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Integrating Asset-based Practices into Engineering Design Instruction

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Abstract: This work in progress paper presents asset mapping activities as a strategy to foster the development of engineering identities, sense of belonging, and engineering self-efficacy in a diverse student population and presents evidence on feasibility of this strategy. Asset-based approaches highlight and leverage students' diverse assets for teaching and learning in course activities. Students' assets or strengths may include community networks, language and communication skills, tinkering skills, and most importantly, their lived experiences. One asset-based pedagogical strategy is asset mapping, where students identify and categorize how their own experiences and backgrounds can provide them with useful skills and insights. Asset mapping has frequently been deployed in community development to help the general public recognize and build on existing resources and capabilities. However, less is known about deploying asset mapping in the engineering classroom. In this paper, we describe implementing asset mapping activities in a first-year engineering course at the University of Arizona, a large land-grant, Hispanic-serving institution. In our College of Engineering, approximately 20% of students identify as Hispanic/Latinx and 30% identify as female. We quantify changes in students' engineering identity, sense of belonging in engineering, and engineering self-efficacy over one semester for students who participated in asset mapping activities (n=31) and compare these changes to students in a control section of the same course (n=38). In our pilot deployment of asset maps, students tended to identify mostly technical skills (e.g., data analysis, prototyping) in their initial asset maps and in subsequent course activities related to asset development. Implementation lessons learned relating to teaming, discussions of implicit bias, and valuing diverse assets in design projects are also presented. These findings can help the engineering education community implement asset-based approaches such as asset mapping.

Keywords: Asset based practices; community cultural wealth; engineering design

Introduction

The design process is the foundation of the engineering profession and a cornerstone of undergraduate engineering curricula. The design process draws on students' strengths and skills such as communication, tinkering, modeling, and brainstorming, informed by their unique experiences and expertise. However, social dynamics may result in women, gender minorities, and racial and ethnic minorities being relegated to clerical or social roles on teams [1]–[3], preventing full participation and benefit from technical design, experimentation, and fabrication activities. This may result in less engagement in hands-on design activities that help build engineering sense of belonging, self-efficacy, and identity.

This marginalization may also impact retention. In the College of Engineering at the University of Arizona, the year-to-year retention rate students who started an engineering degree in Fall of 2015 (n = 733) was around 80%, 68%, 66%, and 65% from first to fourth year, respectively. The 4-year graduation rate for this class was 48% overall. These outcomes highlight the need for equity-centered approaches to improve retention of all engineering students.

One promising equity-centered approach is asset-based pedagogy (ABP), which explicitly emphasizes the holistic student perspective (i.e., students' diverse strengths, experiences, and background). In contrast to deficit-based educational models of the past, which assumed that marginalized groups lacked the ability or cultural resources to succeed in certain academic contexts, ABP includes intentional efforts to incorporate knowledge that affirms students' unique identities into the curriculum. Prior studies indicate that students' identity and achievement are positively influenced by ABP, e.g. [4]–[7]. There is a rich body of literature describing the implementation of ABP in K-12 pre-engineering contexts, e.g. [8], [9]. Specific examples of undergraduate engineering contexts, summarized in [10], include using culturally-responsive of community-inspired design projects and course examples [11]–[13]. Another approach is to ask students to identify and categorize their strengths and assets as part of course projects, creating an individual asset map [14], [15]. Another strategy is to work with students one-on-one and in small groups to identify and draw on their funds of knowledge [16].

Preliminary findings on ABP in engineering education contexts include improved confidence in marginalized students, more equitable distribution of responsibilities, and improved management of conflicts in student teams [14], [15]. Additionally, prior work provides evidence that ABP can inform sense of belonging for marginalized students [16] and promote identity and self-efficacy [17], [18]. These preliminary findings highlight the potential of ABP approaches in engineering, but further study is needed to understand the impact of ABP on engineering student outcomes.

Methods

Study setting: This study focuses on a large, multi-section first-year introduction to engineering design course. The course is taken by all first-year engineering students at the University of Arizona, a large, land-grant, Hispanic-serving institution (HSI) in the American Southwest. The course focuses on giving students experience with each step of the engineering design process through two team projects. This first-year course includes both lecture and lab components, which meets twice a week for 50 minutes with 35 students per section. To evaluate the impact of ABP, we implemented one specific ABP strategy called asset mapping [14], [15] in one lab section of this course, taught by the first author of the study. This section was an honors section. We also collected data from another section with no curricular or pedagogical changes, taught by a different experienced instructor, to serve as a control. This section was co-convened with an honors and a non-honors section.

Positionality statement: The first author is a White American woman with a mechanical engineering background and experience teaching at public universities in Arizona. The second author is an Asian man with a background in biomedical engineering and informatics, and HSI scholarship. The last author is a Mexican American woman with a background in education that included roles as a bilingual teacher and high school counselor in a border city in Texas.

Asset mapping: In Fall 2021, we piloted asset mapping activities in one section of the first-year engineering design course. Activities were drawn from an asset mapping guide [19] and research on interventions to address biases related to stereotype threat [20]. The instructor (the first author of this study) changed several course elements to accommodate the asset mapping activities. The first activity (week 2) asked students to create maps of their personal assets (example in Fig. 1), with categories of: team/project skills, personal background and culture, clubs/organizations/sports, technical expertise, passions/interests, relevant experiences, related coursework and jobs, and creativity.

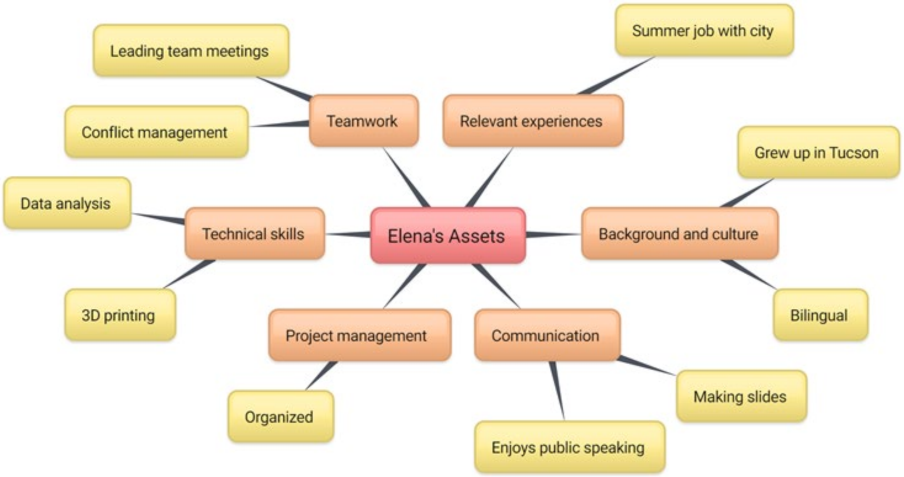

Figure 1. Example of an asset map submitted by students

Shortly after the asset mapping activity, concepts of implicit bias and stereotyping were discussed during a lecture and then students were asked to discuss team member responsibilities for upcoming team assignments, and to submit a list of responsibilities for each team member (week 4). These team responsibility discussions were repeated in class several times (weeks 5-12) during the semester. At the end of the semester (week 15), students were asked to reflect on teaming, the impact of bias and stereotypes on team responsibilities, and how they used and grew their assets during the course.

Instruments: To examine the impact of the ABP activities, students were surveyed at the beginning and end of the semester, using items from validated measures of sense of belonging, engineering identity, and engineering self-efficacy. The measures were collected online using a Qualtrics survey. Data were collected from the ABP intervention section and a control section. We used the three-item sense of belonging survey from Hurtado & Carter [21], with scores ranging from 0 to 10. We used an adapted version of the original survey, replacing the term "campus" with "engineering" to assess sense of belonging to the engineering community, which has shown excellent internal consistency (α = .97). For engineering self-efficacy, we used the survey from Mamaril et al. [22], which assesses general beliefs in engineering capabilities and combines items from several prior self-efficacy surveys. We report the general engineering self-efficacy scale from the confirmatory factor analysis in the 2016 study, which shows good internal consistency (α ≥ .89), and the design self-efficacy scale items with scores ranging from 1 to 6. We also used Godwin's 11-item engineering identity measure [23], which has demonstrated good internal consistency (α ≥ .77). Scores ranged from 0 to 7 (note: a mistake in our survey resulted in an 8-point scale instead of the 7-point scale from 0 to 6 used in the original survey).

Analysis plan: The study team documented strategies and challenges for ABP implementation through self-reflection during the semester and de-briefing at the end of the semester. Differences in mean pre- and post-test scores for each measure in the intervention group was evaluated using paired t-test. Differences in mean scores for each measure between the intervention and control groups was evaluated using Welch's two-sample test. Effect size was calculated using Cohen's d mirroring the t-test as appropriate (i.e., two-sample vs paired test).

Preliminary Results

Implementation lessons and challenges: We have identified several lessons learned by deploying the ABP intervention in Fall 2021. First, systematic professional development for instructors can better support instructors as they make curriculum updates. Instructors should identify multiple opportunities during the semester to allow students to reflect on their assets, rather than a single activity. Second, we found that our students tended to identify technical skills in their asset maps, so additional guidance could help students dig deeper into how lived experiences relate to their strengths. Third, we found that instructors found it difficult to discuss topics of race, gender, and bias with their students without prior training or guidance. Finally, with many courses throughout engineering programs that could benefit from ABP, it is not desirable or feasible to deploy asset mapping in every course. Different course contexts require different strategies.

Quantitative results: Students in the intervention group reported significantly higher sense of belonging, engineering identity, and design self-efficacy at the end of the course as compared to baseline with a medium to large effect size (Table 1). Design self-efficacy, in particular, was significantly higher with a large effect size post-intervention. Students in the control group reported similar results, but with small to medium effect size (Table 2). Outcomes at end of the course were generally higher for the intervention group than the control group with a small effect size but were not significantly different (Table 3). The mean increase in the outcome measures were generally higher for the intervention group than the control group (Table 4). Again, the mean increase in design self-efficacy was higher for the intervention group than the control group, with a medium effect size. Finally, all students in the intervention group persisted for another semester (94% in engineering; 6% in another discipline), while the persistence was lower in the control group (84% in engineering; 11% did not persist i.e., did not enroll the following semester).

Table 1. Comparison of outcomes pre- and post-ABP in the intervention group

Measure	Mean composite score for group with ABP intervention, n = 31		p	Effect Size, *d*
	Pre-test, mean (SD)	Post-test, mean (SD)		
Sense of Belonging	6.58 (1.81)	8.11 (1.56)	< 0.001	0.75
Engineering Identity	5.40 (0.91)	5.88 (0.86)	< 0.01	0.46
General Engineering Self-Efficacy	4.79 (0.76)	5.02 (0.82)	0.08	0.25
Design Self-Efficacy	4.10 (1.10)	4.99 (0.70)	< 0.001	0.87

Table 2. Comparison of outcomes pre- and post-ABP in the control group

Measure	Mean composite score for control group, n = 38		p	Effect Size, *d*
	Pre-test, mean (SD)	Post-test, mean (SD)		
Sense of Belonging	6.47 (1.78)	7.42 (2.00)	< 0.001	0.55
Engineering Identity	5.31 (0.95)	5.56 (0.95)	0.01	0.38
General Engineering Self-Efficacy	4.70 (0.84)	4.87 (0.71)	0.09	0.23
Design Self-Efficacy	4.49 (1.05)	4.89 (0.85)	< 0.01	0.50

Table 3. Comparison of end-of-term outcomes between intervention and control groups

Measure	Mean composite score for group with ABP intervention (n = 31) vs control (n = 38)		p	Effect Size, *d*
	Intervention, mean (SD)	Control, mean (SD)		
Sense of Belonging	8.11 (1.56)	7.42 (2.00)	0.06	0.38
Engineering Identity	5.88 (0.86)	5.56 (0.95)	0.07	0.35
General Engineering Self-Efficacy	5.02 (0.82)	4.87 (0.71)	0.22	0.19
Design Self-Efficacy	4.99 (0.70)	4.90 (0.85)	0.31	0.12

Table 4. Comparison of mean change in outcomes for intervention versus control group

Measure	Mean **increase** in composite score for group with ABP intervention (n = 31) vs control (n = 38)		Effect Size, *d*
	Intervention group	Control group	
Sense of Belonging	1.53	0.96	0.30
Engineering Identity	0.49	0.25	0.28
General Engineering Self-Efficacy	0.23	0.17	0.07
Design Self-Efficacy	0.88	0.41	0.53

Study limitations: Our results may be impacted by our small sample size, different instructors in the implementation/control sections, and influence of student honor status. Most students saw increases in the outcome measures, but ABP may result in larger gains. We also believe that ABP will help retain students who are likely to change majors or drop-out without fully realizing their inherent strengths to thrive in engineering. Future work will analyze outcomes for specific student groups (e.g., women, racial and ethnic minorities) and include qualitative analysis.

Conclusion

Preliminary results from a pilot implementation of an asset-based strategy (i.e., asset mapping) in a first-year engineering design course suggest that ABP can lead positive outcomes in students, particularly in design efficacy. While asset mapping is feasible, it may not be directly applicable to all engineering courses and different ABPs that are contextualized to the needs and format of different courses may be more appropriate. ABPs should allow for flexibility on how students identify and integrate assets in the learning and engineering design process. To this end, instructor professional development on ABP is needed. As a next step, we will explore ways to engage other instructors in ABP-related training and identify a broader set of ABPs.

References

[1] A. Haverkamp, M. Bothwell, D. Montfort, and Q.-L. Driskill, "Calling for a Paradigm Shift in the Study of Gender in Engineering Education," *Studies in Engineering Education*, vol. 1, no. 2, p. 55, Feb. 2021.

[2] A. E. Trauth, J. M. Buckley, T. N. Barnes, J. Enszer, S. Rooney, and R. Davidson, "Adjusting the Lens: Comparison of Focus Group and Cross-Sectional Survey Data in Identifying and Addressing Issues of Diversity and Inclusion in Undergraduate Engineering Programs," in *Proceedings of the ASEE Annual Conference & Exposition*, 2019.

[3] L. A. Meadows, D. Sekaquaptewa, A. Pawley, S. S. Jordan, D. Chachra, and A. Minerick, "Interactive Panel: Improving the Experiences of Marginalized Students on Engineering Design Teams," in *Proceedings of the ASEE Annual Conference & Exposition*, Seattle, WA, 2015.

[4] C. S. Brown and H. Chu, "Discrimination, Ethnic Identity, and Academic Outcomes of Mexican Immigrant Children: The Importance of School Context," *Child Development*, vol. 83, no. 5, pp. 1477–1485, Sep. 2012.

[5] H. Chun and G. Dickson, "A Psychoecological Model of Academic Performance Among Hispanic Adolescents," *Journal of Youth and Adolescence*, vol. 40, no. 12, pp. 1581–1594, Mar. 2011.

[6] F. López, "Altering the trajectory of the self-fulfilling prophecy: Asset-based pedagogy and classroom dynamics," *Journal of Teacher Education*, vol. 68, no. 2, pp. 193–212, 2017.

[7] C. Rios-Aguilar, "Measuring Funds of Knowledge: Contributions to Latina/o Students' Academic and Nonacademic Outcomes.," *Teachers College Record*, vol. 112, no. 8, pp. 2209–2257, 2010.

[8] A. Wilson-Lopez, J. A. Mejia, I. M. Hasbún, and G. S. Kasun, "Latina/o Adolescents' Funds of Knowledge Related to Engineering," *Journal of Engineering Education*, vol. 105, no. 2, pp. 278–311, Apr. 2016.

[9] J. A. Mejia, A. A. Wilson, C. E. Hailey, I. M. Hasbun, and D. L. Householder, "Funds of knowledge in Hispanic students' communities and households that enhance engineering design thinking," in *Proceedings of the ASEE Annual Conference & Exposition*, 2014.

[10] H. D. Budinoff and V. Subbian, "Asset-based Approaches to Engineering Design Education: A Scoping Review of Theory and Practice," in *Proceedings of the ASEE Annual Conference & Exposition*, 2021.

[11] J. Gomez and V. Svihla, "Rurality as an Asset for Inclusive Teaching in Chemical Engineering," *Chemical Engineering Education*, vol. 52, no. 2, pp. 99–106, Mar. 2018.

[12] V. Svihla, J. R. Gomez, S. Bowers, A. K. Datye, P. Prescot, J. Scacco, J. O. James, and N. Loner, "Asset-based Design Projects in a Freshman-level Course," in *Proceedings of the ASEE Annual Conference & Exposition*, 2017.

[13] A. Battistini, "Integrating World Structures Reports, Presentations, and Themed Notes," in *Proceedings of the ASEE Annual Conference & Exposition*, 2020.

[14] J. Gomez and V. Svihla, "Supporting Diversity in Teams through Asset Mapping," in *Proceedings of the ASEE Annual Conference & Exposition*, 2018.

[15] E. A. Stoddard and G. Pfeifer, "Working Toward More Equitable Team Dynamics: Mapping Student Assets to Minimize Stereotyping and Task Assignment Bias," in

Proceedings of the Collaborative Network for Engineering and Computing Diversity Conference, 2018.

[16] J. M. Smith and J. C. Lucena, "Invisible innovators: how low-income, first-generation students use their funds of knowledge to belong in engineering," *Engineering Studies*, vol. 8, no. 1, pp. 1–26, Jan. 2016.

[17] J. A. Mejia, D. Drake, and A. Wilson-Lopez, "Changes in latino/a adolescents' engineering self-efficacy and perceptions of engineering after addressing authentic engineering design challenges," in *Proceedings of the ASEE Annual Conference and Exposition*, Seattle, WA, 2015.

[18] I. Villanueva, M. di Stefano, L. Gelles, P. V. Osoria, and S. Benson, "A race re-imaged, intersectional approach to academic mentoring: Exploring the perspectives and responses of womxn in science and engineering research," *Contemporary Educational Psychology*, vol. 59, p. 101786, 2019.

[19] G. Pfeifer and E. A. Stoddard, "Diversity, Equity, and Inclusion Tools for Teamwork: Asset Mapping and Team Processing Handbook," in *Beyond All Expectations: Project-Based Learning in the First Year*, K. Wobbe and E. A. Stoddard, Eds. 2019.

[20] C. FitzGerald, A. Martin, D. Berner, and S. Hurst, "Interventions designed to reduce implicit prejudices and implicit stereotypes in real world contexts: a systematic review," *BMC Psychol*, vol. 7, no. 1, p. 29, 2019.

[21] 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.

[22] N. A. Mamaril, E. L. Usher, C. R. Li, D. R. Economy, and M. S. Kennedy, "Measuring undergraduate students' engineering self-efficacy: A validation study," *Journal of Engineering Education*, vol. 105, no. 2, pp. 366–395, 2016.

[23] A. Godwin, "The Development of a Measure of Engineering Identity," in *Proceedings of the ASEE Annual Conference & Exposition*, 2016.