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# WIP: QuantCrit Analysis of the Impacts of Teaching Innovations on Student Development

**Dr. Vanessa Svihla, University of New Mexico**

Dr. Vanessa Svihla is a Professor in Organization, Information & Learning Sciences and in Chemical & Biological Engineering at the University of New Mexico. Dr. Svihla received the National Academy of Education / Spencer Postdoctoral Scholarship and the NSF CAREER Award, which President Biden also recognized with a PECASE. Their scholarship has been recognized for its contributions to diversity, equity, and inclusion by the American Society for Engineering Education and the Professional and Organizational Development Network. Dr. Svihla, a disabled and chronically-ill scholar, studies how people learn as they frame problems in power-laden systems and how these activities relate to identity, agency, creativity, equity, and organizational change.

**Dr. Donna M Riley, University of New Mexico**

Donna Riley is Jim and Ellen King Dean of Engineering and Computing, and Professor in the Gerald May Department of Civil, Environmental, and Construction Engineering at the University of New Mexico.

**Dr. Ruben D. Lopez-Parra, Universidad del Norte**

Ruben D. Lopez-Parra is an Assistant Professor in the Instituto de Estudios en Educación (Institute of Education Studies) at Universidad del Norte in Colombia. His Ph.D. is in Engineering Education from Purdue University, and he has worked as a K-16 STEM instructor and curriculum designer using various evidence-based learning strategies. In 2015, Ruben earned an M.S. in Chemical Engineering at Universidad de los Andes in Colombia, where he also received the title of Chemical Engineer in 2012. His research interests are grounded in the learning sciences and include how K-16 students develop engineering thinking and professional skills when addressing complex socio-technical problems. He aims to apply his research to the design of better educational experiences.

**Dr. Susannah C. Davis, University of New Mexico**

Susannah C. Davis is a research assistant professor at the University of New Mexico. She holds a Ph.D. and M.Ed. from the University of Washington and a B.A. from Smith College. Her research explores how postsecondary institutions, their faculty, and thei

**Prof. Eva Chi, University of New Mexico**

Eva Chi is a Professor in the Department of Chemical and Biological Engineering Department at the University of New Mexico. The research in her lab is focused on understanding the dynamics and structures of macromolecular assemblies including proteins, po

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## Abstract

This WIP research paper examines impacts of a faculty development initiative rooted in the ECSJ pillar, "the classroom as a terrain of struggle and site of possibility." The initiative prioritizes an asset-based approach to systems change, emphasizing meeting faculty where they are and fostering sense-making through coaching and community. Fifteen engineering and computer science faculty implemented teaching innovations categorized into scaffolding learning (e.g., paired programming, feedback opportunities) and design-focused projects (e.g., semester-long authentic projects). This study explores how these innovations influence students' perceptions of their engineering identities. Using QuantCrit as a lens, asset-oriented pre/post survey data were analyzed via repeated measures ANOVA and regression modeling. Results indicate that design-focused interventions significantly enhanced students' sense of belonging, identity, and perceptions of cultural compatibility within engineering, compared to scaffolding-focused interventions. These findings underscore the importance of design-focused pedagogy and inform faculty interventions to support equity-centered teaching practices.


## Introduction and research purpose

Much faculty development work positions faculty as "resistant" to change [1, 2]. We argue that this is a problematic and unproductive stance when seeking to promote asset-oriented, emancipatory teaching approaches. While it is understandable that faculty developers and change leaders might experience frustration in the face of pushback, treating faculty as "resistant" is tantamount to deficit thinking about faculty potential.

Through a recently-completed departmental change effort, we developed an asset-based approach to systems change [3-8]: First, we emphasize meeting faculty where they are, relentlessly, even when faculty sometimes hold beliefs misaligned with equity work. Second, pairing this with coaching and community provides opportunities for sense-making. In the ongoing work described herein, we expand this approach across an engineering and computer science department at a research-intensive, Hispanic-Serving public university as part of a project aiming to transform engineering education, starting with a call for teaching innovations. In this paper, we describe the program and share analysis of the impacts the varied teaching innovations had on student development.

## Framework

This work takes up the Theories and Research on Intersectional Power, Learning, and Evolutionary (TRIPLE) Change Framework, which argues that equity-focused organizational change efforts in higher education should be informed by merged theories of learning, change, and power [9]. This framework incorporates a theory of intersectional power to examine and challenge the ways in which structural and disciplinary power perpetuate inequities [10]. This lens is crucial for identifying the entrenched systems of oppression and privilege that must be addressed to foster diversity, equity, inclusion, and justice (DEIJ). Power relations are distributed [11] and intersect across structural, cultural, disciplinary, and interpersonal dimensions [10]. The structural dimension refers to how policies distribute power and resources, often leading to systemic inequities. The cultural dimension refers to how societal values, ideologies, and cultural narratives shape perceptions of and normalize power and privilege. Dominant cultural narratives obscure systemic inequities and maintain the status quo. In higher education, beliefs in meritocracy shape perceptions about research productivity and systemic barriers faced by marginalized groups. The disciplinary dimension refers to the norms and practices that regulate behavior and reinforce power dynamics. The emphasis on quantitative metrics in STEM disciplines devalues alternative, equity-focused approaches to research. The interpersonal dimension refers to the ways social and role identities (e.g., gender, ethnicity, professional status) influence interpersonal relationships and experiences of bias, including microaggressions and direct discrimination. The structural, cultural, disciplinary, and interpersonal dimensions of power provide a framework for analyzing how power operates across different contexts, shaping individual and collective experiences. These dimensions were articulated in the context of intersectional power to highlight how inequities are produced, sustained, and can be addressed.

The TRIPLE Change framework incorporates an organizational change theory to guide systemic transformation. Specifically, we selected communities of practice (CoP), which is distinctive from other types of communities for its mutual engagement, joint enterprise, and shared repertoire [12]: Mutual engagement refers to members interacting together, with trust and interdependence; joint enterprise refers to a shared purpose, which may be dynamically refined and renegotiated by members; and shared repertoire refers to the set of tools, approaches, and practices—including both tangible items like documents and tools, as well as intangible aspects like language, narratives, and ways of working—adopted or adapted by members. Research on CoPs has shown that the informal social relationships developed through regular interaction centered on a shared purpose and collectively negotiated norms and routines [12, 13] can help shift instructional beliefs and practices [14-18]. [14] also highlighted the importance of department-embedded discipline-based education researchers in promoting changes to teaching.

The integration of a learning theory provides insights into how members acquire new knowledge about teaching and power and develop teaching practices that align with equity goals. We choose a sociocultural learning theory, situated learning, with its focus on legitimate peripheral participation [19] to demonstrate the importance of contextual and relational learning for enabling transformative change. A learning theory plays a foundational role in such change because instructors may need to learn about different approaches to teaching and about their students and the everyday and cultural resources they bring that can serve as a foundation for learning [20], and perhaps most importantly, to engage with peers in reflective and curious inquiry about the ways their teaching could support learning and development.

Together, these theories explain how collective engagement and shared practices can be cultivated to foster cultural shifts and policy changes within organizations that directly address power dynamics and avoid perpetuating inequities.

### *Instantiation*

We instantiated these theories into our change efforts by initiating a call for proposals that provided examples of research-based teaching approaches. For instance, the call encouraged faculty to propose "classroom transformations that foster student learning, growth, success, retention, sense of belonging, well-being, self-efficacy, and confidence" such as by providing "opportunities for experiential learning, including undergraduate research, making and design, community-engaged based learning." We requested that faculty include citations to educational research and provided links to resources, such as the *International Handbook of Engineering Education Research*, the *American Society for Engineering Education Proceedings*, and the *Journal of Engineering Education*, among others. Next, we formed a CoP, led by an associate dean overseeing the program and a learning scientist with a joint appointment in the department, with the faculty who submitted proposals. The associate dean convened several meetings to structure planning and reflections. The learning scientist convened several weekly hybrid meetings with instructors, where they had the opportunity to discuss challenges and successes with their projects and seek guidance from peers and the facilitators. The facilitators highlighted connections between what they were doing in their classrooms and education research, reinforcing when their work aligned with research-based practices. Towards the end of the semester, CoP members engaged in guided reflection and sharing of what they learned.

## Methodology

QuantCrit is a relatively recent approach to using quantitative analysis in service of critical aims [21]. This stance explicitly acknowledges subjectivity in quantitative methods [22] and directly engages concerns about reproducing oppression [23]. Emerging QuantCrit practices include making "professional and personal positionality statements, cognizance of community, robust racial/ethnic categories, intentionality on not centering whiteness, use of atypical methods, new measurement tools centering Black and Brown students, and innovative interpretations of findings" [24]. To evaluate the impact of teaching innovations and guide future related efforts, we conducted survey research from the stance of QuantCrit [23, 25]. We conjectured that design interventions should have a bigger impact on identity because such interventions provide more opportunities for students to exercise their agency in consequential ways [26]. Design interventions embody equitable, consequential work [27] by engaging students in more authentic disciplinary practices and facilitating meaningful opportunities for students to access and learn valued disciplinary practices [28-31]. This in turn facilitates the development of students' disciplinary identification and ability to contribute to equitable and inclusive professional teams [29, 30]. We investigate the following research questions, in support of faculty change:

- How do students' perceptions of their engineering identities develop during a semester?
- To what extent does a design intervention play a role?

### *Participants, Setting, and Intervention*

This work takes place in an engineering and computer science department at a research-intensive, Hispanic-Serving public university in the United States. The department-wide program was motivated by leaders' understanding that many instructors were not using evidence-based teaching practices and there were inequitable DFW rates across the department. Faculty were invited to propose teaching innovations supported by education research, and those awarded were given a small stipend for graduate or undergraduate teaching assistants.

In Spring 2024, 15 engineering and computer science faculty proposed teaching innovations (Appendix A), which we grouped into two categories: (1) Scaffolding learning, including by adding new opportunities for feedback, paired programming, and additional learning resources such as videos and demonstrations; and (2) Design projects, ranging from highly authentic, semester-long projects to shorter projects. The courses included first-year through capstone courses, including five technical core courses, only one of which fully implemented the innovation. Seven of the courses were computer science courses and many students were enrolled in more than one of these courses simultaneously. Based on final reports, faculty varied in the degree to which they implemented their plans; five did not implement (Appendix A).

### *Data Collection and Analysis*

Students completed required pre (n = 368, 135 consented) and post (n = 164, 82 consented) surveys worth minimal completion points. The surveys included questions about persistence intentions, design and academic self-efficacy, agency and responsibility, identity, cultural compatibility, and relevance (Appendix B). The survey included demographic questions at the end that asked about gender, race/ethnicity, age, home language, community context, college generation, income, academic standing, work and care responsibilities, and military affiliation (Table 1). All items had previously been subject to validity studies, and factor structure was assessed and in line with prior research [32-36]. We therefore created average scores for each construct. We calculated descriptive statistics and used repeated measures ANOVA to make several deliberate comparisons between students' pre and post survey scores.

**Table 1: Demographics**

| | | | |
|---|---|---|---|
| ***Gender*** | | ***Language*** | |
| Man | 106 (65%) | English only | 95 (58.3%) |
| Woman | 32 (19.6%) | English + other | 28 (17.2%) |
| Non-binary/other | 4 (2.5%) | Other only | 21 (12.9%) |
| ***Race/ethnicity*** | | ***College generation*** | |
| *Only privileged groups* | *89 (54.6%)* | First generation | 48 (29.4%) |
| White | 80 (49.1%) | ***Military affiliation*** | |
| Asian | 28 (17.2%) | Veteran or affiliated | 6 (3.7%) |
| Arab | 4 (2.5%) | ***SES*** | |
| *Includes minoritized group* | *69 (42.5%)* | Low income | 11 (6.7%) |
| Latine | 61 (37.4%) | Lower middle income | 32 (19.6%) |
| Pacific Islander | 21 (12.9%) | Middle income | 58 (35.6%) |
| AIAN | 7 (4.3%) | Upper middle income | 35 (21.5%) |
| Black | 3 (1.8%) | High income | 1 (.6%) |
| ***Work*** | | ***Care-giving*** | |
| 0 hours per week | 30 (18.4%) | 0 hours per week | 92 (56.4%) |
| up to 9 hours per week | 19 (11.7%) | up to 9 hours per week | 22 (13.5%) |
| 10-19 hours per week | 40 (24.5%) | 10-19 hours per week | 10 (6.1%) |

| | | | |
|---|---|---|---|
| 20-29 hours per week | 31 (19%) | 20-29 hours per week | 11 (6.7%) |
| 30-40 hours per week | 13 (8%) | 30-40 hours per week | 4 (2.5%) |
| 41 or more hours per week | 10 (6.1%) | 41 or more hours per week | 2 (1.2%) |

### *Positionality*

Due to space limitations, we offer a collective positionality statement. The authors are diverse, demographically—including People of Color and white people, members of the LGBTQIA+ community and allies, disabled/chronically-ill people and non-disabled people, and include several women and one man—and professionally varied, including non-tenure track scholars through full professors, engineers and social/learning scientists. These perspectives shape our commitments to DEIJ, are not neutral, and differ from many engineering departments. Although this may limit the applicability to other programs, we share details and supplemental resources (contact the authors) to enhance the transferability to other settings.

## Results

First, we evaluated the data for simple demographic differences. We found no difference between men and women/non-binary students in terms of growth in identity, $F(1, 72) = 0.35$, $p = .56$, or persistence intentions, $F(1, 72) = 0.01$, $p = .94$. Likewise, we found no difference between students from privileged versus minoritized racial and ethnic groups in terms of growth in identity, $F(1, 72) = 0.39$, $p = .54$, or persistence intentions, $F(1, 72) = 0.00$, $p = .99$.

Students enrolled in courses that included a design intervention showed significantly higher growth in their sense of belonging, compared to those in scaffolding-focused interventions, $F(5, 141) = 88.13$, $p < .001$. Students who reported stronger beliefs that engineering/CS were compatible with their cultures, higher design self-efficacy, and receiving learning experiences relevant to the work of engineers/computer scientists also reported a stronger sense of belonging in engineering/CS, $F(3, 75) = 19.99$, $p < .001$, $r^2 = .42$.

**Table 2: Linear model of students' engineering identity scores**

| | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Beta | | |
| (Constant) | 0.10 | 0.74 | | 0.14 | 0.89 |
| Cultural compatibility | 0.41 | 0.11 | 0.38 | 3.75 | <.001 |
| Design self-efficacy | 0.29 | 0.14 | 0.21 | 2.12 | 0.04 |
| Relevance | 0.24 | 0.08 | 0.28 | 3.12 | 0.00 |

Because none of the implemented CS courses included design interventions, we compared CS courses with and without a scaffolding intervention. Students in CS courses that did implement the teaching innovation showed significantly higher growth in identity than those who were in classes that did not implement the teaching innovation (Figure 1). On average, students began rather ambivalent about whether they belong in CS but showed growth over the semester. Students in the implementation group, on average, answered "True of me" about their belonging by the end, whereas those in the other group answered, on average "somewhat true of me". While the teaching innovations helped in general, there was a bigger boost to engineering identity with design interventions.

Other indicators, such as the rate of students dropping, withdrawing, or failing (DWF) a course, provide insight about implementation. Specifically, instructors who added an optional intervention noticed that students who opted in benefited but then were overconfident and discontinued their participation. In one class, this led to higher DWF rates.

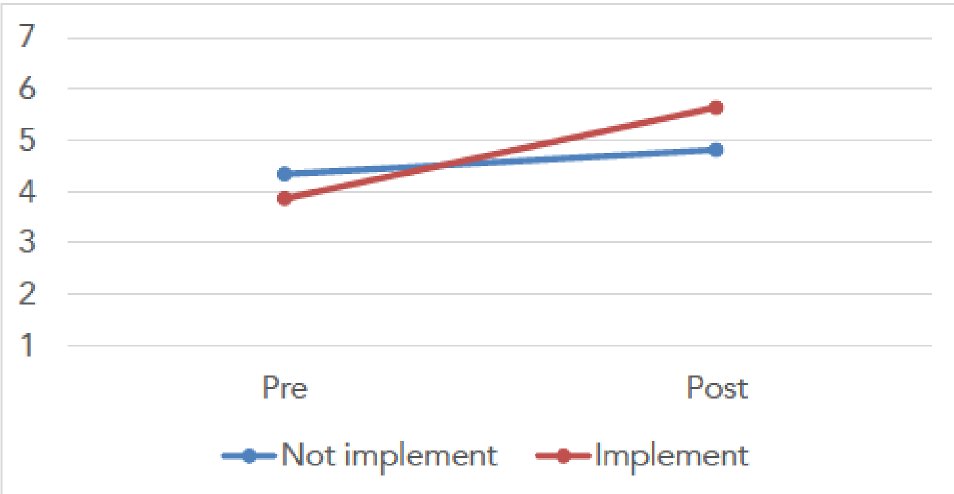


**Figure 1: CS students' average identity/belonging scores, by whether the instructor implemented a teaching innovation.**

## Concluding Thoughts

We found support for our conjecture that design-focused interventions supported student development, compared to those focused primarily on scaffolding. We identified three characteristics of teaching innovations that increased their sense of belonging in the department:

- Courses with a design project;
- Learning experiences that emphasized students' cultures as relevant in engineering and computer science; and
- Learning experiences that were explicitly relevant to the work of engineers or computer scientists.

However, we had no instances of design projects implemented in technical core courses, possibly reflecting both the challenges and perceptions that adding a design project necessitates removing technical content. In ongoing work, we share more detailed examples with faculty that illustrate ways to thread design challenges into such courses without diminishing learning, based in our prior work [8, 37, 38].

Based on these findings, we revised the call for the 2025 teaching innovation fellows, specifically inviting proposals that integrate funds of knowledge—the idea that students' everyday and cultural experiences can serve as a foundation for their learning [20]—and "querencia"—a place-based pedagogy that builds on students' everyday/cultural knowledge and connections to the state in which this university is located [39, 40]. Querencia emphasizes a deep connection to place, grounded in relationships and reciprocity, aligning with Indigenous perspectives that view humans as interconnected with and responsible to the natural world [40-42]. This relationality acknowledges the impact of technological and extractive practices on ecosystems and cultures while recognizing land as an agent, teacher, and codesigner [43-45].

We provided several examples of how funds of knowledge and querencia might be integrated into courses, such as:

- Integrating activities that emphasize belonging. First-year students write letters about how their origins and everyday experiences inspire their future success.
- Course-based research experiences that relate to our state. Students collect (or work with existing) data from our communities and conduct analysis to characterize an issue or understand a phenomenon. They communicate their results in both a short technical memo and a broader impacts communication, such as a social media campaign, letter to a community leader, infographic for a community center or similar.
- Design projects. Students complete a sociotechnical engineering, computer science, or construction management design project that impacts our state. Teams choose a specific community or region and define the problem and propose solutions specific to that community/region.

When faculty submitted proposals to this updated call, several had potential but missed the mark. In some cases, they ignored the focus on querencia, and in others, they proposed ideas potentially misaligned to research on equitable and inclusive learning. The leadership team discussed these proposals and provided specific feedback and ideas to the faculty and invited them to make revisions and resubmit their proposals.

Finally, in line with QuantCrit, we plan additional data collection and analysis following the ongoing implementations. This larger sample will permit intersectionally-disaggregated modeling, such as creating separate regression models for subgroups (e.g., Latina students; multiply-minoritized students).

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### *Appendix A*

Proposed teaching innovations, including whether they featured design projects and if the innovation was implemented. First-year courses are highlighted in yellow; senior design and senior electives are highlighted in red.

| ***Course and Innovation*** | ***Design?*** | ***Implement?*** |
|---|---|---|
| *Chemical Engineering Design - Seniors*<br>Bridge gap from theory to innovative practices needed in industry | Yes | Partial |
| *Civil Engineering Design - First year*<br>Socio-technical design challenges on acid mine drainage and concrete canoe | Yes | Yes |
| *Introduction to Computer Programming - First year*<br>Gamify course with storyline, missions and leaderboard | No | Partial |
| *Computer Science Technical Core A* - Juniors<br>Supplemental videos to guide students through difficult components | No | No |
| *Computer Science Technical Core B* - Juniors<br>Add a strongly guided teaching component; use flipped classroom | No | No |
| *Computer Science Technical Core C* - Juniors<br>Worked/faded examples | No | Yes |
| *Computer Science Elective A - Seniors*<br>Iterative AI feedback | No | Yes |
| *Computer Science Elective B - Seniors*<br>Team, hands-on problem solving for programming | No | Yes |
| *Computer Science Elective C- Seniors*<br>Create a virtual machine infrastructure; initiate student hacking group | Yes | No |
| *Chemical Engineering Technical Core - Juniors*<br>Clean energy design challenge | Yes | No |
| *Circuit Analysis Technical Core - Second year*<br>Active learning | No | No |
| *Electrical & Computer Engineering Elective - Seniors*<br>Develop rural solar farms project in collaboration with high school teachers and communities | Yes | Yes |
| *Introduction to Mechanical Engineering - First year*<br>Active learning | Yes | Yes |
| *Mechanical Engineering Elective A - Seniors*<br>Mini-videos for programming problems, active learning, and pair programming | No | Partial |

| | | |
|---|---|---|
| *Mechanical Engineering Elective B - Seniors*<br>Experimental module to demonstrate hydrogen generation and fuel cell transportation. | No | Partial |

## Appendix B

Survey questions aligned with study constructs. All scaled questions on 7-point scales with ends named in prompt or noted.

| Timing | Prompt | Construct |
|---|---|---|
| Pre/ post | What is your current or planned major?<br>Within your major, do you know what concentration or program you plan to pursue/are pursuing? | NA |
| Pre/ post | How certain or uncertain are you that you can<br>• identify a design need<br>• develop design solutions<br>• evaluate and test a design<br>• recognize changes needed for a design solution to work | Design self-efficacy |
| Pre/ post | How compatible or incompatible is...<br>• engineering/CS with your cultural values?<br>• a career in engineering/CS with your cultural values?<br>• the work that engineers/computer scientists do with your cultural values? | Cultural compatibility |
| Pre/ post | I intend to (Agree/Disagree scale)<br>• complete a degree in engineering/CS<br>• work or study further in engineering/CS after graduation<br>• pursue a career in engineering/CS | Persistence intentions |
| Pre/ post | How true or untrue is each statement below of you?<br>• I feel like I belong in engineering/CS<br>• I feel like I fit in with the people in engineering/CS<br>• My parents & relatives see me as an engineering/CS person<br>• My instructors see me as an engineering/CS person<br>• I feel included by people in engineering/CS<br>• My peers see me as an engineering/CS person | Identity |
| Pre/ post | How certain or uncertain are you that you can<br>• learn the content in the engineering/CS-related courses you are taking this semester<br>• learn the content in even the most challenging engineering/CS course<br>• do a good job on almost all your engineering/CS coursework | Academic self-efficacy |

| | | |
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| Post only | The questions below ask about the learning activities in this course that differed from typical lectures, homework, and exams. For instance, you may have completed a design project, an experiment, worked with a partner, group, or team, accessed supplemental videos, or used a new technology to learn.<br>Please briefly describe the learning activities in this course.<br>How did the learning activities you described support your learning?<br>How could the learning activities you described be improved to better support your learning? | NA |
| Post only | Considering your project, have you had many or few:<br>• opportunities to make decisions personally related to your design project?<br>• opportunities to make decisions as a team related to your design project? | Agency |
| Post only | How responsible or not responsible have you felt:<br>• for making decisions personally?<br>• for making decisions as a team, group, or with a partner?<br>• for coming up with your own ways to make progress on the learning activity?<br>• for the outcomes of the learning activity? | Responsibility |
| Post only | Describe one decision that you have personally made in the learning activity or course that stands out for you.<br>Considering the decision you described, how important or unimportant was:<br>• the decision?<br>• the impact of that decision on your process? | Consequentiality |
| Post only | How much or little have you learned as a result of:<br>• decisions about the learning activity or course that you personally made?<br>• decisions about the learning activity or course that a team mate made? | Learning consequentiality |
| Post only | How relevant or irrelevant...<br>• was the learning activity to the work of engineers/computer scientists?<br>• were the skills you used in the learning activities to those used in engineering/CS?<br>• was the learning activity to how engineers/computer scientists solve problems? | Relevance |