WIP: Development of an Integrated Place-Based Learning Community for First-Year Precalculus Level Engineering Students

Introduction

Students from historically marginalized backgrounds – especially low-income students, students of color, and/or first generation in college – disproportionately place below Calculus level math and are often underprepared for direct entrance to an engineering baccalaureate degree curriculum [1] [2]. This equity gap may have been exacerbated by the COVID-19 pandemic and associated variability of K-12 student outcomes in remote learning environments. In fact, math and science preparation for entering college students is likely to be variable for years as a result of the academic interruptions and social isolation of the pandemic [3] [4]. This work-in-progress paper describes the rationale and design of a new learning community we are developing at Whatcom Community College (WCC) in response to this challenge. We envision a new model to welcome and support precalculus-level students entering the engineering academic pathway with an integrated two-quarter long experience. This experience will feature a place-based curriculum including contextualized precalculus and English composition, Pacific Northwest history, orientation to the engineering profession, and introductory skills such as problem-solving, computing, and team-based design. The following three overarching goals guide this work.

Goal 1: Address disparities in students' academic, social and emotional preparation for an engineering major using a holistic approach.

Goal 2: Accelerate engagement of precalculus-level engineering students with existing curriculum, community, and support systems.

Goal 3: Increase course success rates, improve program retention, and reduce equity gaps in engineering transfer preparation and associate degree completion.

The learning community will synthesize multiple high-impact practices that have been shown to be beneficial for college students from a variety of backgrounds [5] including: a first-year experience course sequence with broad early exposure to engineering academic and career options; community-engaged learning through participation in STEM outreach events; a course-based undergraduate research experience (CURE); a place-based learning community with integrated instruction across multiple disciplines spanning two quarters.

Background

WCC engineering students generally form a community of peer support at the 200-level because most engineering fundamentals courses are offered once per year, resulting in a cohort program by default. Students with similar transfer goals tend to have similar course schedules and build community around their shared interests. Unfortunately, many students who start WCC at the 100 (or pre-college)-level with a goal of pursuing an engineering major never make it to that 200-level. In contrast to the 200-level experience, students earlier in their academic path are more diffuse in 100-level math, physics, and chemistry courses that also serve other STEM majors and include no direct instruction on how course content is relevant to their career goals. Opportunities to build community around engineering are up to individual students to seek out in extra-curricular opportunities such as student clubs. This challenge is amplified for most WCC engineering students who must complete 10-20 credits of prerequisite math and physics coursework before credits apply toward their eventual Bachelor of Science degree.

Table 1 illustrates the differential attrition among WCC engineering students who start at various math levels. As shown in the table, nearly 75% of these students start in MATH& 141 (Precalculus 1) or lower. These students must complete both MATH& 141 and MATH& 142 before progressing to MATH& 151: Calculus 1. Looking later at ENGR& 214: Statics, the percentage of students who started in lower-level math has dropped to about 50%. This pattern is not unique to WCC. The fact that students starting in precalculus or lower mathematics are less likely to succeed in engineering is well documented in a variety of educational contexts [6]. In addition, those students who start in MATH& 141 or below and persist to degree completion take considerably more college credits along the way. Students completing an Associate in Science engineering transfer degree earned on average 137 credits if starting below MATH& 141, 123 credits if starting in MATH&141, or 97 credits if starting in MATH& 142 or higher.

Table 1. WCC engineering student completion of program benchmarks by initial math placement (data for summer 2018 through spring 2022) Source: WCC Assessment and Institutional Research office, 2023.

		Percent of students by first math course		
AS-T completion benchmark	**N**	**Below MATH& 141**	**MATH& 141**	**MATH& 142 or higher**
Completed ENGR 101: Intro to Engr	142	35%	39%	26%
Completed MATH& 151: Calculus 1	168	32%	35%	33%
Completed PHYS& 221: Engr Physics 1	151	26%	34%	40%
Completed ENGR& 214: Statics*	79	22%	29%	59%
Completed AS-T Degree (Graduated)	97	21%	24%	56%

*Note ENGR& 214 is not required for some transfer goals

First Year Experience

Providing an early introduction to engineering with one or more first-year courses is a widely recognized best practice in engineering education and in college in general [7]. Our project builds on the existing two-course first-year engineering sequence at WCC that we have offered since Fall 2017. The first course, ENGR 101: Introduction to Engineering, explores the academic and career options within engineering through hands-on projects that strengthen students' academic preparation for future courses by exploring basic science and math concepts along with problem solving strategies. Activities also encourage goal setting, develop academic skills, and introduce students to the social context of engineering. ENGR 101 generally includes a multi-week service-learning project in which students design and deliver STEM outreach activities for local children and their families. Participation in outreach gives students an opportunity to teach their newly acquired engineering knowledge and can contribute to an improved sense of STEM identity [8]. The second course, ENGR 151: Introductory Design and Computing, features a Course-based Undergraduate Research Experience (CURE) in which students develop applications of Arduino microcontrollers. ENGR 151 students learn computer programming, engineering design processes, and effective teamwork in the context of multi-term research and development efforts to design, build, and test devices to support CUREs in other STEM courses.

Course-based Undergraduate Research Experience

CUREs are identified as a high impact practice [5] [9] [10] because they address multiple strategies known to support both student learning and academic identity. CUREs provide authentic learning experiences, raise the level of expectations for all students, and support the development of a community of learners – all critical for students who have been historically underrepresented in STEM [11] [12] [13] [14]. These experiences support development of self-efficacy, interest and identity in STEM [12] [15], contribute to improved course outcomes [16], and generally result in higher retention and persistence for participating students [17].

Place-Based Learning Community

The term "learning community" refers to a purposeful restructuring of curriculum to link two or more courses from different disciplines to emphasize connections and provide coherence in the curriculum [18]. They are a high-impact practice that promotes student success and retention at both two-year and four-year colleges [19]. Learning communities show promise as a retention strategy specifically for first-year engineering. Documented efforts focus on building a cohort through common course schedules with extra-curricular community building and academic support [20] [21]. Living learning communities include shared residence life and have been shown to improve retention of marginalized student populations in engineering [22] [23]. The cohort model provides repeated opportunities for positive engagement between students with associated peer support and increases in belongingness [24]. Place-based education emphasizes connections between course material and the cultural and/or geographic context of the students' lives [25]. Johnson et al demonstrate the potential of a place-based learning community to improve sense of belonging and address equity gaps in first-year STEM students [26].

Contextualized Math and English Instruction

Contextualization of math and writing can lead to significant gains in students' intrinsic motivation to learn these fundamental skills [27]. Contextualizing math instruction may support students in better connecting the abstract concepts and procedures they learn in typical mathematics courses to the mathematical thinking needed to solve "real-world" problems in STEM [28]. This approach has shown promise at improving student outcomes in developmental math courses for students in community college engineering technology programs [29]. Perhaps the most ambitious, mature, and successful effort at contextualized math instruction for engineering can be found in the Wright State Engineering Mathematics model, which introduces core calculus concepts in the context of engineering applications in an introductory course taught by engineering faculty before the students complete their formal mathematics courses [30] [31]. This approach has been extended to an earlier preparatory course focused on algebra concepts that has also shown promising results in terms of degree attainment by students who were

Formatted: Line spacing: single

initially underprepared [32] and has been adapted by several other engineering colleges [33] [34], including versions focused on precalculus-level students [35].

Contextualized instruction can also improve student engagement in English composition. Students planning to enter STEM fields often find connecting their work in first-year composition to their chosen disciplines challenging. Driscoll [36] found that 45.9% of students feel either “uncertain” or “disconnected” when asked to connect their learning to their planned fields of study and careers. Further, this disconnect can create a false dichotomy in which students believe themselves to be “bad at writing” because they are “more of a science person.” Contextualized learning, which focuses on authentic contexts, problem solving, and cognitive apprenticeship, has a strong track record of combatting this disconnect and motivating students. “Students who learn in a contextual environment are simultaneously introduced to the relevance of the learning content, which commensurately improves motivation” [37].

Rationale

To varying degrees, all these approaches can work to support student learning and success by improving students’ sense of belonging, increasing their intrinsic motivation, and supporting development of their engineering/STEM identity. The concept of sense of belonging generally relates to self-perceptions of fit within a given context [38] [39]. Building a sense of belonging, connection and community is important to persistence and student success in college, particularly in STEM fields [40] [41] [42]. The construct of motivation relates to “self-determination theory” and posits that in general people wish to develop themselves and may do so both for extrinsic reasons (desire for praise or reward) and intrinsic reasons (the need to fulfill an interest) [43]. Increasing engineering students’ intrinsic motivation may lead to a desire for deeper learning as opposed to a surface approach focused primarily on grades [44] and can be promoted by giving students opportunities to engage in independent, self-directed learning [45]. The concept of identity is commonly framed around the concept of “the kind of person one is seeking to be and enact in the here and now” [46] and, in the context of students still defining future goals and career paths, can also be thought of in terms of a future time perspective considering the kind of person a student envisions becoming [47]. Development of a professional engineering identity has been tied to retention in the engineering field [48] and can be weaker for engineering students compared to other science majors [49]. Cultivating students’ development of engineering identity is important to increasing participation rates in engineering by women and underrepresented minorities [50].

Project Approach

The project features cross-disciplinary collaboration of engineering, math, physics, English, and history faculty working together to design, implement, and assess the two-quarter long learning community program that will transcript as six different constituent courses as illustrated in Table 2. In each quarter, the Engineering, Math, and Society Learning Community (EMSLC) will be team-taught by three faculty: one engineering, one math, and one history (first quarter) or English (second quarter) with the intention to blur discipline boundaries and emphasize relevance. We envision that student participation in EMSLC will account for the entirety of an academic course load with sixteen contact hours per week. This level of focus will be the same for the participating faculty for the first two years of the pilot as they work to refine the curriculum. Faculty commitment will reduce to two-thirds of full academic load after two years of offerings to improve the financial sustainability of the intensive approach. All course meetings will take place in the engineering labs.

Table 2. Comparison of a typical first-year engineering course plan with one integrating the EMSLC (grey shading = credit burden eliminated in learning community; green shading = analogous courses that are linked in the learning community). All courses are 5 quarter credits.

Typical first four quarters for WCC engineering student who starts in MATH 99: Intermediate Algebra			
Quarter 1	Quarter 2	Quarter 3	Quarter 4
MATH 99: Intermediate Algebra	MATH& 141: Precalculus 1	MATH& 142: Precalculus 2	MATH& 151: Calculus 1
ENGL& 101: English Composition 1	ENGR 101: Intro to Engineering	ENGR& 114; Engineering Graphics	ENGR 151: Introductory Design and Computing
HUM/SS: Humanities or Social Science Elective	HUM/SS: Humanities or Social Science Elective	CHEM& 161: General Chemistry 1	PHYS& 114: General Physics 1
Accelerated plan with the Engineering, Math, and Society learning community			
Quarter 1	Quarter 2	Quarter 3	Quarter 4
MATH 132: Precalculus for Engineering 1	MATH 133: Precalculus for Engineering 2	MATH& 151: Calculus 1	MATH& 152: Calculus 2
HIST& 214: Pacific Northwest History	ENGL& 101: English Composition 1	ENGR& 114: Engineering Graphics	PHYS& 221: Engineering Physics 1
ENGR 101: Intro to Engineering	ENGR 151: Introductory Design and Computing	CHEM& 161: General Chemistry 1	CHEM& 162: General Chemistry 2

Additionally, the EMSLC curriculum accelerates student progression through prerequisite coursework by up to ten quarter credits through two different mechanisms. First, participation reduces math progression from Intermediate Algebra to Calculus from three courses to two, saving students five credits. The math faculty on the project team are confident they can work with students who place as low as Intermediate Algebra due to the affordances of lower student-to-faculty ratio in their overall teaching load, some unburdening of the precalculus curriculum, and the co-designed distributed practice opportunities planned for the adjacent engineering coursework. Second, participation in the EMSLC will satisfy the physics course prerequisite for the calculus-based physics sequence required for all engineering majors. In contrast, most engineering students at WCC are required to take a preparatory physics course (e.g. PHYS& 114 in Table 1) before they can enroll in calculus-based Engineering Physics. The physics faculty member on the project team is working to ensure the contextualized precalculus content and engineering course activities will provide adequate physics preparation.

Curriculum Development

The faculty team is following the principles of backward design as articulated by Wiggins and McTighe [51] as we work to develop the learning community curriculum. The product of this work will consist of topic re-sequencing, assignment/activity (re)design, project experiences, and assessments in four existing courses in which no course outcomes modifications are anticipated: ENGR 101: Introduction to Engineering, ENGR 151 Introductory Design and Computing, ENGL& 101: English Composition, and HIST& 214 Pacific Northwest History. The team is also developing two new contextualized math courses, numbered MATH 132 and MATH 133, Precalculus for Engineering 1 and 2 respectively. Prior to focusing on the nuts and bolts of this work, the team spent considerable time in high-level discussion focused on creating a shared vision of what we would like students to get out of this experience. We crafted a collection of Essential Questions and Understandings that will weave throughout all six courses as we seek to engage students through multiple touchpoints, activities, projects, and perspectives.

Essential Questions are defined in [51] as guiding overarching questions that experts in the field continue to explore; "A question that lies at the heart of a subject or a curriculum, and promotes inquiry and uncoverage of a subject. [They] do not yield a single straightforward answer but produce different plausible responses, about which thoughtful and knowledgeable people may disagree." Table 3 lists our current working draft of Essential Questions.

Table 3. Draft list of Essential Questions for the EMSLC.

Engineering, Math, and Society Essential Questions
What is my process for improving as a learner?
Why do I want to be an engineer?
How do engineers make decisions?
Who decides what problems engineers work on?
What is the role of engineers in society?
What is the work of engineering?
Who gets to be an engineer?
What is engineering culture?
How does the engineered world affect how we live?

An *Understanding* is defined in [51] as "an important inference, drawn from the experience of experts, stated as a specific and useful generalization...refers to transferable, big ideas having enduring value beyond a specific topic...involves abstract, counterintuitive and easily misunderstood ideas...is best acquired by "uncovering" and "doing" the subject...[and] summarizes important strategic principles in skill areas." Table 4 (on the next page) lists our current working draft list of Understandings.

In addition to articulating an overarching framework for inquiry and assessment throughout the EMSLC courses, the development of these lists provided multiple opportunities for the team (all co-authors on this paper) to engage in wide ranging discussions about the engineering profession, engineering education, and the role of engineers in society. Some of these faculty came to this project with little experience in any professional or academic engineering context and now feel more prepared to engage with teaching their courses in this context. Furthermore, this synthesis work and accompanying exercises mapping existing course outcomes to the understandings helped clarify how the respective courses will fit together and identify commonalities to build on with shared projects and assessments.

Table 4. Draft list of Understandings for the EMSLC.

Engineering, Math, and Society Understandings
Models and algorithms are developed to meet the goals of societies and represent the values of the societies that created them.
Theoretical knowledge gives engineers the breadth and depth to work in a variety of workplaces and leverage a wide array of skills for creative problem solving.
Engineers use math, science and technology to develop models of technical systems and processes.
A model is a tool. It is necessarily a simplification of reality. Choosing what information to leave out is as important as choosing what to include.
Throughout history, engineering decision-making has affected social norms. Sometimes, these norms are for the benefit of society, while other times they create or exacerbate social injustice.
Engineers have shaped land and resource use in the Pacific Northwest, and conversely their designs have been shaped by their perceptions of the landscape and environmental policies.
The most innovative engineering work leverages a diversity of skills, knowledge, experiences, and perspectives in a multidisciplinary team.
Engineers work to solve problems for people. This work is by definition a political act. Engineers cannot be apolitical.
The skill of quickly and independently getting up to speed on new and complex technical information is highly valued in engineering. Much of engineering education is designed as practice to develop skill and confidence in this area.
True learning involves engaging with a community in shared inquiry and practice.
Rhetorical analysis can be used to think about engineering problems.
Real learning can be uncomfortable, frustrating, and nonlinear and generally requires persistence and motivation.
Effective engineering practice requires interpersonal skills such as leadership, teamwork, communication, and emotional intelligence.
Engineers should understand the social and cultural context in which the product(s) of their work will be used.
Learning is a process of encountering new ideas, productive practice, giving and receiving feedback, reflection and continuous monitoring and adjustment.

Research and Assessment and Plan

We plan to pilot the EMSLC for four years starting in Fall 2023 with a cohort of up to 24 students per year. Table 5 lists the research questions we will investigate to assess progress toward the goals described previously.

Research Methodology

We will use a mixed methods approach to investigate RQ1. WCC has been administering the SUCCESS survey since 2018-19 to learn about the non-cognitive and affective (NCA) profiles of the College's engineering student population [52] [53]. The project team will compare survey results for EMSLC students with results from a comparable sample (statistically matched along demographics and course preparation measures) from the rest of the student population to see if there are differences along measures such as motivation, identity, and belongingness. In addition, we will analyze a pre/post reflective writing assignment and apply open, axial, and selective coding [54] to the students' writing to determine if there is evidence of causal relationships between their EMSLC experience and self-reported social-emotional growth. Lastly, the external evaluation team will conduct focus group interviews with subgroups of the learning community students to discuss the relative impact of the various elements of the EMSLC.

Table 5. Research questions the team will use to assess the impact of the EMSLC.

Project Research Questions
RQ1: Do students who complete the EMSLC make larger gains along social-emotional measures such as sense of belonging and engineering identity compared to their peers who complete prerequisites through the current a la carte model?
RQ2: Does participation in the EMSLC contribute to improved learning outcomes in follow-on math, engineering, and physics courses?
RQ3: Does participation in the EMSLC increase rates of completion of an engineering transfer AS-T degree and successful transfer to a BS degree program?
RQ4: How does participation in the EMSLC relate to student engagement in co-curricular activities as they progress deeper into the engineering transfer program?
RQ5: Does the EMSLC program reduce equity gaps in engineering transfer program completion?

For RQ2, we will analyze outcomes in follow on courses to compare success rates and final course grade distributions of EMSLC students to those who completed prerequisites through the current *a la carte* model. This analysis will focus on key foundation courses such as Engineering Physics, Statics, and Calculus, that would typically be completed by students within one to three quarters of their EMSLC experience. We will also compare retention rates, degree completion, and transfer matriculation to address RQ3. The co-curricular student engagement activities of interest for RQ4 are participation in the engineering peer mentor program and in student clubs. We will track EMSLC student participation in club meetings and projects as well as their interest in leadership opportunities and compare engagement levels to non-EMSLC students. We will investigate RQ5 by analyzing the demographic breakdown of findings related to the other four research questions.

Conclusion

This work-in-progress paper describes early development of a new learning community we are designing to welcome and support precalculus-level students into their engineering academic pathway. The approach leverages multiple high-impact educational practices to promote deep conceptual learning, motivate foundational skill development, explore social relevance and connection, and ultimately seeks to strengthen students' engineering identity, sense of belonging, and general academic preparation for success in an engineering major. The curriculum design reduces prerequisite course burden and accelerates new student engagement with the first-year engineering curriculum and support structures.

The interdisciplinary faculty team developed a shared vision for the program by working together to craft Essential Questions and Understandings with which they will seek to engage students through multiple touchpoints, activities, projects, and perspectives throughout the two-quarter experience. Assessment work will investigate a series of research questions with a mixed methods approach combining surveys, coding of reflective writing assignments, focus groups, analysis of success rates in follow-on coursework, and degree completion.

Acknowledgment

This material is based upon work supported by the National Science Foundation under grant number DUE #2147320. Any opinions, findings, and conclusions or recommendations expressed are those of the authors and do not necessarily reflect the views of the NSF.

References

[1] X. Chen, "Remedial coursetaking at U.S. public 2-and 4-year institutions: Scope, experiences, and outcomes. Statistical analysis report.," U.S. Department of Education., Washington, DC: National Center for Education Statistics, 2016.

[2] F. Ngo and T. Melguizo, "The Equity Cost of Inter-Sector Math Misalignment: Racial and Gender Disparities in Community College Student Outcomes," *The Journal of Higher Education,* vol. 92, no. 3, pp. 410-434, 2021.

[3] X. Wang, S. Hegde, C. Son, B. Keller, A. Smith and F. Sasangohar, "Investigating mental health of US college students during the COVID-19 pandemic: cross-sectional survey study.," *Journal of Medical Internet Research,* vol. 22, no. 9, 2020.

[4] P. Sahu, "Closure of universities due to coronavirus disease 2019 (COVID-19): impact on education and mental health of students and academic staff," *Cureus,* vol. 12, no. 4, 2020.

[5] G. D. Kuh, High-Impact Educational Practices: What They Are, Who Has Access to Them, and Why They Matter, Association of American Colleges and Universities, 2008.

[6] J. Van Dyken and L. Benson, "Precalculus as a death sentence for engineering majors: A case study of how one student survived," *International Journal of Research in Education and Science,* vol. 5, no. 1, pp. 355-373, 2019.

[7] M. L. Upcraft, J. N. Gardner and B. O. Barefoot, Challenging and Supporting the First-Year Student : A Handbook for Improving the First Year of College, Jossey-Bass, 2004.

[8] J. Keshwani and K. Adams, "Cross-Disciplinary Service-Learning to Enhance Engineering Identity and Improve Communication Skills," *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship,* vol. 12, no. 1, pp. 41-61, 2017.

[9] N. H. Hensel, Course-based Undergraduate Research: Educational Equity and High-Impact Practice, Sterling, VA: Stylus, 2018.

[10] L. Corwin, M. Graham and E. Dolan, "Modeling Course-Based Undergraduate Research Experiences: An Agenda for Future Research and Evaluation," *CBE Life Sciences Education,* pp. 14, 1-13, 2015.

[11] H. Carlone and A. Johnson, "Understanding the science experiences of successful women of color: Science identity as an analytic lens," *Journal of Research in Science Teaching,* vol. 44, no. 8, pp. 1187-1218, 2007.

[12] M. J. Chang, J. Sharkness, S. Hurtado and C. B. Newman, "What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups," *Journal of Research in Science Teaching,* vol. 51, no. 5, pp. 555-580, 2014.

[13] M. J. Graham, J. Frederick, A. Byars-Winston, A.-B. Hunter and J. Handelsman, "Increasing Persistence of College Students in STEM," *Science,* vol. 341, no. 6153, pp. 1455-1456, 2013.

[14] C. A. Lundberg, Y. K. Kim, L. M. Andrade and D. Bahner, "High expectations, strong support: Faculty behaviors predicting Latina/o community college student learning," *Journal of College Student Development,* vol. 59, no. 1, pp. 55-70, 2018.

[15] C. L. Luedke, G. D. Collom, D. L. McCoy, J. Lee-Johnson and R. Winkle-Wagner, "Connecting identity with research: Socializing students of color towards seeing themselves as scholars.," *The Review of Higher Education,* vol. 42, no. 4, pp. 1527-1547, 2019.

[16] M. Ing, J. M. Burnette III, T. Azzam and S. R. Wessler, "Participation in a Course-Based Undergraduate Research Experience Results in Higher Grades in the Companion Lecture Course," *Educational Researcher,* vol. 50, no. 4, pp. 205-213, 2021.

[17] R. Nerio, A. Webber, E. MacLachlan and D. Lopatto, "One-year research experience for associate's degree students impacts graduation, STEM retention, and transfer patterns," *CBE-Life Sciences Education,* vol. 18, no. 2, pp. 1-9, 2019.

[18] J. Fogarty, L. Dunlap, E. Dolan, M. Hesse, M. Mason and J. Mott, "Learning Communities in Community Colleges," 24 May 2021. [Online]. Available: http://wacenter.evergreen.edu/node/1746.

[19] S. Otto, M. Evins, M. Boyer-Pennington and T. M. Brinthaupt, "Learning Communities in Higher Education: Best Practices," *Journal of Student Success and Retention,* vol. 2, no. 1, pp. 1-20, 2015.

[20] P. R. Lockwood and E. M. Hunt, "Engineering Learning Communities," in *2013 ASEE Annual Conference & Exposition*, Atlanta, GA, June 2013.

[21] M. Howland Cummings, M. Darbeheshti, G. E. Simon, W. T. Schupbach, M. S. Jacobson, T. Altman and K. Goodman, "Comparing Student Outcomes From Four Iterations of an Engineering Learning Community," in *2021 ASEE Virtual Annual Conference Content Access*, Virtual Conference, 2021.

[22] W. Palm, "First-Year Engineering Living-Learning Communities Improve Four-Year Graduation Rates at a Small Private University," in *2022 ASEE Annual Conference & Exposition*, Minneapolis, MN, August, 2022.

[23] C. V. Caldwell and R. Hughes, "Engineering Living Learning Community Experience: A Model for Improving First-Year Retention and Academic Performance of Black Students," in *2021 ASEE Virtual Annual Conference Content Access*, Virtual Conference, July, 2021.

[24] A. M. Locks, S. Hurtado, N. A. Bowman and L. Oseguera, "Extending notions of campus climate and diversity to students' transition to college," *Review of Higher Education,* vol. 31, no. 3, pp. 257-285, 2008.

[25] D. A. Gruenewald and G. A. Smith, Place-Based Education in the Global Age, Milton Park, Abingdon, Oxfordshire, UK: Routledge, 2008.

[26] M. D. Johnson, A. E. Sprowles, K. R. Goldenberg, S. T. Margell and L. Castellino, "Effect of a Place-Based Learning Community on Belonging, Persistence, and Equity Gaps for First-Year STEM Students," *Innovative Higher Education,* vol. 45, pp. 509-531, 2020.

[27] D. Cordova and M. Lepper, "Intrinsic motication and the process of learning: Beneficial effects of contextualization, personalization, and choice.," *Journal of Educational Psychology,* vol. 88, pp. 715-730, 1996.

[28] "Needed Math Conference Proceedings," in *Needed Math*, Baltimore, 2018.

[29] X. Wang, N. Sun and K. Wickersham, "Turning Math Remediation into "Homeroom:" Contextualization as a Motivational Environment for Community College Students in Remedial Math," *Review of Higher Education,* vol. 40, no. 3, pp. 427-464, 2017.

[30] "The Wright State Model for Engineering Mathematics Education," [Online]. Available: https://engineering-computer-science.wright.edu/research/the-wright-state-model-for-engineering-mathematics-education. [Accessed May 2021].

[31] N. W. Klingbeil and A. Bourne, "A National Model for Engineering Mathematics Education: Longitudinal Impact at Wright State University," in *2013 ASEE Annual Conference and Exposition*, Atlanta, 2013.

[32] N. W. Klingbeil and A. Bourne, "The Wright State Model for Engineering Mathematics Education: Longitudinal Impact on Initially Underprepared Students," in *2015 ASEE Annual Conference and Exposition*, Seattle, 2015.

[33] J. C. Minor, E. A. Stephan and A. T. Stephan, "Implementing an Engineering Math Curriculum Sequence: Preliminary Results and Lessons Learned," in *2021 ASEE Virtual Annual Conference*, Virtual Online, 2021.

[34] L. L. Long III, L. M. Abrams, L. Barclay and J. Paulson, "Emulating the Wright State Model for Engineering Mathematics Education: Improving First-Year Engineering Student Retention," in *Proceedings from 8th Annual First-Year Engineering Experience Conference (FYEE)*, Columbus, OH, 2016.

[35] N. Baine, "Effects of a Limited Implementation of the Wright State Model for Engineering Mathematics Education focused on Pre-Calculus Students," in *2020 ASEE National Conference*, Virtual Online, 2020.

[36] D. L. Driscoll, "Connected, disconnected, or uncertain: Student attitudes about future writing contexts and perceptions of transfer from first year writing to the disciplines.," *Across the Disciplines,* vol. 8, no. 2, 2011.

[37] E. D. Baker, L. Hope and K. Karandjef, "Contectualized Teaching & Learning: A Faculty Primer," Academic Senate for California Community COlleges, 2009.

[38] S. Hurtado and D. F. Carter, "Effects of College Transition and Perceptions of the Campus Racial Climate on Latino COllege Students' Sense of Belonging," *Sociology of Education,* vol. 70, no. 4, pp. 324-345, 1997.

[39] K. F. Osterman, "Students' Need for Belonging in the School Community," *Review of Educational Research,* vol. 70, no. 3, pp. 323-367, 2000.

[40] L. Hausmann, J. Schofield and R. Woods, "Sense of Belonging as a Predictor of Intentions to Persist among African American and White First-Year College Students," *Research in Higher Education,* vol. 48, pp. 803-839, 2007.

[41] E. Seymour and N. M. Hewitt, Talking about Leaving: Why Undergraduates Leave the Sciences, Boulder, CO: Westview Press, 1997.

[42] E. Tate and M. Linn, "How Does Identity Shape the Experiences of Women of Color Engineering Students," *Journal of Science Education and Technology,* vol. 14, no. 5/6, pp. 483-493, 2005.

[43] E. L. Deci and R. M. Ryan, "The "what" and "why" of goal pursuits: human needs and the self-determination of behavior," *Psychological Inquiry,* vol. 11, no. 4, pp. 227-268, 2000.

[44] J. W. K. Rowe, "Approaches to study by first-year engineering students," in *Progress 1 Conference: Improving Student Progression and Achievement in Engineering*, Hull, UK, 2001.

[45] N. Savage, R. Birch and E. Noussi, "Motivation of engineering students in higher education," *Engineering Education,* vol. 6, no. 2, pp. 39-46, 2011.

[46] J. P. Gee, "Chapter 3: Identity as an Anaytic Lens for Research in Education," *Review of Research in Education,* vol. 25, no. 1, pp. 99-125, 2000.

[47] J. Husman and W. Lens, "The Role of the Future in Student Motivation," *Educational Psychology,* vol. 34, no. 2, pp. 113-125, 1999.

[48] A. Clark and R. L. Kajfez, "Engineering Identity in Pre-College Students: A Literature Review," in *126th ASEE Annual Conference and Exposition*, Tampa, FL, 2019.

[49] T. Beam, O. Pierrakos, J. Constantz, J. Aditya and R. Anderson, "Preliminary Findings On Freshmen Engineering Students' Professional Identity: Implications For Recruitment And Retention," in *2009 ASEE Annual Conference and Exposition*, Austin, TX, 2009.

[50] S. L. Rodriguez, C. Lu and M. Bartlett, "Engineering Identity Development: A Review of the Higher Education Literature," *International Journal of Education in Mathematics, Science and Technology (IJEMST),* vol. 6, no. 3, pp. 254-265, 2018.

[51] G. Wiggins and J. McTighe, Understanding By Design, Alexandria, VA: Association for Supervision and Curriculum Development, 2005.

[52] M. Scheidt, A. Godwin, R. Senkpeil, S. G. Juliana, J. Chen, B. P. Self, J. Widmann and E. J. Berger, "Validity Evidence for the SUCCESS Survey: Measuring Non-Cognitive and Affective Traits of Engineering and Computing Students," in *2018 ASEE Annual Conference & Exposition*, Salt Lake City, Utah, 2018.

[53] L. Krest, C. Major, M. Scheidt, J. Ge, B. P. Self, J. Chen, J. Widmann, A. Godwin and E. J. Berger, "Examining the Importance of Non-Cognitive and Affective (NCA) Factors for Engineering Student Success," in *2020 ASEE Virtual Annual Conference Content Access*, Virtual Online, 2020.

[54] A. Strauss and J. Corbin, Basics of Qualitative Research: Grounded Theory Procedures and Techniques, Beverly Hills, CA: Sage Publications, 1990.