Autism Spectrum Disorder and Engineering Education – Needs and Considerations

Mary Pilotte, Ph.D.
School of Engineering Education
Purdue University
West Lafayette, IN, USA
mpilotte@purdue.edu

Diana Bairaktarova, PhD
Department of Engineering Education
Virginia Tech
Blacksburg, VA, USA
dibairak@vt.edu

***Abstract* – Universities are experiencing an increase in enrollment of high-functioning students with autism spectrum disorder (ASD). Even though many students with ASD do not attend college, it is reported that students with this diagnosis who do, often come from well to do families, and select STEM (Science, Technology, Engineering, Mathematics) education areas at rates above both the general population, and other differently-abled groups. While students classified with this diagnosis may hail from privileged educational exposures and demonstrate higher cognitive abilities, they often lack the ability to empathize and experience difficulty to socially connect with others. This includes an inability to decode informal social cues, which can impact the ability to communicate ideas during classroom situations.**

Concurrent to this notable shift in STEM student demographics, the landscape of engineering education is also changing. Greater emphasis is placed on providing an engaging and interactive student learning environment, bolstered by research demonstrating improved learning outcomes and higher retention rates. This work in process is the development of an emergent literature review, looking for the intersection between this student diagnosis, and the impact on the engineering education classroom and related stakeholders. Our work is an important first step in informing and guiding faculty and staff engagement on this unique and growing student population, especially in light of a national focus on STEM education, and dynamic changes in engineering education.

Keywords—autism spectrum disorder, engineering classroom, engineering education, inclusive instruction, practice.

I. INTRODUCTION

The ever increasing spotlight on developing capable STEM professionals for the domestic workforce permeates the media. The messages have evolved from meeting simple workforce skill deficits, to upholding and protecting United States national security interests [1-3]. Concurrently, programs promoting engineering earlier in the educational system and to a broader and more diverse student population (across gender, socio-economic, and ethnic barriers) have matured and are slowly gaining ground [4-8]. With this topic ever present in the societal mindshare, it may come as little surprise that a unique population of students is also increasingly interested in pursuing a STEM education. Specifically, universities are reporting an increase in enrollment of high-functioning students on the autism spectrum disorder (ASD) into STEM fields generally, and engineering in particular [9]. While many ASD students do not attend college, it remains interesting that students attending college with this diagnosis often come from well to do families, and select STEM education areas (including engineering) at rates above both the general population, as well as those from differently-abled groups [10]. Likely having the benefit of privileged educational exposures and directed support to meet their early educational and special needs [11], these students often arrive on campus with behaviors that can work at odds against success in the engineering profession. For example, while ASD students demonstrate a deep interest with mechanical objects and their operation [12] via so called "folk physics" [13], and possess higher cognitive abilities in systems and rule-based thinking, they also often lack the ability to empathize[14], they experience anxiety in social settings, and face difficulty simply socially connecting with others [15]. This inability to connect and decode informal social cues, often manifests itself in low or awkward communication levels, loneliness, and academic difficulty, especially in group settings [15-18]. Many of these students who enter post-secondary education are more strongly supported, and taught a variety of coping mechanisms ahead of their entry into college[11], yet in reality, they must quickly adapt and deal with stressful situations associated with personal independence, diverse instructional settings/pedagogies, and a lack of K-12 educational structure, which often poses challenges for their individual success. In addition, it remains likely that university level educators lack understanding of ASD students, and the challenges they will face both academically and socially while on campus [19].

Concurrent to this notable shift in STEM student population, the landscape of engineering education is also changing. Greater emphasis on providing an engaging and interactive student learning environment is seen [20], bolstered by research demonstrating improved learning outcomes and higher student retention rates [21, 22] . In addition, employers have called for engineering educators to apply focus on skills beyond the purely technical, specifically increasing student capability in both oral and written communications, engaging in robust teamwork [23], and making gains in overall professional decorum [24, 25]. These requests have manifested themselves in expanded (and contracted) engineering curriculums which aim to improve the overall employability of graduating students into engineering practice [26-28].

Together, the shift in engineering student body, and informed approaches in engineering education instruction, may be setting up an environment for an unfortunate collision where both students and collective educational experiences are negatively impacted. Providing a thoughtful review of cross-disciplinary research on ASD students in educational settings offers an opportunity to offset potential, preventable, and negative outcomes for all.

II. Purpose of the Study

This work in process initiates the development of an informative literature review, looking for the intersection between students attending college with a diagnosis of ASD, and the impact on the engineering education classroom and related stakeholders. Its aim is to engage a broad survey of research on the topic, with the goal of answering four critical questions:

1. What attributes and behaviors do ASD spectrum students bring to the engineering classroom?
2. How might the university setting work against the success of this student population?
3. What learning frameworks might guide engineering education faculty to serve this demographic?
4. What implications does this growing population have on advanced/active learning classroom pedagogies, and longer term professional development?

This work is an important addition to scholarly engineering education work, as it informs and guides faculty and others who will engage with this unique and growing student population, especially in light of dynamic changes in engineering education. Further, this work aspires to offer insights into promoting diversity in the engineering classroom, by communicating operational considerations and accommodations that can allow for population wide improved learning outcomes. Finally, through increased awareness and sensitivity, the engineering discipline as a whole can begin to directly address individual professional attributes that are often unwanted in the student engineering population at large, and persist into the domain of engineering practice. Once in the open, we can advance the dialogue on life-long professional development, and engage the full range of educational stakeholders in an inclusive discussion on improvements and ways forward.

III. Background

3.1 *ASD and STEM*

In the last handful of years, a few cogent research articles were published exploring the potential intersection of autism, and higher education [10, 11, 29, 30]. Autism is defined as a psychiatric disorder with “a developmental disability significantly affecting verbal and nonverbal communication and social interaction” [13, 31]. The diagnosis for autism is complicated by the wide range of manifestations that can occur in individuals, hence autism is frequently referred to as a “spectrum of disorders”, or ASD - autism spectrum disorder [32]. In the past it was argued that those diagnosed with Asperger’s syndrome (AS) also appeared on this spectrum, lacking only the cognitive and communication delays which can inhibit educational and social integration [33]. Due to the broadening definition of ASD, a large number of individuals considered to be high-functioning are classified to be on the autism spectrum [34]. This may in part explain why the incidents of ASD has been on a steady rise in the United States, reportedly growing to 1 in 68 in 2015, a 120% rise since 2002 [35], with disproportionate diagnosis assigned to white males [10].

A broad range of research indicates connections seem to exist between ASD and STEM orientations, in particular the engineering profession and what are sometimes considered to be engineering ways of being and thinking [13, 16, 36-39]. For example, in research exploring attributes of students competing in math and science Olympiads in the United Kingdom, those students in computer science, and math demonstrated the most ASD characteristics when compared to students studying medicine and other sciences including engineering [33]. Further, while ASD is considered strongly inheritable [40], an examination of relatives surrounding children diagnosed with autism showed a significantly disproportionate number of fathers and grandfathers in occupations related to engineering (i.e. 28.4% vs. 15% in the control population)[37]. More recent work has also found significant links between ASD and maternal occupations in technology [41].

Other investigations explored how those diagnosed with autism seem to display skills and characteristics deemed normal or beneficial to engineering as a field of study. In these studies, results suggest that those diagnosed with ASD often have strong attention to detail [16], are good at understanding how physical objects and machines work [42], and show strong interest in systems with mathematic/spatial relationships [37-39]. In parallel, those with ASD often lack in communication and social skills and become stressed when faced with sensory overstimulation or placed in changing environments [43, 44].

The beneficial cognitive attributes and personal interests of those diagnosed with some degree of ASD place them squarely within a likely population of college bound engineering students. Likewise, the social deficits, while familiar within the profession of engineering, are becoming increasingly problematic within the engineering education setting, and beyond into the space of engineering practice. The question then becomes how to effectively support these unique college students through their engineering experience (post-secondary, and life-long), without diluting or impeding the experiences of other like-minded but differently-abled engineering students?

3.2 *ASD, Higher Education & Engineering Education*

All students who demonstrate proficiency around topics that are considered congruent with engineering (math, science, strong spatial skills, etc.) are often academically advised to consider post-secondary education in a STEM related field. This situation holds true for young adults with ASD, with one study demonstrating ASD students outpaced the general population in their interest in STEM [9]. A recent study indicated, in comparison to other categories of disability (i.e. hearing impairment, visual impairment, general learning disabilities, etc.), ASD students ranked third lowest in post-secondary enrollment [10]. In spite of what may seem to be low relative representation, with the maturation of the Individuals with Disabilities Educational Improvement Act (IDEIA) of 2004 [31], some believe prospective engineering students such as those with ASD, are better positioned, and better prepared than ever for entry into the college setting [11].

For those ASD students who choose higher education, the pathway, the success, and the social acceptance are not certain. For example, as some students (perhaps children of successful engineering and technology program alumni) enter directly into a typical four year college or university. Alternatively a longitudinal study of over 900 ASD diagnosed students conducted from 2001 to 2009 indicated that 81.3% of the students attended a two-year college – some exclusively. About half of those students used the two-year college as a means to bridge their educational experience moving on to a four-year college (48.7%) [45]. In that same study, ASD students in STEM majors were more likely to persist than non-STEM majors; male STEM students persisted over female STEM students; minority ASD students persisted over white ASD students; and greater persistence existed for students with parents who had attended college[45]. Finally, students who only attended a two-year or four-year program (STEM or non-STEM), persisted at significantly lower levels than other students in the evaluated population [45].

Getting into and persisting in the college can be difficult for ASD students, then once on campus, a wide range of unplanned, unfettered, and unexpected social settings present challenges as well. ASD students including the so called "high functioning" autism spectrum disorder individuals (HFASD), function without intellectual deficits and possess relatively strong verbal skills, yet often find themselves particularly disappointed in college settings [15]. Social isolation and social anxiety (co-attributes commonly associated with HFASD) can be aggravated by fear of negative peer perceptions and erratic social settings [46]. These feelings seem to persist and increase with age [46]. At the extremes, engineering students with more features of ASD can demonstrate greater depression, verbal aggression and hostility, and report being the least happy with their college experience [15]. Interestingly, in terms of social acceptance of ASD students in the college, engineering students among all majors, indicated the greatest social comfort engaging them, yet also the greatest fear of their ASD peers [30].

Several studies outside of engineering education have called for increased awareness, understanding, and preparation for students diagnosed with ASD in the post-secondary domain [11, 15, 30, 45, 47]. Considerations suggested range from extending accommodations familiar to those which support students with other/lower level disabilities, to integrating technologies to aid in organization and routine building [30], to providing individual, social/educational coaches who can help not only highlight students strengths, but attend their classes, or support them in finding securing employment at graduation [11]. Acknowledging the core needs associated with these suggestions is critical for the domain of engineering, in part due to the likely absence of awareness [30, 48, 49] related to support structures and educational mechanisms that can guide ASD student success through their individualized challenges.

Within the scholarly works of engineering education, a search of related literature garnered only a few directly applicable articles. For example, Variawa and McCahan, [50-52] have recommended the development of inclusive learning environments that improve learning and social welcoming for all students (those differently-abled, female, and minority students) by simply implementing universal design approaches and "individual focused and system focused" instructional strategies [50]. In 2007, the American Society for Engineering Education magazine ran an article entitled "In their grasp" [53], and highlighted engineering colleges such as The Ohio State University and University of Washington, among others, for their individual efforts to make the discipline of engineering more approachable for all disabilities. A search of those schools websites locates pages such as the "Do-It: Disabilities Opportunities, Internetworking, Technology resource site for students, educators, employers, and more [54]. This site houses links to an extensive resource repository at the virtual Center for Universal Design. While several hundred beneficial and scholarly articles reside at that website, few are specifically aimed toward the interface of engineering education and ASD students.

IV. DISCUSSION

Two key points emerge from the close examination of the literature presented here. First, the landscape of students entering post-secondary educational engineering programs is diversifying in ways that are not always visually apparent. There are an increasing number of high-functioning ASD students with diagnosis across the spectrum, and these students are entering engineering programs with special engineering-like skills and attributes, and yet exhibit significant communication, adaptability, and social deficits. While the engineering education settings of old previously allowed these students to both hide and passively cope within the large lecture halls and individual computer laboratories, the idealized learning settings in today's modern engineering programs have removed these educational "safety harbors" for ASD students and now presenting greater challenges for all involved – ASD students, peer collaborators, educators and administrators. Once a rarity within in large, public, engineering institutions, so called "impact" [55], active, and collaborative learning settings [20, 23] are being rapidly integrated into the normative fabric of engineering education pedagogies. Students are compelled to work interactively within unscripted team collaborations on large and unbounded problems [23, 56, 57]. These classroom changes, viewed as educational improvements by most [21], present a dynamic that seems apparently unaware of the growing number of ASD students in the population that may experience difficulty in these settings. This situation layers onto the already complex social settings associated ASD students in college.

This picture represents a complex and likely underprepared socio-technical system; one wrought with deep past practice, relatively under exercised legislative mandates, intentions of social justice, and involving increasing numbers of affected constituents. In spite of what appears to be slow momentum to realize the needs of students with ASD, those attending four-year colleges in STEM fields are persisting at just over 70% (70.67%) [45], still well above general population averages (43.3%) for students in STEM [58].

Second, the extent to which engineering education generally and engineering programs specifically are willing to acknowledge, research, and respond to the special needs of this expanding ASD constituency appears limited. What is most likely the situation is that engineering educators' lack the awareness of recent demographic trending and the associated essential training required to aid individual ASD student success. Further, for those engineering educators who currently actively support all aspects of classroom diversity, but also support active learning environments, team projects, and open-ended group problem solving, they may require supplemental resources to work through a brief pedagogical transition to fully comprehend the needs of these students, and their student peers. To that end, it is suggested that this exploratory line of engineering education inquiry be considered a new priority, not only to benefit existing ASD students in the pipeline, but also to better equip engineering educators at all levels (faculty and staff administrators) in this unique and diverse population.

Taking the lead from early engineering education work by Wankat, Oreovicz [59] and Felder, Brent [60, 61] we can image one possible way forward, as we begin to consider the abilities and developmental needs of ASD students in the engineering classroom. As suggested by these authors, examining and contrasting models of intellectual development such as Piaget, Perry, Belenky, King-Kitchener and others, allows us to: 1) locate ASD students within existing educational models in the context of understanding what professional engineers must be capable of doing, 2) help students attend to areas of highest developmental need, and 3) provide faculty and advising staff a means for scaffolding ASD students up a developmental progression, as far as they are willing and able to go. Until such time that this work can be advanced and explored through these or other engineering education lenses, the faculty, advisors, administrators, and even engineering employers are likely to face significant and growing challenges as they encounter ASD diagnosed students without full and complete self-awareness and professional preparedness.

V. CONCLUSIONS AND FUTURE WORK

This work-in-progress begins to uncover cogent research on the subject of differently-abled and challenged ASD students in the engineering classroom, and their increasing gravitation toward post-secondary education generally, and engineering programs specifically. Cross-disciplinary and engineering education literature on the topic is elaborated upon. The review of existing research begins to highlight attributes of ASD diagnosed students, and issues that may stand in the way of student success. In tandem, this paper draws attention to possible faculty and administrative awareness gaps that require further consideration.

The emphasis of this paper aims to launch a necessary and timely dialog on the intersection between post-secondary engineering education and ASD student learners. The larger goal is to offer insights into promoting inclusivity in the engineering classroom, by helping engineering educators become aware of operational considerations and accommodations supportive of population wide improved learning outcomes. Finally, we suggest one possible way forward for the community of engineering education, by proposing connections between known intellectual development frameworks and ASD engineering student developmental needs. The ultimate goal is to assist ASD students in their progression toward professional engineering practice and improve their social persona, both in the college setting and beyond well into their engineering career.

VI. CONCLUSIONS AND FUTURE WORK

While our work-in-process presents a comprehensive and current literature review demonstrating clear importance to engineering education, we recognize the absence of articulating the methodology describing a systematic database search and/or use of a citation analytic tool. Our future work will incorporate such information, including visual representations demonstrating their use. To conclude, our next steps for this work will examine other professional fields and their best practices for integrating ASD students, developing specific recommendations for use within engineering education. Our long term goal includes gaining research approval for exploratory engineering education interventions.

Mary Pilotte is an Associate Professor of Engineering Practice in the School of Engineering Education at Purdue University. Dr. Pilotte is Director of the Multidisciplinary Engineering and Interdisciplinary Engineering Studies programs in the College of Engineering, and has over 20 years of engineering, manufacturing and operations excellence experience in automotive, aerospace, airline, and commercial products industries. Her STEM education research interests include engineering knowledge transfer across generations of engineers in the workplace, Millennial engineering, engineering professional development, the intersection of personal attributes and education/career persistence, and inter/multidisciplinary ways of thinking/being in engineering.

Diana Bairaktarova is an Assistant Professor in the Department of Engineering Education at Virginia Tech. Diana has over a decade of experience working as a Design and Manufacturing Engineer. Her research is focused on human learning and engineering, i.e. understanding how individual differences, aptitudes and abilities affect interaction with engineered physical and virtual objects to enhance learning and performance in engineering.

REFERENCES

[1] National Academy of Sciences, Rising Above the Gathering Storm, Revisited. 2010.
[2] National Research Council, Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, ed. C.o.P.i.t.G.E.o.t.s.C.A.A.f.A.S. Technology. 2007, Washington, DC: The National Academies Press.
[3] Kuenzi, J., STEM Education: Background, Federal Policy, and Legislative Action. 2008, Congressional Research Service: Washington DC. p. 34.
[4] Van Aken, E.M., B. Watford, and A. Medina-Borja, The use of focus groups for minority engineering program assessment. Journal of Engineering Education, 1999. 88(3): p. 333.
[5] Epstein, D. and R.T. Miller, Slow off the Mark: Elementary School Teachers and the Crisis in Science, Technology, Engineering, and Math Education. Center for American Progress, 2011.
[6] Wilson, Z.S., et al., Hierarchical mentoring: A transformative strategy for improving diversity and retention in undergraduate STEM disciplines. Journal of Science Education and Technology, 2012. 21(1): p. 148-156.
[7] Council, T.A., Engineering in K-12 Education: Understanding the Status and Improving the Prospects. 2009: National Academies Press.
[8] Brophy, S., et al., Advancing engineering education in P-12 classrooms.

Journal of Engineering Education, 2008. 97(3): p. 369.
[9] Chen, X. and T. Weko, Stats in brief: Students who study science, technology, engineering, and mathematics (STEM) in postsecondary education (NCES 2009-161). National Center for Education Statistics, Institute of Education Sciences, US Department of Education. Washington, DC, 2009.
[10] Wei, X., et al., Science, technology, engineering, and mathematics (STEM) participation among college students with an autism spectrum disorder. Journal of autism and developmental disorders, 2013. 43(7): p. 1539-1546.
[11] .Hart, D., M. Grigal, and C. Weir, Expanding the paradigm: Postsecondary education options for individuals with autism spectrum disorder and intellectual disabilities. Focus on Autism and Other Developmental Disabilities, 2010.
[12] Happé, F. and U. Frith, The weak coherence account: Detail-focused cognitive style in autism spectrum disorders. Journal of autism and developmental disorders, 2006. 36(1): p. 5-25.
[13] Baron-Cohen, S., et al., Autism occurs more often in families of physicists, engineers, and mathematicians. Autism, 1998. 2(3): p. 296-301.
[14] Baron-Cohen, S., Autism: the empathizing–systemizing (E-S) theory. Annals of the New York Academy of Sciences, 2009. 1156(1): p. 68-80.
[15] White, S.W., T.H. Ollendick, and B.C. Bray, College students on the autism spectrum: Prevalence and associated problems. Autism, 2011: p. 1362361310393363.
[16] Jobe, L.E. and S.W. White, Loneliness, social relationships, and a broader autism phenotype in college students. Personality and Individual Differences, 2007. 42(8): p. 1479-1489.
[17] Critchley, H.D., et al., The functional neuroanatomy of social behaviour. Brain, 2000. 123(11): p. 2203-2212.
[18] Quill, K.A., Instructional considerations for young children with autism: The rationale for visually cued instruction. Journal of autism and developmental disorders, 1997. 27(6): p. 697-714.
[19] Huws, J. and R. Jones, 'They just seem to live their lives in their own little world': Lay perceptions of autism. Disability & Society, 2010. 25(3): p. 331-344.
[20] Smith, K.A., et al., Pedagogies of engagement: Classroom-based practices. Journal of Engineering Education, 2003. 94(1): p.87-101
[21] Prince, M., Does Active Learning Work: A Review of the Research. Journal of Engineering Education, 2004. 93(3): p. 223 – 231.
[22] Prince, M., Felder, R., Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. Journal of Engineering Education, 2006. 95(2): p. 123-138.
[23] Smith, K.A., Teamwork and Project Management. 2nd ed. 2003, New York: McGraw-Hill.
[24] Shuman, L.J., Besterfield-Sacre M., and J. McGourty, The ABET "professional skills" – Can they be taught? Can they be assessed? . Journal of Engineering Education, 2005. 94(1): p. 41–55.
[25] National Academy of Engineering. NAE Grand Challenges for Engineering. 2012 [cited 2013 January 22]; Available from: http://www.engineeringchallenges.org/.
[26] Sheppard, S., et al., What is engineering practice? International Journal of Engineering Education, 2007. 22(3): p. 429.
[27] Sheppard, S.D., et al., Educating Engineers: Designing for the future of the field. 2008, San Francisco: Jossey-Bass.
[28] Williams, B., J.D. Figueiredo, and J.P. Trevelyan, Engineering practice in a global context: Understanding the technical and the social. 2014, London Taylor & Francis.
[29] Wei, X., et al., Science, technology, engineering, and mathematics (STEM) participation among college students with an autism spectrum disorder. Journal of autism and developmental disorders, 2012. 42(11).
[30] Nevill, R.E. and S.W. White, College students' openness toward autism spectrum disorders: Improving peer acceptance. Journal of Autism and Developmental Disorders, 2011. 41(12): p. 1619-1628.
[31] Individuals With Disabilities Education Improvement Act of 2004. 2004. Publication L: p. 108-448.
[32] Seltzer, M.M., et al., Trajectory of development in adolescents and adults with autism. Mental retardation and developmental disabilities research reviews, 2004. 10(4): p. 234-247.
[33] Baron-Cohen, S., et al., The autism-spectrum quotient (AQ): Evidence from asperger syndrome/high-functioning autism, males and females, scientists and mathematicians. Journal of autism and developmental disorders, 2001. 31(1): p. 5-17.
[34] Chakrabarti, S. and E. Fombonne, Pervasive developmental disorders in preschool children. Jama, 2001. 285(24): p. 3093-3099.
[35] Centers for Disease Control and Prevention, CDC Wonder-http://wonder.cdc.gov/. 2016.
[36] Baron-Cohen, S., Mindblindness: An essay on autism and theory of mind. 1997: MIT press.
[37] Baron-Cohen, S., et al., Is there a link between engineering and autism? TISM-LONDON-, 1997. 1: p. 101-109.
[38] Leekam, S.R. and J. Perner, Does the autistic child have a metarepresentational deficit? Cognition, 1991. 40(3): p. 203-218.
[39] Leslie, A.M. and L. Thaiss, Domain specificity in conceptual development: Neuropsychological evidence from autism. Cognition, 1992. 43(3): p. 225-251.
[40] Bailey, A., et al., Autism as a strongly genetic disorder: evidence from a British twin study. Psychological medicine, 1995. 25(01): p. 63-77.
[41] Windham, G.C., K. Fessel, and J.K. Grether, Autism spectrum disorders in relation to parental occupation in technical fields. Autism Research, 2009. 2(4): p. 183-191.[42] Baron-Cohen, S., A.M. Leslie, and U. Frith, Mechanical, behavioural and intentional understanding or picture stories in autistic children. British Journal of developmental psychology, 1986. 4(2): p. 113-125.
[43] Association, A.P., Diagnostic and statistical manual-text revision (DSM-IV-TRim, 2000). 2000: American Psychiatric Association.
[44] Welkowitz, L.A. and L.J. Baker, Supporting college students with Asperger's syndrome. Asperger's syndrome: Intervening in schools, clinics, and communities, 2005: p. 173-187.
[45] Wei, X., et al., Postsecondary pathways and persistence for STEM versus non-STEM majors: Among college students with an autism spectrum disorder. Journal of autism and developmental disorders, 2014. 44(5): p. 1159-1167.
[46] Kuusikko, S., et al., Social anxiety in high-functioning children and adolescents with autism and Asperger syndrome. Journal of autism and developmental disorders, 2008. 38(9): p. 1697-1709.
[47] Grigal, M., D. Hart, and C. Weir, Framing the future: A standards-based conceptual framework for research and practice in inclusive higher education. Think College Insight Brief, 2011. 10.
[48] Koegel, L.K., C.M. Carter, and R.L. Koegel, Teaching children with autism self-initiations as a pivotal response. Topics in Language Disorders, 2003. 23(2): p. 134-145.
[49] Carnahan, C., S. Musti-Rao, and J. Bailey, Promoting active engagement in small group learning experiences for students with autism and significant learning needs. Education and treatment of Children, 2009. 32(1): p. 37-61.
[50] Variawa, C. and S. McCahan. Design of the learning environment for inclusivity. in Proceedings of the 2010 American Society for Engineering Education Annual Conference and Exposition. Louisville, KY. 2010.
[51] Variawa, C. and S. McCahan, Universal Design in Engineering Education. Proceedings of the Canadian Engineering Education Association, 2010.
[52] Variawa, C. and S. McCahan. Balancing content contextualization and accessibility in engineering assessment. in Proceedings of the 21st ACM conference on Hypertext and hypermedia. 2010: ACM.
[53] Loftus, M., In their grasp - Students with disabilities seldom pursue engineering or science careers. But that may be about to change., in ASEE Prism. 2007, American Society for Engineering Education: Washington, DC.
[54] Do-It. Do-It: Disabilities, Opportunities, Internetworking, and Technology. 2016 [cited 2016 April 12]; website]. Available from: www.washington.edu/doit.
[55] Campbell, P.F. and C. Langrall, Making Equity a Reality in Classrooms. The Arithmetic Teacher, 1993. 41(2): p. 110-113.
[56] Moylan, W., Learning by project: Developing essential 21st century skills using student team projects. International Journal of Learning, 2008. 15(9): p. 287-292.
[57] Seat, E., J.R. Parsons, and W.A. Poppen, Enabling engineering performance skills: A program to teach communication, leadership, and teamwork. JOURNAL OF ENGINEERING EDUCATION-WASHINGTON-, 2001. 90(1): p. 7-12.
[58] National Center for Education Statistics, Institutional Retention and Graduation Rates for Undergraduate Students., in The Condition of Education 2015 (NCES 2015-144). 2015, U.S. Department of Education.
[59] Wankat, P.C. and F.S. Oreovicz, Models of cognitive development: Piaget and Perry. Teaching engineering, 1993: p. 264-283.
[60] Felder, R.M. and R. Brent, The intellectual development of science and engineering students. Part 1: Models and challenges. Journal of Engineering Education, 2004. 93(4): p. 269-277.
[61] Felder, R.M. and R. Brent, The intellectual development of science and engineering students. Part 2: Teaching to promote growth. Journal of Engineering Education, 2004, 93(4).