

Retention of Under-Represented Minority Engineering Students through Practice-Oriented Experiential Education

*Richard Harris¹, Hameed Metghalchi², Claire Duggan³, Emanuel Mason⁴,
Rachelle Reisberg⁵, Deepti Dutt⁶*

Abstract – New England is home to several universities that have engaged in a well-established National Science Foundation (NSF) Louis Stokes Alliance for Minority Participation (LSAMP) partnership, referred to as Northeast LSAMP. The NELSAMP members include Northeastern University, The University of Connecticut, The University of Massachusetts Amherst, The University of Rhode Island, and Worcester Polytechnic Institute. The NELSAMP are pursuing an NSF-funded engineering educational research study to investigate the hypothesis that participation in practice-oriented experiential education (POEE) programs, such as formal cooperative education, internships and research experiences for undergraduates, leads to enhanced self-efficacy, augmented learning, and an increased likelihood of retention, particularly among minority students who are historically under-represented in engineering. One promising approach to retaining undergraduate minority students is the provision of programs that allow students to gain early POEE. This study will investigate whether POEE is a critical predictor of under-represented students' learning and retention through its impact on self-efficacy.

Keywords: Underrepresented, Minorities, Practice-Oriented, Experiential Education, Self-Efficacy

Under-Representation in Engineering

In the next fifty years, the minority population in the United States will continue to increase at a much faster rate than the non-minority population. In fact, data derived from the U.S. Census Bureau 2000 & Engineering Workforce Commission 2000 shows that “underrepresented minorities now comprise over 25% of the U.S. Population, yet still comprise only 6.4% of total engineering labor force.”

According to the 2010 [8] report issued by the National Academies titled ‘*Expanding Underrepresented Minority Participation: America’s Science and Technology Talent at the Crossroads*’, the U.S. must involve under-represented minorities in science and engineering to maintain a globally competitive edge. This recent report essentially builds on an alarm that was sounded five years earlier in the 2005 publication: *RISING ABOVE THE GATHERING STORM* by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. This has considerable implications for the STEM professions, such as engineering, where minorities make up a disproportionately low percentage of the workforce. According to U.S. Census Bureau projects, non-Hispanic white males will decline as a fraction of the working age population from 37% in 1995 to 26% in 2050. In that same time span, the fraction of African Americans in the workforce will increase from 12 to 14%, Hispanics from 10% to 24%, and Asians from 4% to 9% [22]. Despite comprising a growing portion of the U.S. workforce, minority populations continue to be under-represented in engineering. In 1997, Blacks made up 10.3% of the U.S.

¹ Northeastern University, 360 Huntington Ave., Boston, MA 02115, ri.harris@neu.edu

² Northeastern University, 360 Huntington Ave., Boston, MA 02115, m.metghalchi@neu.edu

³ Northeastern University, 360 Huntington Ave., Boston, MA 02115, c.duggan@neu.edu

⁴ Northeastern University, 360 Huntington Ave., Boston, MA 02115, e.mason@neu.edu

⁵ Northeastern University, 360 Huntington Ave., Boston, MA 02115, r.reisberg@neu.edu

⁶ Northeastern University, 360 Huntington Ave., Boston, MA 02115, deeptidutt.a@gmail.com

Workforce, but only 3.2% of the Science, Engineering, and Technology (SET) workforce. Hispanics comprised 9.2% of the overall workforce and 3.0% of the SET workforce.

Today's engineers need more than simply technical skills. They are expected to be top-producing team players with experience in working and communicating across racial, ethnic, and gender boundaries. The Accreditation Board for Engineering and Technology (ABET) explicitly recognizes the need for diversity in training institutions [9]. As a result, diversity on college campuses is critical to preparing both minority and nonminority engineering students and to help correct imbalances in the workforce. From 1992 to 1996, the number of underrepresented minorities enrolled as full-time first-year students in engineering showed an overall decline of 5%, which exceeded the decline among non-minority students. While there was a 3% drop in Hispanic enrollment, the decline was even more striking for African American enrollment, which fell by 16% [22]. In 1995, under-represented minorities constituted 17.4% of the freshman engineering class, but by 2001, this number had fallen to 15.8% [8]. A significant proportion of African Americans who earn degrees in science and engineering do so at Historically Black Colleges and Universities (HBCU). While HBCUs comprise only about 4% of all four-year colleges and universities, in 2000 they conferred slightly over 26% of all science and engineering degrees awarded to African Americans [8].

Attrition of minorities in engineering majors is cited as a major barrier to producing more minority graduates in engineering. Although there were no measurable differences in STEM entrance among White, Black, and Hispanic students, White students had a higher STEM bachelor's degree completion rate than did Black and Hispanic students. Asian students also had a higher STEM bachelor's degree completion rate than did Black and Hispanic students [6]. A 1995 report by the National Action Council for Minorities in Engineering, Inc. (NACME) found a graduation rate of 35.0% for under-represented minority students who entered a sample of 112 institutions as freshmen between 1986 and 1989 [9]. This compares to a graduation rate of 68.3% for their nonminority counterparts (CAWMSET, 2000). Both minorities and non-minorities were more likely to persist in engineering if they made it to their sophomore years, with 57% of minority engineering sophomores persisting to graduation compared to 87% of non-minority sophomores and furthermore, retention and graduation rates are areas where US engineering schools have some direct control and can exert critical influence [31].

Practice-Oriented Experiential Education

Colleges and universities around the country are placing growing emphasis on programs that allow students to gain work and research experience and are beginning to define success by more than just academic learning. These programs, referred to in this proposal as practice-oriented experiential education or POEE, comprise co-op jobs, internships, apprenticeships, undergraduate research and other methods that integrate experience in the world with experience in the classroom. These approaches are becoming increasingly relevant in a work culture characterized by the need to continuously reflect and learn from ongoing experience [29]. A 1998 census of cooperative education found that approximately 250,000 U.S. students were placed in cooperative education jobs that year [28]. According to the Cooperative Education Division of the American Society for Engineering Education, engineering students comprise approximately 75% of all co-op students which translates to 187,500 students completing co-ops in engineering annually using the 1998 census [27]. Given these high numbers of students around the country completing engineering coops, it is important to study these programs and find ways to strengthen them and scale them up across other STEM disciplines. In addition, co-op experiences provide a means for engineering programs to fulfill several outcome criteria required by ABET, including: an ability to apply knowledge of mathematics science, and engineering; an understanding of professional and ethical responsibility; an ability to communicate effectively; a recognition of the need for, and an ability to engage in life-long learning; and an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. Thus, co-op/internship programs and undergraduate engineering research are seen as affecting not just academic learning but learning that is characteristically practice-based.

Cooperative Education as a feature of POEE

Cooperative education experiences provide a natural opportunity for students to gain hands-on learning experiences and apply theoretical coursework to real-world situations. As stated previously, engineering students constitute the largest group by major of students participating in cooperative education. Further, co-op programs potentially address the discouragement experienced in particular by minority students with the straight lecture style pedagogy common in mainstream science and engineering education [32]. A number of outcome studies have been conducted that demonstrate the positive effects of cooperative education in the domains of career development, academics,

initial employment, economic gains, and personal growth. For example, co-op students have been found to make more informed career decisions [37], have higher academic achievement and persistence [34], to be more likely to hold positions with higher levels of responsibility [3], to take less time to find their first job, to receive higher starting salaries and more frequent raises and promotions [13], and to have higher self-confidence and enhanced career identity [36].

A key discriminator of retention is proposed to be the very presence of formal cooperative education/internships and/or undergraduate research programs within undergraduate education. To acknowledge the relationship between work/research experience and education, these experiences are referred to as practice-oriented experiential education (POEE). One of the sample schools is a co-op school. With the four remaining schools, although some students participate in internships and co-op, the majority do not participate in any formal co-op/internship programs with the possible exception of undergraduate research. In the five school NELSAMP sample, there will be nearly equivalent numbers of students participating in co-op and/or research programs and in 'classroom only' experience.

While some students in engineering programs may supplement their coursework by pursuing part-time or summer employment, or even by volunteering, a critical hypothesis of this study is that it is the intentionality and formality of practice-oriented experiential education that distinguishes POEE from other individualistic work experiences. This study asserts that higher degrees of self-efficacy, learning, and retention are produced because of the formal structure of POEE-related programs, as required of LSAMP students, that intentionally links theory with work experiences and asks students to, in turn, use their practice to inform theory.

Peer Mentoring as a feature of POEE

The tradition of peer reflection has a long history in classroom-based experiential education, though its contribution as a concurrent and collective practice supporting work experience is more recent [30]. There are a number of reasons for this, prominent among which is the stark perspective that learning can occur in the midst of practice rather than more conventionally as a representation transmitted from teacher to student [17]. Instead of banking knowledge into one's mind, knowledge can be viewed as an interactive contention among a community of inquirers who share meanings, interpretations, and ideas [16].

From a contextualized or situated learning perspective, peer reflection has a number of distinctive features that permit its consideration within the branch of learning referred to as praxis. First, it is not merely a cognitive or mental process, but it is also a behavioral process. It can involve others as opposed to being an individual experience. It is typically concerned with critical inquiry, probing into the deep recesses of experience. It often requires some facilitation to help learners reframe their knowledge base but the facilitation is not equivalent to classic teaching. Finally, it can occur concurrently with practice rather than before or after experience.

Peer mentoring can provide unique benefits. A study by McDougall and Beattie [24] found that individuals were more likely to discuss personal feelings and insecurities with their peer mentor than with a hierarchical mentor, although the latter was thought to be more effective in providing insight into organizational politics.

This study calls for facilitation in learning teams constituted of peer mentors. Facilitation in practice-oriented education has its basis in constructivism which stipulates that the purpose of teaching is not to transmit information but rather to encourage knowledge formation and development [5]. Constructivism makes room for a conceptual guide because students' cognition when activated by experience requires integration of new information into a taught knowledge base [1].

Self-Efficacy as a feature of POEE

Social learning theory has emphasized the importance of career-related self-efficacy expectations in understanding the advancement of historically under-represented students in science and engineering fields [14]. Self-efficacy is defined as an individual's perceived level of competence or the degree to which an individual believes she is capable of completing a task. Self-efficacy is a dynamic trait that changes over time and can be influenced by experience. Self-efficacy expectations are considered the primary cognitive determinant of whether or not an individual will attempt a given behavior. Bandura [2] identified four sources of information that shape self-efficacy: (1) performance accomplishments, (2) vicarious experience, (3) verbal persuasion, and (4) affective states.

Unfortunately, since few career self-efficacy studies have included significant minority samples, the relationship between ethnicity and efficacy has not been firmly established for a minority population [14]. The studies that have examined this issue have found evidence for self-efficacy as a framework for minority career development. For

example, in one study where ethnic contributions to self-efficacy ratings were analyzed, Mexican-American engineering students reported lower self-efficacy expectations than did Euro-American engineering students even though these groups showed no differences in academic performance [15]. In a study of Latino college students at an urban, commuter school, self-efficacy was an important determinant of learning outcomes, including increased intentions to graduate and stronger social connections [35]. In a study of eighth graders, social cognitive career theory (which includes self-efficacy as a primary component) did the best job of explaining the persistence of minorities in aspiring to science and engineering careers over a six-year period [23]. In addition, self-efficacy predicted interests and academic choice intentions in a sample of African-American first-year undergraduates [12].

Despite the paucity of data, it appears that minority students may be disadvantaged with respect to exposure to the four sources of efficacy information. Minority students may have difficulty experiencing academic success and attainment, resulting in fewer enactive mastery experiences [14]. The scarcity of minority role models and isolation from peers deprives minority students of vicarious learning experiences and the opportunity to receive verbal encouragement [14]. Finally, affective states are affected by feelings of hopelessness, helplessness, or anger that can arise from feeling different [14].

One study of minority students who had switched out of science and engineering found that they had a distinctive tendency to blame themselves rather than departments, faculty, or institutions for all, or most, of their difficulties [32]. In many cases, a minority student's decision to leave the major was preceded by a loss of confidence in the ability to do science [32]. Additionally, negative stereotypes arising from one's own ethnic group or outright racism can contribute to the weakening of self-efficacy beliefs [38].

Some evidence suggests that self-efficacy beliefs may even be more important in minority career choice and development than for non-minorities. For example, we know that self-efficacy beliefs can moderate the effects of performance on standardized tests. Students who score in the lower range on standardized math tests but have high self-efficacy beliefs, have obtained higher GPAs than those with low scores and low self-efficacy beliefs (Brown, Lent, Larkin, 1989) [4]. Since minorities as a group earn lower scores on standardized tests, self-efficacy beliefs may hold additional importance in academic achievement and retention.

In addition to its importance as a factor influencing retention and success in engineering, self-efficacy theory also provides a promising avenue for tying practice-oriented processes to outcomes [10]. Fletcher [11] provided a theoretical framework to explain how cooperative education experiences enhance self-efficacy and help students make the transition from student to practitioner. Specifically, Fletcher suggested that cooperative education increases self-efficacy through performance accomplishments, one source of efficacy information. In this case, performance accomplishments would be co-op, internship and/or undergraduate research experiences where individuals use skills, abilities, and coping strategies to perform tasks. Further, the peer mentoring interventions are thought to increase self-efficacy beliefs through Bandura's vicarious experiences and verbal persuasion sources.

Learning as a feature of POEE

This study's model explicitly refers to "practice-oriented learning" in addition to academic learning. It is proposed that practice-oriented educational experiences enhanced through reflective practice would be especially inductive of the former kind of learning. Practice-oriented learning can be distinguished by it being practical and dialectical rather than didactic.

According to Raelin [30], didactic learning arises from propositional knowledge which involves placing into practice thoughtful action based on theoretical formulations. Propositional knowledge is concerned with "knowing what." Practice-oriented learning, however, makes use of practical knowledge, which entails deliberation among competing versions of effective practice. The ensuing dialogue helps learners not just know what, but also "know how". Practice-oriented experiential learning is further based on dialectical knowledge, which views reflection as the reorganization or reconstruction of experience. In this view, knowledge is emergent and viewed as a recasting or reframing of conventional ways of understanding so as to generate an appreciation of any novelty in the practice situation. Dialectical knowledge can be used, therefore, to transform practice by asking practitioners to attend to features of the situation that were previously ignored. It might entail reconstructing taken-for-granted assumptions that might even lead the practitioner to identify and address the social, political, and cultural conditions that constrain self-insight. It is concerned with not just knowing what and how, but in "knowing why."

The NELSAMP project therefore seeks to develop and research interventions that effectively address the learning and retention of under-represented minority students in engineering. Research from the fields of cooperative

education, mentoring, reflective practice, learning, and self-efficacy theory will serve as the scholarly basis for the proposed research. The evidence from the project will be used to demonstrate how features of practice-oriented experiential education can be valuable in addressing factors associated with minority attrition in engineering.

This project is innovative in that it sits apart from previous work, while also taking into account the study currently being conducted by Joe Raelin, Northeastern University Asa Knowles Chair of Practice-Oriented Education, in the ‘*Pathways to Self Efficacy and Retention of Women In Undergraduate Engineering*’, which could impact future national studies involving learning outcomes from work experience. This research project seeks to develop a theory that examines the effects various forms of practice-oriented experiential education and mentoring, as well as other factors (demographics, contextual supports and barriers), have on the self-efficacy beliefs, learning, and retention of under-represented minority students. While self-efficacy and social cognitive career theories (SCCT) have provided models that demonstrate pathways between demographics, cognitive variables, and choice behaviors (e.g., persistence), we are not aware of any study that has controlled for practice-oriented experiential education at the undergraduate level by explicitly selecting URM student populations that participate in cooperative education-POEE and non-cooperative education-POEE.

Hypotheses

The study seeks to test whether practice-oriented self-efficacy and academic self-efficacy alone and in interaction with a number of contextual and demographic variables, contribute to the retention of under-represented minorities in undergraduate engineering programs. Survey data will be collected to measure the effect of different program interventions, including cooperative education, undergraduate research, peer reflection, and mentoring experiences, on self-efficacy and retention. Specifically, it is hypothesized that:

- 1) Learning that is both practice-based as well as academic is a fundamental causal factor in promoting the retention of minority students in undergraduate engineering programs.
- 2) Work and academic self-efficacy are primary predictors of learning and retention among minority students in undergraduate engineering programs.
- 3) Practice-oriented experiential education (programs, such as cooperative education/internship and undergraduate research) is a critical predictor of under-represented students’ learning and retention directly and indirectly through its impact on self-efficacy.
- 4) Enriched POEE, which applies adult and peer mentoring to co-op experience, significantly increases the effect of cooperative education and/or undergrad research on self-efficacy and on learning and retention.
- 5) Contextual variables – supports (such as family support) and barriers (such as financial constraints) – affect learning and retention both directly and indirectly through self-efficacy and moderate the effect of practice-oriented experiential education.
- 6) Demographic variables, such as high school performance and socio-economic background, have an independent effect on learning and retention but also interact with practice-oriented experiential education, contextual variables, and self-efficacy to indirectly affect learning and retention.

Findings expected from the proposed research will incorporate the following unique contributions:

1.) Provide additional data on how self-efficacy models applied to career theory explain the behavior of an under-represented population. While self-efficacy models have been tested in numerous studies (Lent et al.[18]; Lent et al. [19]; Lopez, Lent, Brown, & Gore [21]; Nauta & Epperson [26]; Schaefer, Epperson, & Nauta [33]), there have been some concerns about how well the model can be generalized to under-represented groups [19]. Lent and Worthington [20] point out the need for additional studies to continually test the usefulness of a theory with particular populations: “the cultural validity or cross-cultural generalizability of any theory is, ultimately, an empirical question and not solely a matter of expert judgment” [20].

2.) Contribute to the research base on practice-oriented experiential education. A number of studies have provided information on the outcomes associated with participation in cooperative education. However, there have been virtually no studies that explain what elements within the cooperative education model and/or undergraduate research works. While self-efficacy theory has been cited in theoretical pieces [11], there is a need to empirically test the inherent processes of practice-oriented experiential education [10].

3.) Identify which aspects of POEE and mentoring experiences are most valuable to under-represented minority students in engineering. Although there is anecdotal evidence that the quality of the experiences in undergraduate research, cooperative education, internships and reflection matter, there are no established general criteria to determine which aspects are most beneficial. The research is more thorough on mentoring and this study will be able to build off of established criteria for effective mentoring programs. This study will determine which factors and combination of programs are most likely to enhance self-efficacy in minority engineering majors and will lead to recommendations about enriched features of POEE.

4.) Determine the utility of a new construct, work self-efficacy, in measuring the effect of self-efficacy on retention among under-represented minority students. This study will include well-established measures of Science/ Math/ Engineering academic self-efficacy and coping efficacy. However, work self-efficacy represents a new construct that focuses specifically on young workers' confidence in managing workplace conditions. The study will feature a newly validated Work Self-Efficacy Inventory written by Joseph A. Raelin, at Northeastern University, and published by Mind Garden, Inc.

5.) Collect longitudinal data on the pathways to self-efficacy and individual-tracked retention in engineering by following a cohort over a critical two-year time span. Most of the pivotal studies that established the relationship between self-efficacy and persistence had methodological limitations. For example, Schaefer et al. [33] measured persistence in engineering from college entry to their third, fourth, or fifth years, but measured self-efficacy only at the later point by asking students to provide retrospective responses on early college experiences. Although Nauta et al. [26] obtained S-E measures both in high school and three to five years later in college; they recommended assessments of additional variables to fully understand the pathways. In short, the research will help to address Schaefer's recommendation that more longitudinal studies be conducted that include antecedent measures to persistence in order to better address issues of causality [33].

6.) Include a significant sample of both minority males and females so that these groups can be looked at as distinct populations. The 2002 National Science Foundation report *Women, Minorities, and Persons with Disabilities in Science and Engineering* states that the "greatest disparity between male and female enrollment (and also between male and female degree attainment) occurs among minorities and low-income students." This study will focus on much-needed services and research geared toward the declining male population. The data will be analyzed to evaluate any gender differences and make specific recommendations for minority males.

Conclusion

In conclusion, it is our contention that the results of this current study will have broader implications for undergraduate engineering programs to have formal support systems in place, as in the case of the LSAMPs. In addition to the contributions to research in the fields of engineering education, social cognitive psychology, career development, and diversity studies, this project has a number of broader impacts that have national implications: (1) The research results will provide engineering colleges with data-supported measures of the effectiveness of POEE programs on historically underrepresented minority students. By empirically tracking the effectiveness of these contextual supports, the study will make it possible for engineering colleges to emphasize programs that work. (2) The study will assess the value of formal POEE programs and identify features which can be replicated at other universities, using the methods created through this study. (3) The use of cleaned retention data will create a means for comparison across the five partnering schools, and since one of them represents a significant percentage of engineering cooperative education, the new retention data may contribute to defining a new parameter or refocused attention on a pre-existing parameter. (4) The prominence of the role of self-efficacy in this study will help to determine if it merits inclusion as one of the most critical explanations of academic outcomes, in this case, the outcomes of learning and retention among minority engineering undergraduates. (6) This project will seek to build on the newly validated measure of work self-efficacy introduced by Joe Raelin, the Asa Knowles Chair of Practice-Oriented Education in the 'Pathways to Self Efficacy and Retention of Women In Undergraduate Engineering' research study currently underway, which could impact future national studies involving learning outcomes from work experience. (7) The model has the potential to become a standard that can be replicated with other populations (such as students with disabilities), with other educational levels (such as graduate studies), or among multiple areas of education beyond engineering (such as the physical sciences).

REFERENCES CITED

- [1] Bruner, J. (1996). *The Culture of Education*. Cambridge, MA: Harvard University Press. References
- [2] Bandura, A. (1986). *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall.
- [3] Brown, S.J. (1976). *Cooperative Education and Career Education: A Comparative Study of Alumni*. Boston: Northeastern University, Cooperative Education Research Center.
- [4] Brown, S.D., Lent, R.W., and Larkin, K.C. (1989). Self-Efficacy as a Moderator of Scholastic-Aptitude. Academic Performance Relationships. *Journal of Vocational Behavior*, 35, 64-75.
- [5] Bruning, R, Schraw, G., and Ronning (1995). *Cognitive psychology and instruction*. Second Edition. Englewood Cliffs, NJ: Prentice-Hall.
- [6] Chen, X., Weko, T. (2009). *Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Post Secondary Education*. (NCES 2009, 161). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, Washington, DC
- [7] Chubin, D., and Babco, E. (2003). *Walking the Talk in Retention-to-Graduation: Institutional Production of Minority Engineers*. A NACME Analysis.
- [8] Committee on Underrepresented Groups and the Expansion of the Science and Engineering Workforce Pipeline; Committee on Science, Engineering, and Public Policy; Policy and Global Affairs; National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. (2010).
- [9] Denes, R, Highsmith, R.J. *Keeping Score: Comparative Performance of Engineering Institutions in Creating Access* (1998), NACME Research Letter, National Action Council for Minorities in Engineering (NACME), Inc
- [10] Eames, C. (2004). *Researching in Cooperative Education: How a Practitioner Met the Challenge* In P.Linn (Ed.), *Handbook for Research in Cooperative Education and Internships* (pp. 71-94). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.
- [11] Fletcher, J. (1990). Self Esteem and Cooperative Education: A Theoretical Framework. *Journal Of Cooperative Education*, 26(3), 41-55.
- [12] Gainor, K. A., & Lent, R. W. (1998). Social cognitive expectations and racial identity attitudes in predicting the math choice intentions of black college students. *Journal of Counseling Psychology*, 45(4), 403-413.
- [13] Gardner, P. D., Nixon, D. C., and Motschenbacher, G. (1992). Starting Salary Outcomes of Cooperative Education Graduates. *Journal of Cooperative Education*, 27(3), 16-26.
- [14] Hackett, G., & Byars, A. M. (1996). Social cognitive theory and the career development of African American women. *The Career Development Quarterly*, 44, 322-339.
- [15] Hackett, G., Betz, N. E., Casas, J. M., & Rocha-Singh I.A., (1992). Gender, ethnicity, and social cognitive factors predicting the academic achievement of students in engineering. *Journal of Counseling Psychology*, 39(4), 527-538.

- [16] Howard, A., & England-Kennedy, E. S. (2001). Transgressing boundaries through learning communities. *Journal of Cooperative Education*, 36(1), 76-82.
- [17] Lave, J. and Wenger, E. (1991) *Situated Learning. Legitimate Peripheral Participation* (Cambridge: Cambridge University Press).
- [18] Lent, R.W., Brown, S. D., Brenner, B., Chopra, S. B., Davis, T., Talleyrand, R., and Suthakaran, V. (2001). The Role of Contextual Supports and Barriers in the Choice of Math/ Science Educational Options: A Test of Social Cognitive Hypotheses. *Journal of Counseling Psychology*, 48(4), 474-483.
- [19] Lent, R.W., Brown, S. D., Schmidt, J., Brenner, B., Lyons, H., and Treistman, D. (2003). Relation of Contextual Supports and Barriers to Choice Behavior in Engineering Majors: Test of Alternative Social Cognitive Models. *Journal of Counseling Psychology*, 50(4), 458-465.
- [20] Lent, R.W., & Worthington, R.L. (2000). On school-to-work transition, career development theories and cultural validity. *The Career Development Quarterly*, 48, 376-384.
- [21] Lopez, F., Lent, R., Brown, S., and Gore, P. (1997). Role of Social-Cognitive Expectations in High School Students. Mathematics-Related Interest and Performance. *Journal of Counseling Psychology*, 44(1), 44-52.
- [22] May G.S., Chubin D.E. (2003) A retrospective on undergraduate engineering success for under-represented minority students. *Journal of Engineering Education* 92(1): 27-39.
- [23] Mau, W.C. (2003). Factor influencing persistence in science and engineering career aspirations. *Career Development Quarterly*, 51, 234-243.
- [24] McDougall, M. and Beattie, R. S. (1997), Peer mentoring at work. *Management Learning*, 28, 4, 423-437.
- [26] Nauta, M. M., and Epperson, D. L. (2003). A Longitudinal Examination of the Social-Cognitive Model Applied to High School Girls. Choices of Nontraditional College Majors and Aspirations. *Journal Of Counseling Psychology*, 50(4), 448-457.
- [27] Patterson, J. (1997). *Coming clean about organizational change*. Arlington, VA: American Association of School Administrators.
- [28] Pettit, D.E., 1998 *Census of Cooperative Education Executive Summary*. Cooperative Education Experience, 1998.
- [29] Raelin, J. A. 2000. *Work-based learning: The new frontier of management development*. Reading,MA: Addison-Wesley.
- [30] Raelin, J. A. 2001. Public reflection as the basis for learning. *Management Learning*, 32(1): 11-30.
- [31] Reichert, M., Absher, M. (1997). Taking another look at educating African American engineers: The importance of undergraduate retention. *Journal of Engineering Education* 86(3): 241-253.
- [32] Seymour, E., and Hewitt, N. (1997). *Talking About Leaving*. Boulder, Colorado: Westview Press.
- [33] Schaefer, K., Epperson, D., and Nauta, M. (1997). Women's Career Development: Can Theoretically Derived Variables Predict Persistence in Engineering Majors? *Journal of Counseling Psychology*, 44(2), 173-183.
- [34] Somers, G. (1986). How Cooperative Education Affects Recruitment and Retention. *Journal of Cooperative Education*, 25(1), 72-78.

- [35] Torres, J. B., & Solberg, V. S. H. (2001). Role of self-efficacy, stress, social integration, and family support in Latino college student persistence and health. *Journal of Vocational Behavior*, 59, 53-63.
- [36] Weston, W. D. (1986). Career Identity and its Relationship to Participation in a Cooperative Education Program. *Journal of Cooperative Education*, 23(1), 25-36.
- [37] Wilson, J. (1974). *Impact of Cooperative Education upon Personal Development and Growth: Final Report to the Braitmayer Foundation*. Boston: Northeastern University, Cooperative Education Research Center.
- [38] Steele, C. (2003). Stereotype threat and student achievement. In T. Perry, C. Steele & A.Hilliard (Eds.), *Young, Gifted, and Black : Promoting High Achievement Among African-American Students*. Boston: Beacon Press.

Biographical Information

Richard Harris

BS Industrial Engineering, MS Applied Educational Psychology. Assistant Dean for Academic Scholarship, Mentoring and Outreach; Director of Northeastern University Program In Multicultural Engineering; Co-PI of Internal NELSAMP. Chapter Advisor for the Society of Hispanic Professional Engineers; Chapter advisor for the National Society of Black Engineers. Member of the American Society for Engineering Education; member of the National Association of Multicultural Engineering Program Advocates (NAMEPA); member of Empowering Leadership Alliance (ELA) for Computing Scholars of Tomorrow; National GEM Consortium Representative; Co-Executive Director for the ExxonMobil-Bernard Harris Summer Science Camp at Northeastern University.

Mohamad “Hameed” Metghalchi

BS Mechanical Engineering, MS Mechanical Engineering, Doctor of Science Mechanical Engineering. Northeastern Univ. Chair, Mechanical & Industrial Engr.Dept. 2004-'11; Northeastern Univ. Interim Dean, College of Engineering 2006-'07; Northeastern Univ. Faculty of Mechanical & Industrial Engr. 1979-Present; Dr. Metghalchi has authored books and been published on Combustion Fundamentals, Fluid Mechanics, and Thermodynamics. Dr. Metghalchi is Co-PI on NSF supported STEP-UP project; Co-PI on NSF supported S-STEM project; and Co-PI on Northeast Louis Stokes Alliance for Minority Participation (NELSAMP). He is an Active Member of American Society of Engineering Education (ASEE) and serves on GK-12 Committee.

Claire Duggan

BS Political Science, Master Public Administration. Director, The Center for STEM at Northeastern University. K-12 Outreach Coordinator; CenSSIS/ALERT Northeastern University; Co-PI/Program Director, Research Experience for Teachers (RET) at Northeastern University; Executive Director/Founder, Young Scholars Program; Co-Executive Director, ExxonMobil-Bernard Harris Summer Science Camp; Liaison, StepUP Initiative, Coordinate Northeastern University's involvement with the StepUP initiative. A partnership effort between five universities and eleven Boston Public Schools; Project Director, IMPACT New England: A Regional Curriculum Implementation Effort, Coordinated program development and implementation

Emanuel Mason

BS Psychology, MS Educational Psychology, Ed.D. School and Educational Psychology. Professor of Counseling and Applied Educational Psychology. Fellow of the American Psychological Association and the Association for Psychological Science. Dr. Mason has authored books on methodology of research in educational settings and computers in school settings, and has co-edited a monograph series on recruiting and retaining diverse students in American higher education. He also has published numerous articles on thinking and reasoning, testing in education and other related fields.

Rachelle Reisberg

BA Electrical Engineering, MS Electrical Engineering. Assistant Dean for Engineering Enrollment and Retention; Director of Women in Engineering; PI of NSF grant titled: Pathways to Self-Efficacy and Retention of Women in Undergraduate Engineering. Chapter Advisor for the Society of Women Engineers (SWE). Member of the American Society for Engineering Education (ASEE); member of the Women in Engineering Program Advocates Network (WEPAN); member of the Society of Women Engineers (SWE); Co-Executive Director for the ExxonMobil-Bernard Harris Summer Science Camp at Northeastern University.

Deepti Dutt

PhD Student, Mechanical Engineering at Northeastern University, Boston MA (NEU), Research Assistant for NSF funded project: Pathways to Self-efficacy and retention of women in Undergraduate Engineering, NEU; MS Mechanical Engineering, NEU; BE Mechanical Engineering, Osmania University, Hyderabad, India.