Building STEM Pathways for Students with Special Abilities

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Celena Arreola graduated on May 13, 2017 with Bachelors of Science in Engineering Leadership at the University of Texas at El Paso with a concentration in Mathematics and Civil Engineering. Currently she is pursuing an M.S. in Engineering and is due to graduate in May 2019. She has been actively involved within the Department of Engineering Education & Leadership as a recruitment leader and administrative assistant. Currently she serves as the graduate advisor for the American Society for Engineering Education student chapter and is a research team leader in the Center for Research in Engineering and Technology Education where she focuses on the success of students in science, technology, engineering and mathematics of two post-secondary educational institutions based in El Paso.

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Mike Pitcher is the Director of Academic Technologies at the University of Texas at El Paso. He has had experience in learning in both a traditional university program as well as the new online learning model, which he utilizes in his current position consulting with faculty about the design of new learning experiences. His experience in technology and teaching started in 1993 as a student lab technician and has continued to expand and grow over the years, both technically as well as pedagogically. Currently he works in one of the most technically outstanding buildings in the region where he provides support to students, faculty, and staff in implementing technology inside and outside the classroom, researching new engineering education strategies as well as the technologies to support the 21st century classroom (online and face to face). He also has assisted both the campus as well as the local community in developing technology programs that highlight student skills development in ways that engage and attract individuals towards STEAM and STEM fields by showcasing how those skills impact the current project in real-world ways that people can understand and be involved in. As part of a university that is focused on supporting the 21st century student demographic he continues to innovate and research on how we can design new methods of learning to educate both our students and communities on how STEM and STEAM make up a large part of that vision and our future.

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Dr. Cory Brozina is an assistant professor and the Director of First-Year Engineering at Youngstown State University. He completed his B.S. and M.S. in Industrial & Systems Engineering from Virginia Tech, and his Ph.D. is in Engineering Education, also from Virginia Tech. His research interests include learning analytics, student support and success, first-year engineering, and assessment.

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Helen Geller is the Program Manager for the STEMGROW grant, funded by the Department of Education at the University of Texas at El Paso.

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Carolina Favela is currently a Senior at the University of Texas at El Paso (UTEP) and plans to graduate with her Bachelors of Science in Mechanical Engineering in the Fall of 2018. Carolina is currently a yearlong university Undergraduate Research Student and Development Specialist for the STEMGrow program, a partnership with El Paso Community College (EPCC) that focuses on achieving the next

generation of student engagement and professional preparation. As a current STEMGrower, Ms. Favela strives to innovate and improve university diversity through exemplary mentoring, merging students who transition between UTEP and EPCC to improve the graduation rate of students in STEM fields. She also encourages students with disabilities (or as one calls it "special abilities") to pursue degrees in STEM as well as break barriers for women in engineering to create a broad spectrum of opportunities and meet the 21st century STEM demands. Although having a passion of helping beyond students learning, Carolina also had advocated and helped students who major in Mechanical Engineering as an exemplary Teachers Assistant in the Mechanical Engineering department laboratory "Lockheed Martin" to have a reflection of a real-world engineering experimental environment. She has also pushed the most updated modern engineering revolution of 3D printing to its limits by showing several students the importance of creativity, critical thinking, team building and problem solving. As a lifelong learner, Carolina plans to pursue a Masters in Mechanical Engineering with a focus on Propulsion as well as attain a doctorate degree in Aerospace Engineering to meet the demands of a future employer such as NASA, Boeing, Lockheed Martin, or Space X.

Ms. Melissa Stearns

Work in Progress: Building STEM Pathways for Students with Disabilities

Abstract

Over the last two years, we have been working closely with undergraduate students designated as having disabilities within the engineering sciences and related STEM fields. As we identify and collaborate with these students, we find that they are able to teach us many valuable lessons. Chief amongst these lessons is that in the face of adversity, success within STEM fields may still be achieved by hard work, patience, kindness, and 'grittiness'- a determination to achieve goals, overcome obstacles and discover opportunities. To celebrate this awareness, we have partnered with the Center of Accommodation and Support Service (CASS) at The University of Texas at El Paso (UTEP) and the Center for Students with Disabilities at the EL Paso Community College (EPCC) to organize and implement a Science, Technology, Engineering, and Mathematics (STEM) Ability Awareness program. This work in progress is part of a STEMGROW program [1] that is informed by a theory-to-practice model [2] and uses a funds of knowledge framework [3]. The goal is to bring together students already studying STEM fields and learn more about how they can serve as an an inspiration not only for future students with disabilities, but for all all students at EPCC, UTEP, in STEM-fields and beyond. Our work centers on our students' self-efficacy development and growth pathways. Therefore, we ground our project in the Model of Co-Curricular Support (MCCS) [4], whereby it is posited that there exist four main areas in which students become integrated and educationally engaged within the university. The MCCS builds off Tinto's model of institution departure [5], and contains four main areas which are: Academic, Social, Professional, and University Integration (AI, SI, PI, and UI, respectively). In our action research, we share illustrative example of the impact of using integrated and applied learning practices [6], which are currently being widely instituted at UTEP.

Introduction

Today an estimated 12% of undergraduate students—more than two million—report having some type of disability [7], [8]. The percentage is even higher for full time, first-year students at 15% [9]. However, not all students may disclose their disability so that number is on the conservative end. Institutions of higher education have witnessed an increase in the number of students with disabilities over time, and as significant, the range of disabilities in the student population has expanded [10]. The most substantial proportion of students with disabilities, 24%, reported having either a mental, emotional, or psychiatric condition, or depression, while attention deficit disorder (ADHD) was the next most common type, accounting for 19% of such students. Regarding physical disabilities, 15%, reported that they had an orthopedic or mobility impairment [8].

The proportions of non-apparent and apparent disabilities have reversed, with significant growth occurring in the former category and decline in the latter. Moreover, as the dynamics of students with disabilities changes, the decline in students with disabilities is quite evident as you progress up higher education. Representation for students with disabilities at less than 2-year institutions is 16%, 2-year institutions is 12.4%, non-doctorate granting 4-year institutions is 10%, and doctorate-granting institutions is 8.3% [7]. We are working on a novel way to gain awareness and focus on the students with disabilities. This pathway has grown thanks to the efforts of undergraduate students in engineering and business disciplines at The University of Texas at El Paso.

Additionally, the number of people with disabilities who participate in the labor force is also much lower than those without disabilities. In January of 2015, reported by the Office of Disability Employment Policy (2015), 20% of people with disabilities were a part of the workforce, compared to 70% for those without a disability. It is evident that there is an opportunity to increase the number of people with disabilities throughout higher education, thus increasing the number of people with disabilities who enter the workforce. If we can focus on increasing these numbers, it will diversify the workforce. One way in which to do so is to increase the number of students with disabilities who participate in STEM fields, which would heed calls to increase the robustness of the STEM workforce [12].

Development of our Asset-Based Focus

Specifically, our work in progress focuses on students in the growing major of computer science. Students with disabilities are historically excluded from postsecondary STEM education, as these students face significant barriers to access and inclusion in such programs. Participation in postsecondary education is significantly lower for students with disabilities than for their peers without disabilities. For students with disabilities who enroll in postsecondary education, only 11% are pursuing STEM degrees [13]. This number drops to 7% in graduate programs in STEM, with only 1% earning a doctorate degree in STEM [14] and only 5% entering the science and engineering workforce [13].

These low numbers indicate *a need to value, appreciate, encourage and support* students with disabilities to enter and complete postsecondary education in STEM so they can compete in this growing job market. In the workforce, people with disabilities holding STEM bachelors, masters and doctoral degrees comprised less than 7% of the STEM workforce [7] and compared to those without disabilities, people with disabilities are more likely to be unemployed or not participating in the STEM labor force.

There are many barriers for students with disabilities, which may be part of why students with disabilities do not pursue STEM majors. Some of the barriers include a lack of STEM role models, lack of appropriate information and counseling, technical barriers, and a lack of encouragement

from parents and teachers [15]. Yet, as noted by Kimball, Wells, Ostiguy, Manly and Lauterbach [16], "there are empirical results showing that students with disabilities enroll in STEM at rates similar to students without disabilities [17], [7], suggesting the barriers may pose greater problems once in the major rather than discouraging access to the major in the first place" (pg. 120). Therefore, it may be the institutional resources, access, awareness, and encouragement that may be letting STEM students down, and not actually the disability of the student. By focusing on the system and not the disability of individual students as most attention has been spent [18] we can begin to understand how students with disabilities are supported and can be better supported across the institution to help them succeed.

Beginning with a *Theory-Informs-Practice Model* and a *Funds of Knowledge Framework*

We began this work in progress project with the development and implementation of a theory-informs-practice model in which engineering and education practice are founded upon inquiry-based learning approaches [2], coupled with using a funds of knowledge framework [3]: this is a vital step toward addressing approaches to improving STEM learning by integrating mathematics and science education through engineering applications not just for students with disabilities but for all students. Student disabilities education importantly includes students developing "STEM literacy" [12] through engineering because of its natural connections to science, mathematics, and technology. A funds of knowledge framework is particularly appropriate in our border community of learners. We systemically believe in our students; we see them entering EPCC and UTEP with many talents, great strengths, and big dreams.

Through the systemic institutionalization of this realization, we have initiated a program called The UTEP Edge (UTEP, 2018). The UTEP Edge develops these primary student assets through a variety of high-impact experiences made possible by the expertise and dedication of our faculty, staff, alumni, and community partners. Ranging from undergraduate research and civic engagement to study abroad and student employment, these experiences increase confidence, enhance personal and professional skills, and equip students with competencies that assist lifelong success. Growing educationally, our border region corroborates the statistics provided by Sheppard, Gilmartin, Chen, Donaldson, Lichtenstein, Eris, and Lande [19] regards citizenship and language: Roughly one-in-ten EPCC and UTEP first-year students is not a U.S. citizen, the majority are first-generation US citizens, and English is a second language for 82% of our collective student population.

Our students helped us to realize that disability service units within University systems are an essential entity for the support and success of students who need accommodations because of a disability, whether that is a visible or invisible one. Students who utilize the services provided by such centers tend to have higher achievements overall than those students who do not use the services provided [20]. Moreover, students with disabilities were more likely to persist to graduation if they used the support and services provided for them [21], [22].

Funds of knowledge in our context refers to the abundance of cultural and cognitive resources that our EPCC and UTEP student have. This is consistent with the original coining of the term by Moll, Amanti, Neff, and Gonzalez [23], funds of knowledge is:

> *"Historically accumulated and culturally developed bodies of knowledge and skills essential for households or individual functioning and well-being" (p. 133).*

In UTEP Edge, we focus on developing these assets through a variety of high-impact experiences made possible by the expertise and dedication of our faculty, staff, alumni, and community partners. Ranging from undergraduate research and civic engagement to study abroad and student employment, these experiences increase confidence, enhance personal and professional skills, and equip students with a competitive advantage when they graduate and enter the workforce or pursue a graduate degree.

Preparing students with disabilities to excel in the workforce is impacted through classroom instruction and beyond as we connect our students' cultural understanding with traditional STEM learning; thisaligns with the approach of Moll, Amanti, Neff and Gonzalez [32], is thoughtfully presented by Moll, Amanti, Neff and Gonzalez [24] and contextually reviewed by Verdin, Godwin and Capobianco (2016). This approach enables us to help and support student learning by building knowledge and connections within our students' daily lives. Our student's abundant cultural and cognitive resources further support their capacity for learning in the engineering sciences.

Our students have also helped us grasp what Kimball et al. have reported, namely, that there are many students who do not use disability services despite meeting the qualifications for them [16]. Students may choose not to use disability services because of the difficulties they encounter, such as discriminatory attitudes from university personnel [25]. This is unfortunate, as those students with disabilities who do not look for helpful services may find their academic achievements to be hindered [26]. This highlights the critical role that a University's disability service center plays; they should not only provide appropriate and quality services for students, but also recruit those students to partake in services by ensuring proper access and awareness.

As support has increased for students with disabilities, the accommodations provided to students are inconsistent between institutions [27]. These institutional differences for support of students with disabilities relate to the access mission, support services provided, and curricula [28]. At EPCC and UTEP we are focused on aligning these services. In concert with Collins and Mowbray [28], we find that mission, the number of students served, facilities and budget impact institutional service provided.

Moreover, we definitively corroborate the recent work of Pearson Weatherton, Mayes and Villanueva-Perez [30] whose study of barriers to persistence for engineering students conclude:

> *"Students with disabilities are likely to face a myriad of challenges transitioning to postsecondary educational opportunities in*

addition to their pursuit of an engineering degree. Students may face systemic barriers like a general lack of support and negative views from faculty members while also struggling personally with the overall adjustment to college as someone with their unique abilities. These experiences alone can push students with disabilities out of engineering and, perhaps, out of college altogether. However, when universities and engineering programs commit to cultivating the talent of all students, especially those with disabilities, students can develop the self-confidence needed to be successful." (p. 8)

This has been our exact experience at EPCC and UTEP, namely that initially our students face systemic barriers (as described in the quotation above) but with recognition (of barriers and needs) they begin to develop. It is through mentorship and encouraging students – in other words growing their self-confidence that leads to outstanding success.

Advancing the Lee and Matusovich' *Model of Co-Curricular Support* (MCCS)

As our work continues, we recognize it is crucial to understand the services provided or not provided exclusively for engineering students yet these services may be vital to how engineering students integrate within the overall university environment.

Therefore, we ground our project in the Model of Co-Curricular Support (MCCS) [4], whereby it is posited that there exist four main areas in which students become integrated and educationally engaged within the university. The MCCS builds upon Tinto's model of institution departure [5], and contains four main areas which are: Academic, Social, Professional, and University Integration (AI, SI, PI, and UI). Our students with disabilities advance and develop each of these areas as they proceed in their engineering education at EPCC and UTEP.

'Academic integration' includes academic performance and faculty/staff interactions. Students experiencing positive academic performance and interactions with faculty and staff achieve positive academic integration. 'Social integration' includes extracurricular involvement and peer-group interactions, and with positive involvement, leads to positive social integration. 'Professional integration' refers to the professional development activities, activities which students participate in that lead to successful professional integration. 'University integration' refers to the services provided by the university which students utilize which leads to becoming a part of the university.

This effort is a first step toward creating a disability services design plan with recommended awareness and support strategies for engineering students with disabilities integration. The proposed research will capture the institutional support structures provided for engineering students with disabilities, and will focus on awareness and access to those supports. As

engineering students with disabilities are rarely studied, we begin by interviewing disability service center administrators and staff, though we suspect that student interviews will shed the most light on future areas of work. Our work in progress study will serve as a useful source of knowledge regarding how awareness and access to support structures for students with disabilities influence their integration and ultimate graduation with a STEM degree.

Action Research: Institutional Context and Approach

Our approach has changed from an initial (and in retrospect, naïve) belief that we could assist students with disabilities a priori by providing additional services, to now recognizing that we can best support their success by listening and growing our understanding of how they use their considerable assets to build their success. Through this recognition, we are able to retool our efforts to be individual student-focused. This new paradigm is an outgrowth of our internal research, which demonstrates that those practices based on our students' assets best support their exceptional achievement [1]. Through the intersection of curricular and co-curricular experiences that can be synthesized, transferred to new situations, and articulated for the student's benefit, we developed a Quality Enhancement Plan (QEP). This was part of our Southern Association of Colleges and Schools (SACS) reaccreditation process, the purpose is to establish and enrich student learning and pre-professional achievement.

In our working with students with disabilities, we are adopting this approach and using a variety of such practices, commonly called Integrative and Applied Learning Experiences [6] to ensure that students with disabilities will: (A) engage in and integrate experiences within and beyond the classroom, and (B) adapt and apply skills, abilities, and theories from these integrative experiences to new situations (C) articulate their unique assets and experiences (e.g., in our case English-Spanish bilingualism, US-Mexican biculturalism, management of complex life demands, communication skills, and leadership talents) and (D) apply them to their future aspirations, such as graduate school, careers, civic responsibility, et cetera. Our curricular and co-curricular experiences intersect in what are known as high-impact practices, eight of which are at the center of our UTEP Quality Enhancement Plan (QEP): 1. First-Year Experience; 2. Student Employment & Leadership; 3. Undergraduate Research & Creative Activity; 4. Learning Communities; 5. Internship & Practicum; 6. Study Abroad/Study Away; 7. Community Engagement & Service Learning, and 8. Capstone Experiences.

We have chosen for practical purposes to focus on supporting our students with disabilities to engage in the second and third of these practices. Further, in this work we have chosen to share a case study, to illustrate an example of the learning we have benefited from through working closely with our students.

A Purposeful Illustration: The Case of Diana Gonzales

Diana Gonzales (pseudonym) realized she was progressively losing her hearing from the time of her earliest memory of primary education. Promptly placed by administrators in "special education," she and her guardians were told time and time again that she was not suited to regular math and science courses, and that she would be "left behind" in such regular classes. Diana not only railed against this bias, but she also reported finding a sense of achievement – coupled with peacefulness and inner solace – in studying and completing complex math problems. She reports that her greatest advocates in high school were teachers and others (teachers) were her greatest critics. Her mother was a constant source of support for Diana, helping her to continue through her first year in University, in spite of all challenges she faced. These included being placed in large courses, and lack of understanding and caring – to the point of facing hostility – from misunderstanding faculty. Eventually, through the support of her family, some caring faculty and staff, and the Center for Students with Disabilities, Diana found her place in higher education.

Following her completion of common core courses at EPCC, Diana transferred to UTEP. Diana reports that it is through (A) Student Employment and Leadership at UTEP that she has found her voice and through (B) Undergraduate Research and Creative Activity that she has found her passion. In terms of student employment, Diana began managing a 3-D printing engineering laboratory for undergraduate students, which increased her sense of belonging and helped her to build awareness of her abilities. She could converse with her fellow students through lip-reading and sign language. These skills provided a gateway to understanding her "customers," and she found reward in solving the problems arising from design challenges and their impact on model production in Mechanical Engineering courses.

Finally, Diana learned of the STEMGROW program [1] and commenced participating in research and creative activities. In research, she contributes to the development of understanding the cases of the challenges faced and opportunities provided by engaging in engineering education research. In creative activities, she led, for example, the implementation of a Disabilities Awareness Week at UTEP (held at Centennial Plaza, in October 2017), and personally contributed as a keynote speaker in a research, industry and community workshop (held at UTEP's Tomas Rivera Conference Center), where she highlighted her experiences, learning and trajectory in engineering education and beyond. Diana presented a poster as part of our STEMGROW team at the ASEE Southwest Conference in Austin in March 2018 [31]. Diana reported that this was the first time that she flew on a commercial airplane flight and that she was thrilled to help represent our programmatic efforts.

Diana's case demonstrates the impact of intersecting curricular and co-curricular experiences that can be synthesized, transferred to new situations, and articulated for the student's benefit. This also exemplifies the practical application of our UTEP QEP and how it helps us in working with

our students to focus on enhancing their access to and participation: ultimately, in these eight practices.

Concluding Remarks

Through our work in progress with students designated as having disabilities, we are guiding our strategies and implementation processes toward achieving the following institutional and student learning outcomes: (a) students will engage in/integrate experiences from within and beyond the classroom; (b) students will adapt and apply skills, abilities and theories learned from these integrative experiences to new situations; and (c) students will articulate their unique assets and experiences (to include bilingualism, biculturalism, management of complex lives, communication skills, and leadership talents) in a context that applies to their future aspirations, such as graduate school, careers, and/or civic responsibility.

The focus of this effort is on improving the outcomes for students with disabilities. Our goal is to recognize and support the fundamental premise that diversity drives innovation. We plan with the 2016 QEP to make students with unique backgrounds and capabilities to become increasingly aware of their personal assets, each of the high-impact practices, and the importance of curricular and co-curricular participation. Students will come to understand the relationships among their classes and their beyond-class experiences; ultimately, they will be invited to articulate this integrative learning and how it applies to their next steps – including graduate school or employment. With this student-centered and -driven effort, the UTEP community will serve our "disabled students" in more holistic and deliberate ways than ever before, providing them with the meaningful culture and structure of support they deserve.

The students we are serving are those currently enrolled through disability services at EPCC and UTEP and identified as being in STEM degree programs. The overarching design goal is for EPCC and UTEP together to complete an HSI STEM program "STEMGROW Program: Pathways to Broadening the STEM Workforce" that grows (hence the name "STEMGROW") Hispanic and low-income student success in STEM education through a partnership between UTEP and EPCC [30].

In our STEMGROW Program, we will increase the retention of STEM students with disabilities, through strategies to support special needs students' persistence. Our goal is to grow the number of students with disabilities in STEM fields at both institutions. Our EPCC Center for Students with Disabilities (CSD) is partnering with UTEP's Center for Accommodations and Support Services (CASS) to institute the evidence-based interventions to overcome barriers affecting the engagement of students with a disability in STEM fields. CSD and CASS provide accommodations for STEM students with disabilities that may include physical, mental health, learning, deafness or hard of hearing, blindness or visual impairment, and autism. CSD and CASS currently serve 910 students with disabilities and out of this 11% of students are in a

STEM field at UTEP; the fraction of students at EPCC is currently much less (below 2%). There is room for us to attract, engage, support and grow STEM graduations of students with special needs from our two institutions. We are hopeful that our experiences in this study will have implications for the broader engineering education community. This study can impact policy, curriculum, professional development, and outreach programs but much more experience is information is necessary for us to provide such impact statements. Presently, the status of the study adds to the current body of knowledge related to students with disabilities and the programs in place that create more inclusive environments for these students.

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