying or doing volunteer work). In addition, it should be noted that the sample of Astin's study included a wide range of college students from multiple disciplines.

Tinto's study [30], also frequently cited in engineering retention research, was based on urban community college students primarily enrolled in Humanities programs. Therefore, results from their research should be read and cited with caution when researchers make implications for students in a specific discipline such as engineering.

Empirical Studies on Social Engagement in Engineering

Ten studies met the criteria we specified for inclusion in our analysis (see Table 3). For each study, the items used to measure social engagement were categorized into one of the three predetermined categories (see Table 1). The results of each study were then examined to determine statistical significance of the social engagement factor(s) in predicting the outcome, specificity to STEM/Engineering, and demographic characteristics of the participant sample.

Table 3: Summary of Effects of Peer-Oriented Social Engagement by Outcome in Engineering Education Studies

Outcome	Statistical significance of results	Participation in extra-curricular activities		Satisfaction/quality of relationship with peers		Belongingness to institution	
		Eng/ STEM	General	Eng/ STEM	General	Eng/ STEM	General
Persistence	statistically significant	35, 38[a]		38	4, 5, 6		7
	Not statistically significant		6, 10, 32	35	7, 10, 30	35	6, 30
Intention to persist/ adjustment	statistically significant			34[b], 36[c], 37		34[b], 36[c]	
	Not statistically significant						
Academic performance	statistically significant		5[d]		5[d]		
	Not statistically significant		33		30, 33		30

[a]Results were statistically significant only for women of color.

[b] Campus climate/inclusivity showed a statistically significant (SS) relationship with adjustment in engineering; SS relationship with a feeling that they had someone to talk to and adjustment in engineering. Then, the student adjustment in engineering has an SS relationship with the comfort level with the decision to stay in engineering at $p < 0.001$ level.

[c]Social engagement constructs used in this study included some survey items asking about non-peer relationships. However, the constructs used survey items on peer interactions and we included this study in our review.

[d]Negative correlations were found between the variables.

Our review resulted in four critical syntheses. First, about one-half of studies that examined relationships between three aspects of peer-oriented social engagement and persistence/adjustment measures reported no statistically significant results [7,10, 30, 32,33]. Out of

29 analyses, only 12 reported a statistically significant and positive association, yet two significant relations reported in Meyers and colleagues' study [34] reflect somewhat indirect relationships between a persistence measure and social engagement through another construct, students' adjustment in engineering. Based on the studies we reviewed, it seems reasonable to conclude that the impact of peer-oriented social engagement on college adjustment/persistence varies across studies. Therefore, it is hard to draw a monolithic, conclusive interpretation regarding the universal relationship between different types of social engagement and engineering students' persistence/success.

The second critical synthesis we elicited is that a lack of association is clearly visible in studies which examined relationships between general social engagement (social engagement that is not specific to engineering or STEM) and student outcome variables. Among the 12 analyses linking non-engineering/STEM- related social engagement to engineering student persistence/retention, only one [7] reported a statistically-significant relationship. Three studies that generated a statistical significance (4, 5, & 6) are based on general education student sample. None of our proposed three categories, participation in extra-curricular activities [10,32], satisfaction/quality of relationships with peers [7,10,30,33], or sense of belonging to institution [30] showed an impact on student outcome variables. This result suggests that social engagement not specific to engineering (or STEM) has a minimal impact on engineering students' persistence or academic success.

Thirdly, we noted that studies that examined the relationships of engineering/STEM-specific peer engagement with student persistence showed mixed results. Among eleven examinations, seven analyses reported a statistically significant relationship. For example, Trenor et al. [36] reported significant associations between female students' intention to persist in engineering and two engineering-specific social engagement variables, social support and sense of belongingness. Amelink and Creamer's study [37] also demonstrated that two survey items of peer-oriented social engagement, "getting along with other students in the engineering major" and "feeling as though they are treated with respect by male students" in their program, were significantly correlated with engineering students' intent to pursue an engineering-related career. Meyers et al.'s [34] study presented an indirect relationship. First, their initial analysis showed a statistically significant relationship between students' rating of climate/inclusivity of their engineering school and their adjustment in engineering. Students who had "someone to talk to" in their program also exhibited a higher level of adjustment in engineering. In a later analysis, students' adjustment in engineering and intention to stay in engineering were highly correlated ($p < 0.001$). Compared to the weak relationship found in the analysis of general, non-engineering/STEM- specific social engagement, it is clear that engineering/STEM-specific social engagement exerts a stronger impact on student persistence and/or success.

It should be noted that not all studies on engineering-specific social engagement generated a statistically significant result. Two studies [35,38] presented mixed results indicating a significant association only in a specific social engagement category or in a particular sub-group of students. Hartman and Hartman [35] reported a statistically significant difference between the percents of stayers and leavers who were members of or participated in discipline-specific engineering organizations. Student leavers were less likely to participate in or be members of discipline-specific engineering organizations. However, there was no statistically significant

difference between stayers and leavers in having roommates in engineering or science/math, or in satisfaction with peer relationships. Espinosa's study [38] found that some categories of social engagement are positively related to the persistence of female students as a whole, while others have a meaningful association only with women of color.

Last, and most importantly, one-half of studies that found positive correlations between peer-oriented social engagement and student outcome variables were conducted with students who have been viewed as underrepresented minorities in engineering (e.g., females, racial minority students). Three studies that showed statistically significant relationships between social engagement and persistence were conducted with all female students [36,37,38]. Furthermore, the only study that reported a statistically significant relationship between general, non-engineering-specific peer-oriented social engagement and student persistence [7] was conducted with African-American engineering students at Historically Black Colleges and Universities (HBCU). When these results are viewed together, it suggests that peer-oriented social engagement may play a more critical role in explaining the persistence of women and racial minority students than that of white men in engineering. In contrast, three studies that generated no statistical significance between peer-oriented social engagement constructs and outcome variables were all based on predominantly male and White student sample [10,30, 33].

Summary and Conclusions

This paper presented results from two separate, yet interconnected analyses. First, we examined four survey measures of social engagement that have frequently been utilized by engineering education researchers: the Cooperative Institutional Research Program (CIRP) Freshman Survey, the College Student Experiences Questionnaire (CSEQ), the National Survey of Student Engagement College Student Report (NSSE) Survey, and the Pittsburgh Freshman Engineering Attitude Survey (PFEAS). We noted four major limitations of these measures of social engagement related to the precision of measurement in the items and scales, the timing and focus of the survey, and the lack of items that assessed social engagement in the student's major. The majority of large scale surveys were designed to assess student engagement at the institutional level to determine areas for improvement, rather than to assess psychological and behavioral constructs of engagement. There is insufficient evidence that the surveys provide reliable and valid measures of social and other types of student engagement. However, the survey designers themselves, and other researchers, use institutional and national level survey data to test hypotheses linking engagement with retention and other student success outcomes.

The critical review of the empirical studies in classic higher education research and more recent engineering education research drew four important syntheses to make sense of contradictory research results regarding the role of this construct in engineering student retention and academic success. First, our analytic result indicated that the impact of peer-oriented social engagement on engineering students' persistence and/or academic success varies across studies. Therefore, it is difficult to enact one universal relationship between different types of social engagement and engineering students' persistence/academic success.

Second, we found that peer-oriented social engagement that is not specific to engineering (or STEM) seems to have a minimal impact on engineering students' persistence or academic

success. Considering the relatively high academic demand that characterizes engineering programs, this type of non-academic and non-professional social engagement may not be relevant to explaining the type of social engagement required of and preferred by engineering students. In other words, the pattern or characteristics of social engagement among engineering students might be different from those majoring in non-engineering sectors. This difference has been noted by other researchers [33]. It is also important to note that measurement quality may also play a role in dampening the significance of these factors.

Third, studies that examined the relationships of engineering/STEM-specific peer engagement with student persistence were mixed. However, compared to the weak relationship found in the analysis of general, non-engineering/STEM-specific social engagement, engineering/STEM-specific social engagement presented stronger evidence of being an impact on student persistence and/or success. The measurement of these factors tended to be more specific and precise, increasing the validity of the measures.

Fourth, more than one-half of the studies [36,37,38] that generated positive correlations between peer-oriented social engagement and student outcome variables were conducted with students who have been viewed as vulnerable minorities in engineering. This result suggests that peer-oriented social engagement may play a more critical role in explaining the persistence of females and racial minority students than that of majority students in engineering. In fact, many qualitative research studies that explored the social and emotional experience of females, non-traditional, or racial minority engineering students have provided compelling evidence regarding the importance of social engagement in their academic and professional pursuit [42,43].

Critical analyses of assessment measures, such as the one undertaken in this paper, are essential to advance understanding of the mechanisms that affect student learning and success in engineering education. We propose that the construct of "social engagement" be re-developed to reflect any distinguishing characteristics of the engineering fields and engineering student dispositions, and a valid instrument be designed and consistently used in future studies in order to draw a reasonable evaluation of the construct in engineering student retention and academic success. There may be aspects of engineering social engagement that are unique compared to other disciplines, and this is worthy of greater research attention. Additionally, future research on the dispositions and patterns of social engagement among sub-groups of engineering students is warranted, based on our findings related to the importance of social engagement for underrepresented groups.

1 U.S. Bureau of Labor Statistics. *Occupational outlook handbook, 2010-11 edition.* Retrieved from http://www.bls.gov/oco/ocos027.htm#outlook.

2 Gibbons, M. (n.d.) *Engineering by the numbers.* Retrieved from http://www.asee.org/papers-and-publications/publications/college-profiles/2009-profile-engineering-statistics.pdf

3 Burtner, J. (2005). The use of discriminant analysis to investigate the influence of non-cognitive factors on engineering school persistence. *Journal of Engineering Education, 94*, 335-339.

4 Astin, A.W. (1993). *What matters in college? Four critical years revisited*. San Francisco: Jossey-Bass.

5 Tinto, V. (1997). Classrooms as communities: Exploring the educational character of student persistence. *Journal of Higher Education, 68*(6), 599-623.

6 Nora, A., Cabrera, A., Hagedom, L., & Pascarella, E. (1996). Differential impacts of academic and social experiences on college-related behavioral outcomes across different ethnic and gender groups at four-year institutions. *Research in Higher Education, 37*(4), 427-451.
7 Brown, A., Morning, C., & Watkins, C. (2005). Influence of African American engineering student perceptions of campus climate on graduation rates. *Journal of Engineering Education, 94*(2), 263-271.
8 Chachra, D., Chen, H. L., Kilgore, D., & Sheppard, S. D. (2009, October). *Outside the classroom: Gender differences in extracurricular activities of engineering students.* Proceedings of the 39th ASEE/IEEE Annual Frontiers in Education Conference, San Antonio, TX.
9 Kilgore, D., Atman, C.J., Yasuhara, K., Morozov, A., and Chachra, D. (2009). *Driven by passion, curiosity, engagement, and dreams: Findings from the Academic Pathways Study on Undergraduates/ Motivations to Study Engineering*. Paper presented at the American Educational Research Association Annual Conference, San Diego, CA.
10 Lichtenstein, G., McCormick, A. C., Sheppard, S. D., & Puma, J. (2010). Comparing the undergraduate experience of engineers to all other majors: Significant differences are programmatic. *Journal of Engineering Education, 99*(4), 305-317.
11 Veenstra, C. P., Dey, E. L., & Herrin, G. D. (2009). A model for freshman engineering retention. *Advances in Engineering Education, 1*(3), 1-33.
12 Astin, A.W. (1977). *What matters most in college: Four critical years*. San Francisco: Jossey-Bass.
13 Pace, C. R. (1984). *Measuring the quality of college student experiences.* Los Angeles, CA: Center for the Study of Evaluation, University of California Los Angeles.
14 Chickering, A. W., & Gamson, Z. F. (1987). Seven principles for good practice in undergraduate education. *AAHE Bulletin*, 3-7.
15 Tinto,V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45*, 89-125.
16 Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition* (2nd ed.). Chicago, IL: University of Chicago Press.
17 Kuh, G. D. (2002). *The college student report*. Bloomington, Indiana: Indiana University, National Survey of Student Engagement, Center for Postsecondary Research and Planning.
18 Higher Education Research Institute (HERI). (n.d.). *About CIRP*. Retrieved from Higher Education Reseearch Institute web site: http://www.heri.ucla.edu/abtcirp.php
19 CSEQ. (2007). *The College Student Experiences Questionnaire assessment program*. Retrieved from CSEQ website: http://cseq.iub.edu/cseq_generalinfo.cfm
20 Pace, C. R., & Kuh, G. D. (1998). *College Student Experiences Questionnaire* (4th ed.). Bloomington:Indiana University Center for Postsecondary Research and Planning.
21 National Survey of School Engagement (NSSE). (2011). *About NSSE*. Retrieved from National Survey of Student Engagement website: http://nsse.iub.edu/html/about.cfm
22 Besterfield-Sacre, M.E., & Atman, C.J. (1994). *Survey design methodology: Measuring freshman attitudes about engineering*. Proceedings of the 1994 American Society for Engineering Education Conference, pp. 236-242.
23 Besterfield-Sacre, M., Atman, C.J., Shuman, L.J., Porter, R.L., Felder, R.M., & Fuller, H. (1996). *Changes in freshman engineers' attitudes-a cross institutional comparison: What makes a difference?* Proceedings of Frontiers in Education Conference, FIE '96. 26th Annual Conference, vol.1, pp.78-82 doi: 10.1109/FIE.1996.567992
24 Besterfield-Sacre, M.E. et al. (1999). *Comparing entering freshman engineers: Institutional differences in student attitudes*. Proceedings of 1999 American Society for Engineering Education Conference, Charlotte, NC, June 1999.
25 Seymour, E., & Hewitt, H. M. (2000). *Talking about leaving: why undergraduates leave the sciences*. Boulder, CO: Westview Press.
26 Besterfield-Sacre, M.E., Moreno, M., Shuman, L.J., & Atman, C.J. (2001). Gender and ethnicity differences in freshmen engineering student attitudes: A cross-institutional study. *Journal of Engineering Education, 90*(4), 477 - 489.
27 Porter, S. R. (2011). Do college student surveys have any validity? *Review of Higher Education, 35*(1), 45-76.
28 McCormick, A. C. & McClenney, K. (2012). Will these trees ever bear fruit?: A response to the special issue on student engagement. *Review of Higher Education, 35*(2), 307-333.
29 Astin, A. W. (1984). Student involvement: A developmental theory for higher education, *Journal of College Student Personnel, 25*, 297-30.

30 French, B. F., Immekus, J. C., & Oakes, W. C. (2005). An examination of indicators of engineering students' success and persistence. *Journal of Engineering Education, 94*(4), 419-425.
31 Ohland, M. W., Frillman, S. A., Zhang, G., Brawner, C., & Miller III, T. K. (2004). The effect of an entrepreneurship program on GPA and retention. *Journal of Engineering Education, 93*(4), 293-301.
32 Eris, O., Chachra, D., Chen, H. L., Sheppard, S., Ludlow, L., Rosca, C., Bailey, T., & Toye, G. (2010). Outcomes of a longitudinal administration of the persistence in engineering survey. *Journal of Engineering Education, 99*(4), 371-395.
33 Veenstra, C. P., Dey, E. L., & Herrin, G. D. (2008). Is modeling of freshman engineering success different from modeling of non-engineering success? *Journal of Engineering Education, 97*(3), 467-479.
34 Meyers, K. L., Silliman, S. E., Gedde, N. L., & Ohland, M. W. (2010). A comparison of engineering students' reflections on their first-year experiences. *Journal of Engineering Education, 99*(2), 169-178.
35 Hartman, H., & Hartman, M. (2006). Leaving engineering: Lessons from Rowan University's College of Engineering. *Journal of Engineering Education, 95*(1), 49-61.
36 Trenor, J., Yu, S. L., Waight, C. L., Zerda, K. S., & Ting Ling, S. (2008). The relations of ethnicity to female engineering students' educational experiences and college and career plans in an ethnically diverse learning environment. *Journal of Engineering Education, 97*(4), 449-465.
37 Amelink, C. T., & Creamer, E. G. (2010). Gender differences in elements of the undergraduate experience that influence satisfaction with the engineering major and the intent to pursue engineering as a career. *Journal of Engineering Education, 99*(1), 81-92.
38 Espinosa, L. 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), 209-240.
39 Reyes, M. (2011). Unique challenges for women of color in STEM transferring from community colleges to universities. *Harvard Educational Review, 81*(2), 241-263.
40 Tate, E. D., & Linn, M. C. (2005). How does identity shape the experiences of women of color engineering students?.*Journal of Science Education and Technology, 14*(5-6), 483-493.