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Synthesis of Engineering Undergraduate Students' Out of Class Involvement

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Synthesis of Engineering Undergraduate Students' Out of Class Involvement

Abstract

As engineering educators prepare more high-quality engineers for the global workforce, more emphasis has been placed on developing students' professional skills, increasing student persistence, and improving diversity in the engineering workforce. Out of class activities have been considered as a unique way to improve these outcomes. Some empirical studies have been conducted to examine the effectiveness of out of class involvement in promoting engineering students' development. However, many of these studies focused on a single out of class activity or a single outcome and did not focused on engineering students. In order to better understand the role of out of class activity in engineering education and to accurately identify future research areas, the present study synthesized the findings on two domains: what factors are related to engineering students' participation in out of class activities and what are the outcomes of student participation. The results indicate that female and minority students are more likely to engage in out of class activities. Some institutional characteristics influence student participation. In general, out of class activities support engineering students' cognitive development, affective development, persistence in engineering, and career preparation. Different types of out of class activities are associated with different outcomes. These findings suggest that educators should encourage and support students to participate in out of class activities and point to the need for additional research.

Introduction

Increasing the number of engineering graduates and preparing the students for the global workforce is a national priority in the U.S.[1] In order to address this need, educational institutions have made great efforts to increase the recruitment and retention of students in engineering and improve students' professional skills through engagement in educational purposeful activities. Involvement in out of class activity has been believed as an effective way of promoting students' cognitive, affective, and career development in higher education.[2, 3] The Final Report for the Center for the Advancement of Engineering Education posits that research on student experience is fundamental to informing the evolution of engineering education.[4] College impact research suggests that focusing on what students do during college, both inside and outside of the classroom, is the best way to enhance student persistence. [3, 5] Though existing literature proves that co-curricular (associated with school, but not with a class) and extracurricular (not associated with school) activities are significant learning experiences for undergraduate students that positively impact their academic and career pathways, undergraduate engineering students are less likely than students in other majors to take advantage of such experiences.[6, 7]

Higher education literature review and its application to engineering students

Some systematic review and meta-analysis studies on co-curricular, extracurricular, and out of class activities in higher education have identified the educational outcomes of student participation. Five literature review studies on student involvement in collegiate settings have been reviewed for the present study.

Terenzini et al. provided a broad review of the relationships between out-of-class activities and student academic, intellectual, and cognitive learning outcomes.[8] First, they found that after controlling for precollege academic learning and cognitive ability levels, out-of-class experiences—such as living in a residence hall, working part time on campus, spending a term studying abroad, socializing with students from different racial groups, and interacting with students and faculty members on academic related activities—exerted a positive influence on student academic and cognitive development. However, not all out-of-class activities exerted positive influence on student learning. Students who belong to a fraternity or sorority, participate in men's intercollegiate athletics, work full time, and spend more time on socializing with friends and less time on academic interaction with students and faculty members had smaller academic gains compared to their peers.

Moore, Lovell, McGann, and Wyrick reviewed three specific co-curricular activities: Greek life, student government, and orientation programs, which are common on many campuses.[9] There were mixed findings on Greek membership; earlier studies tended to report Greek life influences student academic achievement in a negative way, but some recent studies did not find negative influence. Through participating in student government, students gained greater personal autonomy, more control over the organizational interests, and greater influence regarding nonacademic rule making. Orientation programs exerted positive influences on student retention and academic performance.

Hernandez et al. examined whether student involvement did make a difference to student learning and development by reviewing important literature on student involvement.[10] This study examined student involvement in athletics, Greek organizations, general activities and organizations, on-campus living, out-of-class involvement with faculty, peer interaction, and employment. Most of these studies showed positive influence of student involvement in student development (e.g., student organizations, living on campus, interaction with faculty, interact with students, and part-time employment) whereas a few indicated negative effects (e.g., athletics and Greek membership).

Montelongo discussed the factors that related to student involvement and consequences of student involvement.[11] First, this study summarized that some student and institutional characteristics are related to student involvement. For example, the students who maintained a high level of involvement in high school were more likely to be involved in college activities. The institutional size influenced student involvement, for example, non-greek and non-governing organizations were prevalent in large institutions. Second, the researcher found that participation in college student organizations had positive associations with students' overall college experiences. Increased satisfaction motivated students to actively engage in the campus activities of their institution. However, there were mixed findings in student learning and development when these constructs were measured differently. For example, the activity involvement was positively related to student educational aspiration and leadership skills but negatively related to student GRE score.

Gellin conducted a meta-analysis on the effect of undergraduate student involvement on critical thinking.[12] In this study, student involvement includes participation in athletics, Greek life, clubs and organizations, faculty interaction, peer interaction, living on campus, and employment. This study indicated that students who were involved in out of classroom activities experienced an overall .14 effect gain on critical thinking compared to their peers who were not involved, indicating that out of class experience explained 14% variance in student critical thinking. The researcher also examined the effect of specific involvement on critical thinking: involvement in clubs and organizations led to a .11 gain on critical thinking; peer interaction led to a .11 gain on critical thinking; living on campus led to a .23 gain on critical thinking; employment led to a .13 gain on critical thinking. The author also found that the definition of critical thinking varied across the synthesized studies and that no universally accepted definition exists.

In summary, these review studies generally concluded that students developed and learned when they were involved in activities outside of the classroom. However, these 5 review studies primarily focused on the *outcomes* of student involvement, little is known on the *factors* that explain why student become involved. Second, these 5 review studies were conducted more than 10 years ago. These represent the vast body of literature on undergraduate student involvement from 1980 to 2000 and all are focused on the general undergraduate student. Given the generational characteristics of students today differ in many ways from those 10 or more years ago, the patterns of student out of class involvement may also have changed in recent years.

Purpose

As the previous section described, some higher education literature review studies have synthesized the findings on general undergraduate student involvement. Because of links to preparing engineers for the global workforce, out of class activities have been getting more attention in recent years. There is growing research on the effectiveness of co-curricular and extracurricular involvement on engineering students' development. However, to our knowledge no systematic review or meta-analysis has been conducted to synthesize the findings on engineering student involvement in these activities. Why is this a concern? To explain, a startling fact must be stated. Despite the long established, known for more than three decades, link between participation in out of class activities and development of students' academic and professional skills needed in the global engineering workforce, recent studies show that engineering students still tend to be less involved in these educationally enriching activities than students in other majors.[6, 7] Does out of class involvement benefit engineering students the same as their peers in other majors? Why are engineering students less likely to participate in out of class activities? To begin to answer these questions, an examination of the factors related to engineering student participation is necessary. Therefore, this study takes a critical look at research that includes engineering students in order to examine demographics, institutional characteristics and outcomes for engineering students who participate as a way to position future research on their participation decisions.

The learning that occurs outside of the formal classroom environment plays important roles in students' cognitive and affective development and professional preparation. This paper explores the current state of the literature on participation and outcomes from out of class involvement. Two research questions guided the analysis:

1. What demographic and institutional characteristics are associated with engineering students who participate in out of class activities?
2. What are the positive and negative outcomes on engineering students stemming from out

of class involvement?

Methods

Article selection criteria

The focus of the present study is to synthesize the findings on factors related to engineering student out of class involvement and the influence of out of class involvement on engineering students' development. To select the articles for synthesis, we established the following criteria: (1) studies that focused on the factors that related to student involvement or the influence of out of class involvement; (2) studies that focused on undergraduate students in engineering-related majors in the U.S.; (3) studies that were quantitative, qualitative, or mixed methods research; (4) studies that were published in peer-reviewed journals or conference proceedings after 2000.

Article search process

Three approaches were utilized to search articles of our interest. First, a broad initial search in the databases of Engineering Village, ERIC, EBSCOhost, and Google scholar were conducted, using the keywords "co-curricular", "extracurricular", "out of class", and "engineering". These four databases were searched for the following reasons: Engineering Village incudes the journal articles and conference proceedings in engineering education such as the American Society for Engineering Education (ASEE) conference proceedings; the ERIC and EBSCOhost include research articles in higher education and provide access to the largest academic databases; Google scholar is a web search engine that provides access to scholarly literature across an array of disciplines. A total of 82 records were found in the initial search and 17 of those matched the criteria of the present study. Second, the Journal of Engineering Education, where the studies of out of class activities in engineering are most likely to be published, has been examined. Three articles have been identified from this journal. Third, a follow-up screening of the reference lists of the articles identified in the previous two steps has been conducted. Additional three articles were identified. In total, 23 articles on engineering students' out of class involvement were included for the present study.

Data analysis

Before synthesis, the articles have been categorized into groups. Among the 23 identified articles, four investigated the reasons students participate or the factors related to student participation, and 19 examined the outcomes of student out of class involvement. The articles on outcomes of student involvement have been categorized in to six groups by types of activity: undergraduate research, living learning community, service learning and practice learning, professional development programs, work experience, and general out of class activities. Different researchers applied different methods and focused on different sample of students, so the research findings should not simply be added up when exploring the patterns across studies. Instead, the participant samples and research methods will be described in order to accurately synthesize research findings.

Results

Overall characteristics of the data set

Using the search procedures and selection criteria previously described, 23 research articles on undergraduate student out of class involvement in engineering majors were identified (See table 1). These articles include three qualitative studies, 15 quantitative studies, and five mixed methods studies. Fourteen studies include only engineering students, and nine studies include students from Science, Technology, Engineering, and Mathematics (STEM) majors.

These articles were published in 1 conference proceeding and 6 journals: ASEE conference proceeding (9), Journal of Engineering Education (6), European Journal of Engineering Education (1), International Journal of Engineering Education (1), International Journal for Service Learning in Engineering (1), Journal of Women and Minorities in Science and Engineering (1), The Journal of Higher Education (1), Research in Higher Education (3).

Table 1
Summary of Research on Engineering Student Out of Class Involvement

Author/Year	Article Source	Research Methods	Types of Activity	Participants
Allendoerfer et al., 2012	Journal of Engineering Education	Mixed methods	Outside communities (e.g., family, extracurricular activities, religious organizations)	791 students in engineering, computer science, or pre-engineering major
Burt et al., 2011	ASEE conference proceeding	Qualitative	Co-curricular experiences (i.e., internships, co-ops, service project, and clubs and organizations)	23 engineering faculty and 31 engineering students
Carberry et al., 2013	International Journal for Service Learning in Engineering	Quantitative	Engineering service experience	261 engineering students
Ciston et al., 2011	ASEE conference proceeding	Quantitative	Living-learning community	135 engineering students with both living learning community participants and non-participants
Gerber et al., 2011	International Journal of Engineering Education	Mixed methods	Extracurricular design-based learning	13 students in STEM majors
Hirsch et al., 2005	Journal of Engineering Education	Quantitative	Integrated Summer Research Experience	39 bioengineering students
Holland et al., 2011	Journal of Women and Minorities in Science and Engineering	Qualitative	Professional development activities	62 students from engineering and computer science majors
Leiserson et al., 2004	ASEE conference proceeding	Quantitative	Undergraduate Practice Opportunities Program	223 engineering students with 80 in the treatment group and 143 in the control group
Meyers et al., 2012	ASEE conference proceeding	Quantitative	Engineering student organization	240 engineering students

Table 1
Summary of Research on Engineering Student Out of Class Involvement (continued)

Author/Year	Article Source	Research Methods	Types of Activity	Participants
Micomonaco, 2011	ASEE conference proceeding	Quantitative	Living learning community	499 pre-engineering students with approximately 30% living in the living learning community
Prewitt, et al., 2007	ASEE conference proceeding	Mixed Methods	Stratus mentoring program	8 engineering students
Ropers-Huilman et al., 2005	European Journal of Engineering Education	Mixed Methods	Service learning	40 engineering students
Samuelson et al., 2013	ASEE conference proceeding	Qualitative	Work experience	27 female engineering students
Schuurman et al., 2008	ASEE conference proceeding	Quantitative	Work experience	865 senior engineering student
Schuurman et al., 2008	Journal of Engineering Education	Quantitative	Work experience	1,479 senior engineering students
Soldner, et al., 2012	The Journal of Higher Education	Quantitative	Living Learning Program	5,240 first-year students in STEM majors
Strauss, et al., 2007	Research in Higher Education	Quantitative	Out-of-class activities	4,198 engineering students
Szelenyi, et al., 2011	Research in Higher Education	Quantitative	Living-learning program	294 women in STEM majors
Szelenyi, et al., 2011	Research in Higher Education	Quantitative	Living-learning program	294 women in STEM majors
Thompson et al., 2005	Journal of Engineering Education	Mixed methods	Undergraduate research	38 engineering students
Wilson et al., 2013	ASEE conference proceeding	Quantitative	General extracurricular activities	Over 1200 undergraduate engineering, computer science, and mathematics students
Wilson et al., 2014	Journal of Engineering Education	Quantitative	Co-curricular activities	Over 1000 undergraduate students in engineering and computer science
Zydney et al., 2002	Journal of Engineering Education	Quantitative	Undergraduate research	245 students graduated from engineering majors with 157 had undergraduate research experience and 88 had no undergraduate research experience

Factors related to participation

Student characteristics. Some individual characteristics were associated with student involvement. Meyers, Pieronek, and McWilliams explored the factors related to student involvement and leadership in student organizations in a medium-sized private institution.[13] A total of 240 engineering students participated in the survey. First, the researchers found that male students reported a lower level of involvement in all types of extracurricular activities than female students. Second, non-White students are more likely to be involved in the engineering and community organizations than White students. Third, students with the intention to work in an engineering-related field after graduation were less likely to be involved in the community organizations, while the students without the intention to work in engineering-related fields are more likely to be involved in the community organizations (e.g., off campus organizations) instead of engineering organizations (e.g., student organizations within engineering).

Micomonaco examined the relations between pre-college characteristics and students' involvement in a living-learning community.[14] A total of 499 first-year pre-engineering students in a large research university participated in the survey. The living-learning community participants and non-participants were similar in most pre-college characteristics, for example, ACT composite, ACT math, and high school GPA. However, the females were more likely to participate in the living-learning community than the males, and the Asian American and African American students were more likely to participate than the international students.

Holland, Major, Morganson, and Orvis conducted a qualitative study to explore how students in engineering and computer science were involved in professional activities.[15] A total of 62 students from a Primarily White Institution (PWI) and a Historically Black Community and University (HBCU) participated in 8 focus groups. First, the researchers found the females were involved in the university-focused professional activities much more than their male peers, while males were more interested in the informal professional activities, such as networking and causal interactions with peers and alumni. Moreover, this study explored students' intrinsic and extrinsic motivation in participating in the professional activities. The intrinsic motivation included intrinsic interest in the major, valuing the interaction with peers, and considering out-of-class involvement as a nice break from their coursework. The extrinsic motivation included improving student marketability and enhancing the chance of obtaining a better job. In addition, the researchers found that some factors support students' involvement in professional activities, for example, advisor and faculty encouragement, and the role models of senior students or alumni, while some factors prevent student participation, such as scheduling issues and lack of the information about the opportunity.

Institutional characteristics. Wilson et al. examined the influence of institutional characteristics on engineering, computer science, and math students' involved in extracurricular activities.[16] Over 1,200 students from five institutions—a HBCU, a small teaching institution, a large research institution, a medium sized teaching university, and a small women's college—participated in the survey. The researchers found that institutional culture rather than student characteristics affect what students do outside of class and how often they do it. Among the 5 institutions that were examined in the study, small institutions tend to have more students involved in extracurricular activities. In addition, the students in the institutions with faith-based missions or cultures have a higher level of extracurricular involvement than students in other institutions. Holland et al. found that students in the PWI were more active in the career-building activities, while students enrolled in the HBCU were more interested in the organizations that targeted women and minorities.[15]

Although there is a lack of studies on how students make decisions in out of classroom involvement, there is some research on the factors related to participation. In summary, females and minorities are more likely to participate in different types of out of class activities than males and White students. Both intrinsic (e.g., personal interest) and extrinsic (e.g., to get a better job) motivations encourage students to participate in out of class activities. Some institutional characteristics are related to student involvement, such as the size and culture of the institution.

Outcomes of student participation

Undergraduate research. Hirsch, Linsenmeier, Smith, and Walker investigated the effectiveness of summer research experience in improving bioengineering students' competency in ethics and communication.[17] Through comparing 39 participants' assessment results at the beginning and end of the summer research, this study revealed that students developed a greater awareness of key concepts in ethics, and understood the importance of audience and the multifaceted nature of technical communication.

Zydney, Bennett, Shahid, and Bauer investigated the impact of undergraduate research on student development by comparing 157 graduates with research experience and 88 graduates without research experience.[18] They found that the graduates with undergraduate research experience were more likely to pursue graduate degrees and had greater improvement on cognitive and personal skills.

Overall, these two articles reported positive influences of undergraduate research experiences on student development, including ethical development, communication skills, career development, cognitive development, and personal skills. These studies highlighted the importance of undergraduate research experiences in engineering education.

Living learning community (LLC). Ciston, Carnasciali, Nocito-Gobel, and Carr compared the engagement and sense of affiliation with the engineering program between 53 engineering students who participated in LLC and 82 students who did not.[19] The LLC participants benefited from academic support, a sense of affiliation with the engineering program, and access to the academic resources. Compared with the non-participants, LLC participants were more likely to engage in extracurricular activities within the Engineering College and in the university. In addition, they were more likely to have study groups and were more likely to persist in the study groups over multiple years.

Micomonaco investigated the influence of LLC in first-year engineering students' disciplinary retention.[14] A total of 499 students were asked to complete a survey at the beginning and the end of the academic year. Students who participated in LLCs tended to have a stronger sense of connection with the engineering program and peer students—viewing themselves as members of engineering, expecting more friends in engineering, and studying with engineering students. However, the LLC participation is not related to students' intention of persisting in engineering.

Soldner, Rowan-Kenyon, Inkelas, Garvey, and Robbins investigated how LLC influences students' intention to persist in STEM disciplines using a sample of 5,240 freshmen across the nation.[20] The researchers found that students who participated in the STEM-focused living learning programs were likely to graduate with a degree in a STEM field, but found no effect for the non-STEM living learning programs. More importantly, the path analysis found that the living learning program influenced students' decisions to persist in STEM majors through academic interactions with peers, academic and nonacademic interactions with faculty, and the social supportive residential environment.

Using two-wave longitudinal data from 2004-2007 National Study of Living Learning Programs

(NSLLP), Szelényi and Inkelas investigated how the living learning program affected 294 female students' persistence in STEM majors.[21] The researchers found one year involvement in the living-learning program at the beginning of the women' college education has a long-term positive relationship with plans to attend graduate school in the fourth year of college. Szelényi, Denson, and Inkelas investigated how living-learning program participation influenced women's professional outcome expectations using the same data.[22] They found, after controlling for students' demographic and academic background characteristics, pre-college self-efficacy and self-confidence, learning experience, academic and social contextual influence, and fourth year self-confidence, participation in the living learning program positively influenced students' overall professional outcome expectation, as well as achieving career success and combining a professional career with having a balanced personal life.

To sum, these studies reported positive influences of LLC on student engagement, connection with engineering programs, and career expectations. The LLC involvement affects student development through interactions with peers and faculty and the supportive residential environment. However, there is mixed findings on the relationship between LLC involvement and persistence in STEM majors, one study reporting positive influence and another study revealing no influence. Therefore, more studies will be needed to confirm the impact of LLC on students' persistence in engineering.

Service learning and design based learning. Carberry, Lee, and Swan investigated the service learning experiences of 261 students and found that on average students identified 45% of what they have learned about technical skills and 62% of professional skills was gained through the engineering service experience.[23] Ropers-Huilman, Carwile, and Lima examined how a first-year biological engineering design course that incorporated a service-learning project helped students to achieve learning objectives using a survey and focus groups.[24] The results indicated that service-learning project was a useful method for achieving the learning objectives that are set forth by the Accreditation Board of Engineering and Technology (ABET).

Gerber, Marie Olson, and Komarek explored the influence of designed-based learning on students' learning outcomes using a survey, daily diary, interviews, and observations.[25] The results revealed that the design-based learning experience developed students' self-efficacy in innovation and learning outcomes outlined by the ABET.

The ABET requires educational institutions to provide opportunities for students to practice technical and professional skills. Service learning and design-based learning emphasize students' problem solving skills, critical thinking, and application of classroom knowledge in practice. These two studies supported the role that service learning and design-based learning played in improving students' learning outcomes that outlined by ABET.

Professional development programs. Leiserson, Masi, Resto, and Yue assessed the effectiveness of an Undergraduate Practice Opportunities Program (UPOP) at MIT using both qualitative and quantitative methods.[26] The UPOP is a co-curricular program that provided professional engineering experiences and non-technical professional abilities for sophomores. Compared with the control group, the researchers found that the UPOP participants gained improvement in non-technical professional abilities in many areas, for example, interpersonal and teamwork abilities, presentation, identification of customer needs, and comprehension of organization dynamics.

Thompson, Alford, Liao, Johnson, and Matthews investigated the influence of a Research Communication Studio (RCS) on student learning.[27] A total of 38 engineering students participated in the RCS program with 60-75 minutes of weekly meetings for one year. The RCS program taught undergraduate researchers authentic written, oral, and graphical communication skills while they were learning to do research. Survey data from the RCS participants, advisors, and graduate mentors suggested that the undergraduate researchers gained progress in cognitive development and communication skills.

Prewitt, Daily, and Eugene examined how a mentoring program of the National Society of Black Engineers influenced minority students' retention and success in engineering.[28] The purpose of the mentoring program was to help minority students adjust to college life and matriculate confidently through the Engineering curriculum. Using survey and interview data, the researchers found the mentoring program created social support for students to succeed. For example, the mentoring program created a family atmosphere, which in turn improved the interconnectedness among members.

In sum, these professional development programs successfully achieved their goals in improving students' knowledge, skills, and adjust to new environments. The results highlighted the roles of these specific programs in engineering education.

Work experience. Schuurman, Pangborn, and McClintic compared the career development of engineering graduates with workplace experience and those without workplace experiences.[29] A total of 865 senior students participated in the survey. The results revealed that students with workplace experiences reported higher starting salary and more on-campus and on-site interviews. Female students benefited more from the work experiences. In another study, Schuurman, Pangborn, and McClintic examined how undergraduate work experience affected engineering students' academic achievement and career development.[30] A total of 1,479 senior engineering students participated in the survey. The results revealed that the students with more working experiences had a higher starting salary after graduation and were more likely to get a job offer prior to graduation. But the influence of work experiences on GPA is minimal. In addition, the work experiences equally benefit male and female students. Samuelson and Litzler specifically explored the influence of work experiences on female students.[31] They interviewed 27 female engineering students with an internship or co-op experience. The internship and co-op experiences influenced students' perceptions of the engineering field, persistence in engineering, and career decisions. Overall, the students with work experiences are more likely to get a job offer, have higher starting salaries, and persist in engineering.

General out of class activities. Some studies examined the overall impact of out of class involvement on student development. Allendoerfer et al. investigated that how the outside community affected student success using survey and focus group data.[32] A total of 791 students from engineering, computer science, and pre-engineering attended the survey. The survey data revealed that students have strong connections with family, religious organizations, clubs (primarily on-campus), and classes during their undergraduate years. Focus group data revealed that the connection with outside communities meet students' esteem needs, belonging needs, and safety needs, which in turn facilitate their engagement in engineering education.

Burt et al. examined the benefit of involving engineering students in co-curricular experiences using focus group data.[33] The researchers found that co-curricular involvement promoted students' development in leadership skills, exposure to decision-making, and the ability to articulate ethical development.

Strauss and Terenzini examined the contribution of out-of-class experiences on engineering students' analytical and group skills using data from 4,198 graduating engineering students on 39 campuses nationwide.[34] After controlling for an array of student precollege characteristics and student classroom experiences, some out-of-class experiences—including internships and cooperation education, engineering design competitions, and involvement in professional societies or associations—had unique contributions on both analytical and group skills.

Wilson et al. examined the co-curricular experiences of undergraduate engineering and computer science students.[35] The analyses of the survey data from over 1,000 participants revealed that the relationship between the hours spent in co-curricular activates and emotional engagement was not significant. But some specific activities have significant relationship with emotional engagement. For example, faculty-led groups, informal study groups, and university community had positive relationship with emotional engagement whereas sorority or fraternity membership had negative relationships with student emotional engagement.

In general, student involvement in out of class activities promoted the development in leadership skills, analytical skills, group skills, and engagement. However, not all study reported significant positive results. More studies will be needed to confirm the influence of out of class activities on different aspects of student development.

Discussion

Engineering education historically focused on developing students' technical skills. Now more and more policy makers and educators emphasize engineering students' holistic development, for example, the ABET outcomes and Engineer of 2020 include both technical and non-technical (e.g., leadership and communication) skills. As a result of this change, the learning that occurs outside of the classroom has attracted increasing attention in recent years because co-curricular/extracurricular activities supports the development of the whole engineer. Empirical studies have been conducted to justify the associations between student out of class involvement and learning outcomes. Some review studies synthesized the findings of student involvement in higher education, but no review study has been conducted in engineering education. The present study examined the studies of engineering students' out of class involvement, and synthesized the findings on what factors are related to student participation and what outcomes are developed from student participation.

The present study has mainly four findings. First, there is limited number of empirical research on out of class involvement in engineering education. An extensive search only generated 23 articles between January 2000 and December 2014. Among the limited articles, most of them are published in the ASEE conference proceedings and few of them are published in peer-reviewed journals. This finding indicates that very few studies specifically examined engineering students' out of class involvement. Although the studies in higher education have consistently reported that positive influence of out of class experiences on student development, we still need to confirm the findings with engineering students.

Second, some demographic and institutional characteristics are related to engineering student out of class involvement; for example, women and minority students are more likely to participate in out of class activities. Women and minority groups has long been an important policy concern in postsecondary education. The policymakers and educators have made great efforts to improve the engagement, persistence, and educational attainment of under-representative groups in engineering. The finding that women and minority students were more likely to participate in out of class activities indicates that the efforts of promoting the engagement of under-representative groups in engineering take effects. In addition, institutional characteristics, such as the institutional size and culture, influence students' involvement in out of class activities. This finding confirmed the proposal that the institutional policy and practice can affect the way students spend their time and energy in academic pursuits, which in turn affect students' gains.[2] For example, the administrative decisions on the number and types of activities and regulation regarding participation will influence the resources and opportunities that students can access, which play critical roles in student development.

Third, the majority of the studies reported positive influence of co-curricular experiences on engineering students' engagement, persistence, learning outcomes, and career development. When students invest more time and energy on campus activities, participate more actively in in-class and out-of-class activities, and interact more frequently with peers and faculty, they are more likely to gain educational progresses. According to Austin's involvement theory, the goal that a student can achieve is a function of the time and effort they devote to specific activities that designed to produce certain gains.[2] The greater involvement in college, the greater amount of cognitive and affective gains students will achieve. This finding is consistent with the results in higher education that students learned and developed in out-of-class activities. For example, living on campus has consistent positive effects on student development.[3, 8, 10]

Fourth, different types of out of class activities are associated with different types of outcomes. Undergraduate research was associated with students' ethical competency, communication skills, career development and personal skills. LLCs facilitated student engagement, connection with the college, and career expectations. Student outcomes from involvement in service learning and design-based learning aligned with many of the student outcomes outlined by ABET. Professional development programs improved students' specific professional skills. Working experiences during undergraduate years was more associated with students' job opportunities and starting salary. This finding suggests that educators could take specific steps to improve students' development.[9] For example, in order to improve students' communication skills, educators could encourage students to participate in undergraduate research, to communicate their ideas with faculty, and to present their finding to public. These results provide a comprehensive list of outcomes from involvement in out of class activities that can now be used to support future research to fill knowledge gaps noted.

Conclusion & Future Work

The present study made significant contribution to the literature of out of class involvement in engineering education. To our knowledge, no review study has been conducted to integrate the findings of out of class involvement in engineering. This study confirmed that out of class activities have positive influence on student development in engineering. Student participation is related to student and institutional characteristics. These findings have important implication for practice and future research. In order to effectively prepare engineering students for a competitive workforce, the faculty and advisors should encourage students to be actively involved in both formal and informal learning.

However, there are some limitations of the present study. First, there is no consensus on the definition of co-curricular and extracurricular activities. The lack of clear definition influenced the selection of articles for the synthesis study. Second, this synthesis study is based on a limited number of empirical studies on engineering students' out of class involvement. Only four studies examined the factors related to student participation and one examined the reason why student participate. Six types of out of class activities have been examined in this study, but only two to five articles have been reviewed for each type of activity. Third, the majority of the research that reviewed in the present study are based on a small number of sample at specific types of institutions, so the findings could not be generalized to all engineering students or engineering programs.

There are at least three areas that scholars could pursue in the future research. The first area is the reasons why students participate in out of class activities or not. Although some studies revealed the individual and institutional characteristics were related to student involvement, it is still unknown that why some students actively involved in out of class activities and other students were not. Understanding the reasons or decision-making process of student participation will help the college administrators to promote student involvement. The second area is why out of class involvement impact student development. Although most of the studies found positive impact of out of class activities on student development, very few studies explored why some co-curricular or extracurricular programs have the effects they do. Without the understanding of influence mechanism, it is difficult to implement the successful co-curricular or extracurricular programs in a different context or setting.[36] The third area is the long-term effect of out of class activity on students' life after college. Most of the studies examined the short-term impact of student experiences within college. How postsecondary education affects students' career success and personal life after college has received increasing attention in recent years.[36] Future research will be needed to explore the long-term effect of out of class experiences on students' development.

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