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Opportunity Gap and Women in the Energy Infrastructure Workforce

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Abstract

The Bureau of Labor Statistics (BLS) predicts above-average employment growth for jobs in the construction industry. And despite the majority of entry-level jobs in construction requiring a high school diploma or less, median annual wages in the industry are over 8,000 dollars higher than other industries (Torpey 2018). Despite this growth and relatively high wages, women are severely underrepresented; just 3.5 percent of workers in the construction occupations are women while women make up 47 percent of the labor force. Career and Technical Education (CTE) in high school can provide an avenue for increasing the participation of young women. Through a Researcher Practitioner Partnership (RPP), a team of teachers, trades educators, and administrators from high schools, community colleges, and apprenticeship centers sought to increase access through a virtual design and construction STEM (Science, Technology, Engineering, Math) career pathway program. The team explored if a Project-based Learning (PBL) approach in Virtual Design and Construction (VDC) is a feasible method for woman-focused CTE. We found evidence that targeted recruiting through a feminist positive pathway to create a critical mass of female participants in conjunction with PBL can offer an opportunity for women to enter a traditionally male-dominated field. Furthermore, our study calls for continued theory development into and provides evidence that higher concentrations of women has the potential to increase the industry's focus on safety, environmental protection, and labor standards. We argue that the lack of female representation is due to an opportunity gap for young women to learn about and join high-skill high-wage occupations.

***Keywords**:* Workforce, Energy infrastructure, Social justice, Ethnography, Tradeswomen

***Type of contribution**:* PBL research

1 Introduction

We posit that a gap in women's participation in the STEM labor force and STEM-CTE is not a personal 'choice.' Iloh (2019) proclaims individuals likely receive indirect and direct messages about higher education opportunities and expected pathways. These messages work as barriers to the high-skill high-wage energy infrastructure industry occupations (Tarantino 2016). Hegemonic masculinity in

STEM-CTE careers and pathways perpetuate enrollment of young women into traditionally female-dominated sectors (Bonilla 2020). These forces actively exclude young women from an industry that, according to Kellie McElhaney, is male-dominated, but finally addressing the gender pay gap, "with women earning 93¢ for every male dollar... a stark difference from the business average of 82¢ per dollar." Although this narrowing gap has experienced more progress in construction, many women are left out of this promising industry.

In this paper, we make three important contributions. First, we recognize that the underrepresentation of women in the STEM labor force stems from a variety of sociocultural realities. Second, we aim to break down these barriers to women's participation by developing a unique CTE experience focused on providing a feminist learner-centered environment. Lastly, we document the effects of increased women participation and inclusion in a CTE experience. Specifically, we examine if a Virtual Design and Construction Project-Based Learning (VDC-PBL) approach is feasible for creating a woman-focused CTE experience by drawing on rich partnerships with labor unions, affinity-based trade groups, and educational institutions spanning the K-12 and postsecondary systems (K-14).

We were able to co-create an idealized feminist education using Project Based Learning and an enduring Research Practitioner Partnership (RPP). To disrupt the traditional power dynamics in the classroom; the research-practitioners intentionally created a learner-centered environment of construction feminism in which the young women took ownership of their VDC learning through group based projects and interactions with a variety of construction industry actors. We introduce the feminist learner-centered environment through a focused 'over-recruitment' of women into the program as lecturers, mentors, and student-learners. Our approach was centered on a feminist approach through the use of critical mentoring and support throughout the course. This specific and intentional mentoring by tradeswomen and researchers were key components of the feminist intervention modifying workforce VDC originally conceived by Tarantino and colleagues (2016). This program design allowed the researchers and community partners to curate and contribute to a tradeswomen-centered curriculum and pathway that at its very essence worked to tear down barriers and the resulting opportunity gaps for women in the trades.

As a result of this feminist approach, we observed a change in gender role perceptions and an unexpected outcome of the education process. We find preliminary evidence of a greater interest in and understanding of workplace safety, environmental protection, and labor standards. This finding suggests that there is potential for all workers in the industry to benefit from the increased presence of women. For example, the construction industry has a high rate of injury and is often implicated in adverse environmental and community impacts. We saw preliminary evidence that the participants had an increased awareness of a need in the construction industry for a cultural change towards safety, environment, and society. For example, many of the construction management programs have rebranded using variations of "sustainable construction" to highlight this need. Our finding suggests that all workers stand to benefit in the industry and women would likely see higher wages in a sector that has higher union density in some geographic regions.

This paper is organized with a point of departure and a review of theories of education, by our intervention, followed by the methodology of our research, the observed results, and we then conclude with a discussion of the lived experience, research limitations, and our recommendations.

2 Theory review

Montoya and colleagues (2018) found that underrepresented youth perceive the building industry (including the energy infrastructure industry) as a career pathway to higher education when given an opportunity to learn VDC through PBL. However, they observed a multi-step mechanism that limits the participation of women in the building trades; an opportunity gap (Ladson-Billings 2013) creates a perception that the building industry does not lead to advanced STEM degrees, and that forms a barrier for young women applying to building trade apprentice programs. Young women's limited access to careers in the energy infrastructure industry can be summed up by Iloh's 2019 research on college 'choice' models. Iloh proposes a model that predominates privilege as a driver of choice and that is a starting point to showcase the building trades as the pathway to STEM careers that it is. Correll (2004) reminds us that a failure to recognize a constrained aspect of choice obscures some processes by which gender inequality is perpetuated. Privileged-choice means that as Correll asserts, "if gender differences in aspirations emerge, men and women will likely make different career-relevant choices" (2004).

The current ratio of women in construction education programs is 14 percent (Lufkin et al. 2014); and 3.4 percent of building tradespeople (Hegewisch 2019). Through ethnography and prior experience in the building trades industry, the authors experienced the low numbers of women in both the building industry and in the pipeline courses which function as the predominant feeders to this industry. Much of the research that has been done to uncover the toxic work environment in the building industry sheds light on issues that extend into the secondary and post-secondary classrooms. There are gendered education pathways (Bonilla 2019). Due to such low numbers of women, the authors were able to teach a significant percentage of women in CTE career pathways courses in the Silicon Valley of Northern California. Women in secondary CTE courses are around 3 percent, this means that in a typical high school CTE course we would expect to see fewer than 2 women per class. Using 2006-2010 data from Affirmative Action/Equal Employment Opportunity education plans, the post-secondary student profile is typically 99% male and predominantly white and Latino, which is also true for the construction industry in this region—Fig. 1 shows one of the Workforce VDC teams that fit this demographic. Even fewer women complete the program. With such low numbers, women's exclusion in the industry begins before they even consider future careers. Secondary education is a crucial moment to disrupt women's social exclusion through Workforce VDC, which at its core employs inclusion and agency through its pedagogical framework.

Tarantino et al. (2016) envisioned a pedagogical framework that was set in motion in 2018. Using theory from Fruchter's PBL at Stanford University School of Engineering, the workforce VDC framework worked to directly disrupt the current trend of excluding young women through its key component of mentorship.

The social circumstances that help to exclude women from this industry are examined by Kniveton (2004). Kniveton considered motivations and influences of career choice for students in rural and urban England. The research in England corroborated Iloh's assertions that "the greatest influence on students' choice of career was their parents, followed by that of their teachers." Furthermore, in England, there is a peerage factor, firstborn students' careers were heavily aligned with their parents and that of younger children were influenced more by their older peers than their parents. This follows with Willis' seminal ethnography that was also situated in England, Learning to Labor, where the 'lads' follow the lead of their parents and peers (1977). The role of these peerage influences in San José is not clear, however, we are aware of the possibility.

The research in England added a layer of depth by identifying that their findings may be a result of "the limitations of power of unions, and the virtual elimination of apprenticeships." The role of unions and apprenticeship education is at play in San José and the idea that unions replace the influence of peerage is an interesting note.

With limited apprenticeships and dwindling union influence, Vuolo and colleagues (2014) explored pathways from school to work using a longitudinal youth development survey. They examined the role of factors to distinguish youth who establish themselves in careers and those who flounder; these factors are: Adolescent achievement orientations; Experiences in school and work; And, sociodemographic background. The students were divided into four school-to-work pathways from ages 18 to 31; two groups attained careers through post-secondary education (via Bachelor or Associate - vocational degrees) and two groups did not attain vocational degrees (distinguished by attempting college without completion). They found that reduced "floundering" was predicted by factors of academic orientation, socioeconomic background, and steady paid work during high school. We see support for the findings by Vuolo and colleagues in an earlier study by Kerckhoff and Bell (1998). They found that in order to become established in occupational careers some workers obtained associate degrees or vocational certification—we see this as indicating an intuition on the part of workers that these degrees reduce floundering. Strengthen this notion, Kienzl (2005) notes that those earning associate degrees show substantial payoffs. Completing some college, whether at a four-year university or at a community college, received near-equivalent wage returns. These factors appear consistent with the privilege-choice theory proposed by Iloh—those more privileged are likely to obtain education and therefore fulfill their 'choice.'

Women leaving the male-dominated occupations is the ''leaky pipeline'' (Frome 2006, NCES 1997, Oakes 1990). The leak is repeatedly found in studies that examine gendered occupational aspirations in the traditionally male-dominated fields. Frome (2006) studied 104 18-year-olds who were surveyed twice, at 18 (1990) then 25 (1997). The study's young women who initially aspired to male-dominated occupations lost these aspirations if they also desired a family-flexible job, as can be seen through gender research is common with women (Anderson et al. 2017).

Looking at the feminization of workforce education from a policy standpoint, there is a need in the feminization of workforce education to provide services for childcare, emergency cash assistance, mental health services, and domestic violence services (Anderson et al. 2017). A number of centers focus on policies for women as a workforce and some specifically the construction workforce, some of which we have been in contact with and or are finding we parallel and share some contacts, examples, the Rising Sun: Center for Opportunity, Tradeswomen Inc, Women's Equity Center, and the National Center for Women's Equity in Apprenticeship and Employment. An open question is what relationships tie together women's labor education, leadership development, and movement building—for now, the answer is collaboration along these relationships and providing labor education through a social justice curriculum (Twarog, Sherer, O'Farrell, and Coney 2016). There are barriers in the education system that are outside our reach, such as prerequisite courses. The education for electrical workers requires that students have begun a STEM education pathway as a prerequisite to applying to the apprenticeship (IBEW-NECA 2020). Possibly schools do not perceive CTE students as needing STEM prerequisites.

There have been gender issues in construction that over time push many motivated women out of the trades, at the forefront is gaming of affirmative action rules to meet the employer's minimum legal requirement; there are complacencies throughout the system that short women the number of work hours they were offered (Eisenberg 2018). Occupational segregation by sex is practiced throughout the world and it is a concerning practice that is not usually practiced for the benefit of the women (Anker 1997). Anker uses gender theory to propose that policy solutions are necessary that reduce family responsibilities, remove gender stereotypes, and that increase educational opportunity. There are studies that look at women in cultures outside the northern European cultural context; Russo looks at craftswomen in the Indian continent marketplace—there, a local pattern of female strength can be found that differs from the globally enlightened narrative of perceived weakness, further complicating the narrative of women (2018). Universally, it is clear that low wage women are vulnerable to wage theft and that can be prevalent in the construction industry when policy protections are not in place (Gleeson, Silver Taube, and Noss 2014). Low wages can lead to criminal activity; a union job in construction is a pathway needed for women to move from incarceration to earning a living wage (County of Santa Clara 2008). These are pieces of the narrative and there are many gaps, more research is needed to understand the educational experiences of women in the building trades (Hegewisch and O'Farrell 2015) and more policy work is necessary from those labor unions that have not finished development of a gender democracy (Kirton 2017). A recent study showed that contractor lead apprenticeship programs, that did not work with a labor union, had an exceptionally low graduation rate (Illinois Economic Policy Institute 2020). In collaboration together, then contractors and unions are better able to address the widespread hazards that cause work-related injuries to construction workers (Boatman, Chaplan, Teran, and Welch 2015). In a similar approach, a joint collaboration of contractors and unions could better address a feminization of construction workforce education.

3 Workforce education model

We created a learner-centered environment of feminism around young women through thoughtful intentional recruitment of women mentors. The feminist environment gave the impression that the construction industry has a higher percentage of women than is actually the case. Our intention is to bring a level of comfort to the young women that allow seeing oneself in the construction industry in similar roles as the women mentors. The idea of a feminist learner-centered environment was discovered through discussions with Meg Vasey at Tradewoman Inc.; Meg is a lifelong advocate for women in the trades and is a union journeywoman electrician. Through Meg's guidance, we focused to give women a voice and were cognizant of a different lens that these young women would view the construction industry through, and made ourselves open to observing that lens—in Fig. 3, a female breakout space.

The experiment platform is an education model formed from a merger of two programs that reside in the same hallway at the Stanford Sustainable Design and Construction program. One is a well-known Executive Virtual Design and Construction program that over the past decade has successfully through learning-by-doing provided hundreds of executives and their teams around the world a refresher and update in construction project planning theories. The other is the equally well-known graduate-level Architectural-Engineering-Construction Global Teamwork program that over the past thirty years has through project-based learning taught generations of graduate students around the

world to collaborate through a virtual presence. We literally took the lecture slides and phases of the VDC program and combined it with the virtual collaboration mentored project-based learning format and milestones of the AEC Global program. When we directed our merged program at the workforce, we termed it Workforce VDC.

As Workforce VDC, the program gained two new foci, one is feminism and the other is social justice. As a workforce education program, the authors were free to explore the topics, given the workforce focus in the curriculum on optimizing, for labor protections and safety as opposed to profit margins. These goals fit with the ideals of the unionized apprenticed workforces in construction, a high wage, high skill, and an exceptionally productive workforce. To introduce social justice in a clear structure, Dr. Anthony Kinslow II, a Stanford doctoral candidate, provided curriculum development based on his undergraduate engineering education at North Carolina A&T State University.

In feminism, Alissa Cooperman, also a Stanford doctoral candidate, provided curriculum development. Alissa outlined a technical education around social goals and interesting games. For example, each year, Alissa provides a guest lecture of engineering fundamentals that includes labs such as a catapulting of items with different weights. The intention is to make engineering accessible and fun. The students can take the engineering as far as they would like and there will always be a depth of mentors to support that pathway—in Fig. 4, students present their project idea to a virtual panel of mentors. For example, one young woman took an interest in electrical calculations and by the conclusion of her project she was beyond the remaining casual knowledge on the topic by the civil engineers in the room. The program is not intimidating; it is rigorous but there is not that certain type of masculine gatekeeping.

The Workforce VDC program became a popular testbed in the department to explore these social issues that form thorny problems in civil engineering. The social justice component as presented to the workforce students took a view to the community around students—we asked the students to observe their community, describe a problem, and then develop a potential solution to that problem.

In operation, the Workforce VDC program contains three overlapping programs: There is a twelve-month program for educators; There is a nine-month program for secondary students; There is a five-month program for post-secondary students. The twelve-month educator program is based on the VDC executive program's three phases of summer introduction, fall-winter-spring implementation, and then a May reflection on findings and lessons learned. Those educators during the fall-winter-spring implementation are teaching the nine-month and five-month secondary and post-secondary programs. The secondary students start in the fall and continue for nine months while the post-secondary students start in the winter due to a need to align with college quarters or semester.

The curriculum itself consists of engineering and trade skills. As described in the methodology section, we divided the program components into certificates, units, and credits. We have a pathway model from secondary through apprenticeship, to post apprenticeship, with a potential upper education achievement of graduate school—see Fig. 5 for our working idea of this pathway. We follow this pathway with a stackable credential approach to allow students to exit the pathway with their credentials documented and re-enter the pathway at a later time or at a different location without losing ground in the pathway. We have seen success in piloting best practices in the pre-apprenticeship side of this pathway and are transitioning to focus on developing post apprenticeship pathways; there is good early feedback on acceptance from potential collaborating universities.

The Engineering component includes Science-Technology-Engineering-Math skills embedded in a narrative of Architectural-Engineering-Construction design and planning skills—in Fig. 6, 7, 8 the students build their skills through mentored feedback. The trade skills component follows a career technical education, however, we maintain this at a novice level to respect a need for secondary students to focus on academic education. We are well aware of the exploitation that occurred through vocational education programs (Groeger 2017 2020). Further, there are indications that workforce education programs in Europe have a lead in regard to gender equity and academic equivalency (Hansen 2011). As said by Professor Fischer, a construction engineering theorist at Stanford, *"you are not training workers, you are educating the workforce."*

As a result of participating in the Workforce VDC program, the students gain a lasting network of mentors and contacts in the industry, academia, labor unions, and public policy. We think we are activating elevations in Maslow's hierarchy of needs (Maslow 1948). We bring a sense of belonging as well as a higher level of prestige to the students. Disrupting and reframing these pathways then allows students to rise to the academic performance and community actualization to meet each student's potential.

4 Research methodology

The authors implemented a Virtual Design and Construction (PBL) course following a template inspired by the Stanford PBL format Architecture-Engineering-Construction (AEC) Global Teamwork course. That course is based on a mentoring education format; students are given a constructed mentor relationship through which they learn technical skills, theory, and what it means to have a particular profession (Fruchter and Lewis 2003). The strategy is for the student to be the center of activity at times and peripheral to the mentor at others. Students see themself in the profession of the mentor and oftentimes continue with courses in the profession. Mentoring is both in-person at specific program events and as teams and individuals through innovative collaboration technologies (ICT) (Fruchter, Ponti, Jungbecker, and Alfen 2007). Through ICT, the AEC Global Teamwork course scales to an international and cross-disciplinary network of students and mentors in multiple 'social worlds.' This scalable platform has hosted numerous research projects over the past twenty-five years of operations, such as the role of multiculturalism on team success (Frank and Fruchter 2014) and modeling building CO2 levels for occupant well-being (Grey and Fruchter 2017).

This research relies on a Researcher Practitioner Partnership (RPP), which is a type of action research that involves long-term collaborations between colleagues of practitioners and researchers. These partnerships are fundamentally about bringing relevant and often on-demand research to bear on contemporary problems of educational practice (Ahn 2019, Gutiérrez and Penuel 2014). Our RPP included teachers from secondary and postsecondary institutions in addition to organized labor leaders who served as partners for this work. The postsecondary institutions included apprenticeship, college, and adult education. These are four high schools, two community colleges, three apprenticeship centers, and one adult education program.

To provide input to the research project, the RPP engaged many figures from the construction industry. Community participants included over one hundred leaders in education, union labor, policymaking, and construction businesses. Every three months over several years, the community participants met for a morning of reflection, collaboration, and planning of the next steps. The researchers attended these meetings to build community input and provide feedback on the research. This group is the Santa Clara County Construction Careers Association (S4CA); Montoya (2018) describes this organization and Fig. 2 provides an updated graphical map. The S4CA is predominantly the Santa Clara County Building Trades Council member labor unions, construction businesses that are signatories to labor union agreements, policymakers of public prevailing wage infrastructure, and consumers of a unionized wage workforce on secondary and post-secondary education infrastructure.

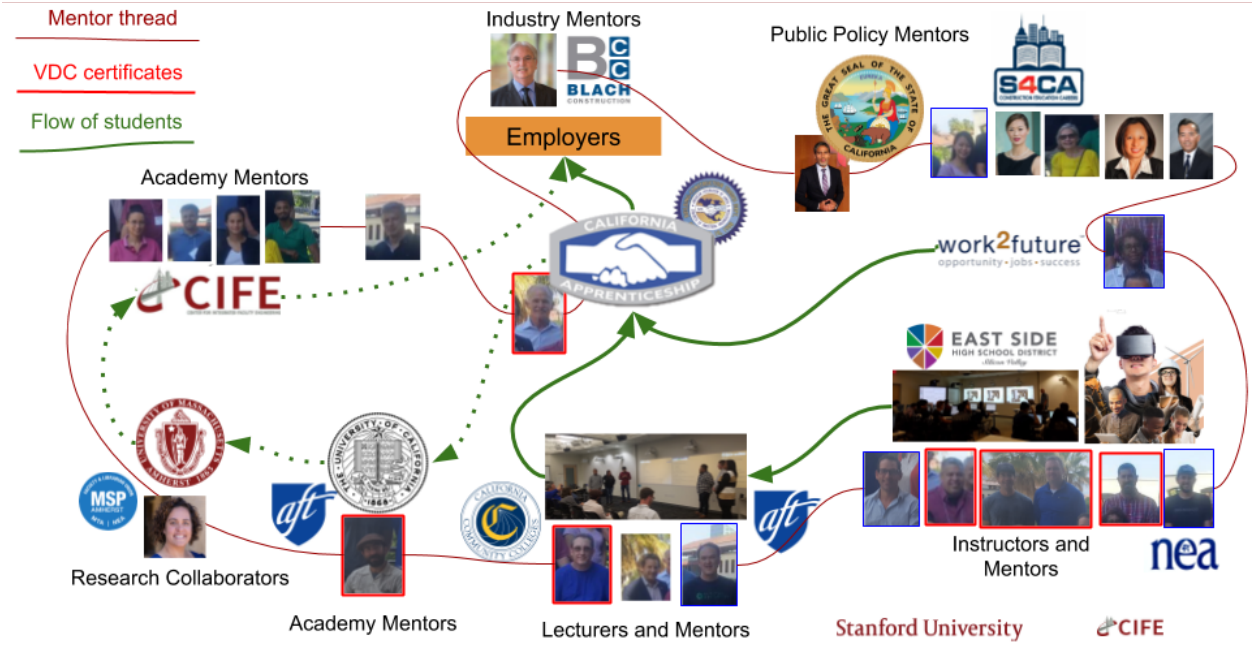

Figure 2: An evolving network of community participants, researchers, and practitioners. The participants represent each stop in the workforce pathway from education, to employment, to public policy, to labor standards oversight.

As a measure of the intervention effect on the opportunity gap, Fruchter's engagement metrics provide indicators of student opportunity; we looked for instances of engagement, disengagement, side conversations, gaze foci, and use of technological tools (2007). Data collection was through our roles as participatory action researchers and ethnographers. Through participation as mentors and instructors, we were able to analyze and code student artifacts such as PBL presentations and recordings of virtual mentoring sessions. Less observable of Fruchter's indicators, such as gaze foci, were understood within body-language feedback. At the conclusion of each event and at each of the four milestone events, the ethnographers compared their observations of artifacts and discussed their meaning. These observations and discussions were then compiled and were published as a peer-reviewed conference paper. The time in observation for the researcher to-date is 265 hours over 41 events which are over four cohorts (2017, 2018, 2019, 2020); in addition, there are 25 hours of dual enrollment and 25 hours of post-secondary classroom observations. The time in observation for the practitioner to-date is 760 hours in the classroom over three cohorts (2017, 2018, 2019) and

200 hours over 23 events which are also over four cohorts (2017, 2018, 2019, 2020), and again, in addition, there are 50 hours of post-secondary classroom observations. In total, the researcher and practitioner were in participatory ethnographic observations for over 1,300 hours over the course of four years. In addition, the authors pull coded ethnographic data from feedback and informal interviews from another dozen colleague researchers and practitioners that are participants in the ethnography through their everyday roles as mentors and instructors.

The feminist intervention was the continued research situation as defined in Tarantino et al. (2016) and as piloted in Montoya et al. (2018). To reiterate here, the experiment platform is situated in teaching Fischer's Virtual Design and Construction theory (Kunz and Fischer 2005) as a STEM skills course. In Montoya et al. (2018), the VDC theory was modified with a social justice theme to carry the technical skills with a narrative and taught to the students as an intervention. The social justice theme continues in the current iteration of the program. The new intervention in this current study is the addition of feminism to the VDC theory. Following the project-based learning format, the feminism component was added through a more prominent role of a dozen female role models from leadership roles in industry, engineering research, trades, and technology. Pragmatically, this emphasis took the form of women-only breakout sessions at the October BIM Bootcamp, and strong female leads in the virtual mentoring and at the in-person Dry Run and Final presentations.

The student cohort demographic is within the San José metropolitan region, which is the tenth-largest city in the United States. That region has a racial demographic approximately evenly divided between Latinx, Asian, and White; half of the homes speak English as a second language. The region has the highest per-capita gross domestic product of any metropolitan economy (Pulkkinen 2019). That said, the region is not without disparities. The student population resides in a region that has one-tenth the rate of admissions to top-tier universities as neighboring affluent communities; A typical classroom has thirty-five students taught by a single teacher; Secondary schools graduate 500 students per year. The population is predominantly Latinx (50 percent) and Asian (40 percent); in addition to being lower income. 50 percent of students qualify for free and reduced-price meals compared to 10 percent of students in an affluent neighboring district. The academic performance of this population is 90 percent of the metropolitan mean, 80 percent of an affluent district, and surpasses the performance of some outlying bedroom communities (ed-data 2018). Racial disparity, social justice, and environmental justice aside, this is a well-performing though distinctly working-class demographic—it is not a demographic of privilege, we expect to have a situation of limited choice.

Taking a sample of the more active mentors provides a snapshot of their demographic: A third of mentors are women; The mentors are mostly educators (38 percent) and tradespeople (31 percent) with the participation of industry business practitioners (15 percent), and Workforce VDC educator program alumni from 2017 and 2018 (16 percent); Racially, the mentors are White (46 percent), Asian (31 percent), Latinx (15 percent), and Black (8 percent). The regional demographic for women is comparable; 31 percent White, 38 percent Asian, 26 percent Latina, and 2 percent Black (Office of Women's Policy 2018). The mentors represent typical roles in the construction industry, these are technologists, construction managers, educators, lawyers, public policymakers, union labor leaders, social justice champions, civil engineers, and tradespeople.

5 Observed situation

Three young women from a pair of secondary schools provide our insights into the feminist potential of the Workforce VDC program.

It was one of these young women that initially brought awareness to her perspective as a young woman in the workforce VDC program. She explained to the researchers that she could see a role for herself at her dad's employment on a construction site. This was a role that at the start of the program she did not feel was a situation that included her.

A second young woman demonstrated through her actions a difference in expectations for young men versus young women. This student developed a cost estimating tool using spreadsheet software. She used spreadsheet coding to turn her estimate format into a reusable program. This was actually a pair of young women working as a team. The assignment was to calculate the cost of their team's proposed social justice mitigation—neither a spreadsheet nor equations were required. These young women asked mentors for advice then took their own initiative to develop a solution to the problem they were presented. Together they supported each other and gained strength to create something they otherwise did not see themself working on. Their work was excellent, surpassing some of the coursework produced by Stanford civil engineering graduate students—in Fig. 9 the young women's spreadsheet and their public recognition. Their use of spreadsheet coding and an ability to format the spreadsheet into a coherent layout is not as universally understood as one in the civil engineering field might expect. In separate research, one of the authors observed a recent graduate of a regional civil engineering program, who was respected in his field office, use a calculator to sum a list of values and then entered that sum in a spreadsheet—these young women had outperformed that civil engineer. There was a confidence in these young women in their footing in technical topics alongside their male peers.

Confidence was a recurring theme; the third young woman took on a leadership role on a team of four young men. Under her leadership, they developed a study of homelessness in Silicon Valley, see Fig. 10. They then proposed an affordable housing solution that included both a design for housing units and a design for a community of the housing units. Her role is explained by her VDC instructor:

> ***"For the last two years, due to their extraordinary resilience and creativity, our female VDC students have become the de facto leaders for their teams. Without a doubt, the entire team looked to them to set the pace for the entire project. In fact, Emily is consistently referred to by her team as 'our fearless leader.' "***

It was through this experience that this young woman approached the program lecturers and asked for a letter of recommendation to accompany her university application. Through the program, she had seen the opportunities for her in public infrastructure professions and she had decided to apply for these degree programs. In the subsequent cohort of the Workforce VDC program, this young woman continued with the program as a team steward.

> ***"So not only has VDC allowed our female students to develop their leadership skills, but it also gives them numerous opportunities to meet and be directly mentored by industry professionals who are also female. In the end, one of the greatest benefits I've found with VDC is that it shatters the 'glass ceiling' and shows our female students what opportunities are open to them in the future. What other High School class can come close to offering this? In a decade of teaching, I have yet to find one."***

It is the experience of these young women that we draw from for a discussion on women in the construction education system.

Through teaching numerous construction courses over the past decade, it is our observation that the young women in the Workforce VDC showed greater sensitivity and readily accepted social issues of justice and the environment as problem topics. We observed a similar trend in Dr. Fruchter's Architectural-Engineering-Construction Global Teamwork course—safety is often raised unprompted as a topic by women and in particular students from universities in Nordic countries, this is regardless of a student's country of origin outside the Nordic world.

These three young women will each continue in the construction industry on a pathway that will increase the participation of women in the construction industry.

6 Lived experience and theory development

The authors contribute a feminist positive pathway to the virtual design and construction theory through three theoretical modifications: (1) recognizing the existence of a barrier for female participation, (2) a novel model for creating a feminized space, and (3) a framework for documented effects of increased female inclusion.

As Russo (2018) saw with craftswomen in India, globally, a marketed image kept them in a marginalized place as inferior women; however, these women were more than that image and while globally the perceptions of the elites constrained these women's image, there was a freedom in gendered space locally in which these women exercised their power in a way quite different than their global image would suggest.

While we see a potential of women in AS-CTE to reduce inequality, there is a concern about a historical fact that as women enter a field they can come to dominate it (PBS 2020). Our goal is not a purely female cohort, we are looking for a co-ed cohort. The mixture of that cohort is not our concern, as United States Supreme Court Justice Ruth Bader Ginsberg said at a Stanford talk, there were more men than women in academics, so why not have a time when there are more women than men in academics! Using our education platform as a pragmatic situation, of the teachers that are the subject of this paper not one of them is a woman—we are not concerned about an imminent feminization of education, see Fig. 11.

A concern that the authors are acutely aware of is that the young women in the Workforce VDC program could fall victim to the 'acting white' label. This is a tacit concept understood by our students and does not require a citation. However, there is much research on higher education being traditionally white spaces. Post-secondary CTE is not immune to this phenomenon. Because we are in the San José region, this term takes on a social class dimension that transcends race and becomes more of a label of selling out your working-class peers to act middle class. Many students believe

secondary education spaces are 'white spaces' therefore, they do not belong. As educators we have collectively observed students who attempt to transcend these barriers and partake in these spaces, only to become further isolated from their communities. As a result, many students end up in 'white spaces' which are culturally, and physically far from their communities which further exacerbate their isolation. To make matters worse, often upon return to their communities, they are stuck with a label of privilege that they may or may not actualize. This label is powerful and can divide peers instantly and permanently. Fortunately, we did not observe accusations of acting white. However, it is possible we were not sufficiently calibrated to detect this phenomenon. We have also considered that because we are a workforce construction program, this may not fit despite an alignment with education and symbols of prestige like Stanford University. Perhaps we have successfully bridged the gap between traditionally blue-collar and 'white' collar spaces. If not, this is the hope for future iterations of our curricula of gender equity and social justice.

Despite observing success in a novel education platform that supports young women, once these women continue in the construction industry, they will potentially find systemic issues that present a new set of challenges. Are trades a viable pathway for women? A discussion that developed during feedback with dedicated academics of feminism is if women choose to join the trades or if systemic barriers prevent women from joining and retaining in the trades. To address this question, a fifth-term union apprentice in the pipe trades shared her experiences (apprentices have five terms of education before turning out as a journey skill level). In her experience as a tradeswoman within the San José metropolitan region, she has not experienced gender discrimination—her experience is the opposite. That said, she hears first-hand from tradeswoman in other metropolitan regions around the country who experience severe gender discrimination. If her gender-neutral experience is representative of the region, then the young women in the Workforce VDC program should find a clear gender-neutral pathway from secondary education, through post-secondary pre-apprenticeship, and on to apprenticeship (while outside the scope of this paper we heard feedback that a transgender individual found difficulty). The issues that slow the advancement-in and even abandonment-of the trades are the same that plague mothers in academia (termed MIA). There are numerous graduate student parent alliances that address these well understood gendered issues, at the core, it revolves around access to childcare, living wages, and dependent healthcare (Stanford 2017). For the 4 percent of households that are led by a single mother, these issues are dire—particularly given that over half live below the California Self-Sufficiency Standard (Office of Women's Policy 2018). As the workforce in this paper is unionized, therefore, healthcare and wages are not an issue as union pay is equal and quality healthcare is provided, however, childcare is an open issue. Three specific situations were given as case examples.

- On-call childcare when a work shift is unexpectedly extended from eight hours to ten, twelve, even sixteen hours or more.
- Family leave during birth and maintaining a priority on the out-of-work list despite a break in work.
- Childcare during weekly evening apprenticeship classes and monthly general membership meetings.

In the United States, unlike some global regions, childcare is a private for-profit industry. As such, if the market forces do not find a suitable profit in your specific situation, you can find zero available childcare options. In the study region, 47 percent of children have access to high quality subsidized preschool (Office of Women's Policy 2018). Universal childcare is a topic of discussion amongst some

public policymakers, however, to date, it is a discussion and not a reality. It is our impression that as collective bargaining agreements include gender-neutral benefits that childcare will find a solution. Further, we look towards a future that includes universal childcare.

We observed a possible corroboration of Correll's lab findings given the introduction of our feminist positive pathway to Correll's gender-neutral pathway and then saw the expected disruption that Correll observed in gender biases, our validation is within construction workforce education pathways.

7 Limitations and recommendations

To explore issues with social justice we introduced specific situations in the experiment platform. However, those are things not normally seen in the industry nor at a top university. We assume this feminization of the construction industry is representative of a future gender-neutral construction industry. A limitation to generalization was the sample size. Also, given the unique setting in California, it is difficult to generalize the findings.

We recommend educators adopt the feminized gender-inclusive VDC curriculum guided by PBL. An increase in young women entering the energy sector trades would likely bring social change to the worksite.

In particular, there are questions relating to childcare public policies and provisions in agreements through social public policy such as those being developed by David Campos' County offices of social justice (Bay Area Reporter 2018). The union training centers are an important college pathway that both develop the next generation of a skilled workforce, as well as the next generation of union leadership; we see an expanded role of the union education system in the oversight of the workforce education pathways—in Fig. 12 a panel of union leaders attend a Workforce VDC event. The authors recommend continued research into the role of a feminist positive pathway in a cultural change towards a greater focus on safety, environment, and society.

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Appendix

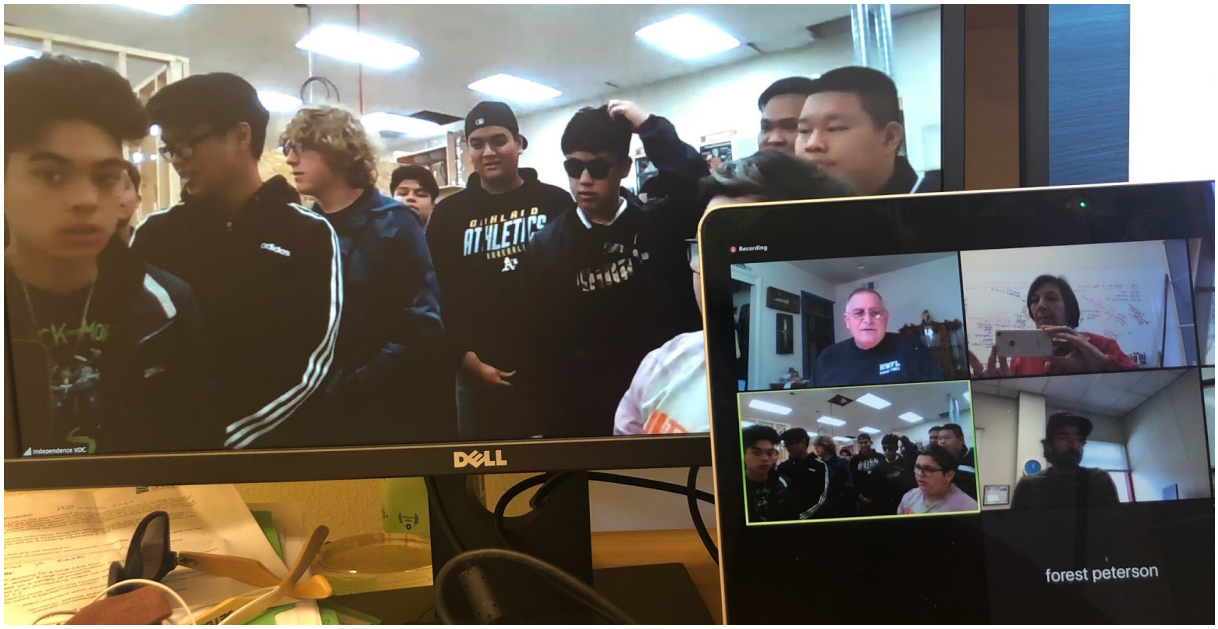

Figure 1: typical secondary construction program with a predominantly male cohort; the image is of a VDC team preparing to present.

Figure 3: The 2020 cohort of young women gather around an international Stanford construction engineering doctoral student to share insights into being women in the construction industry.

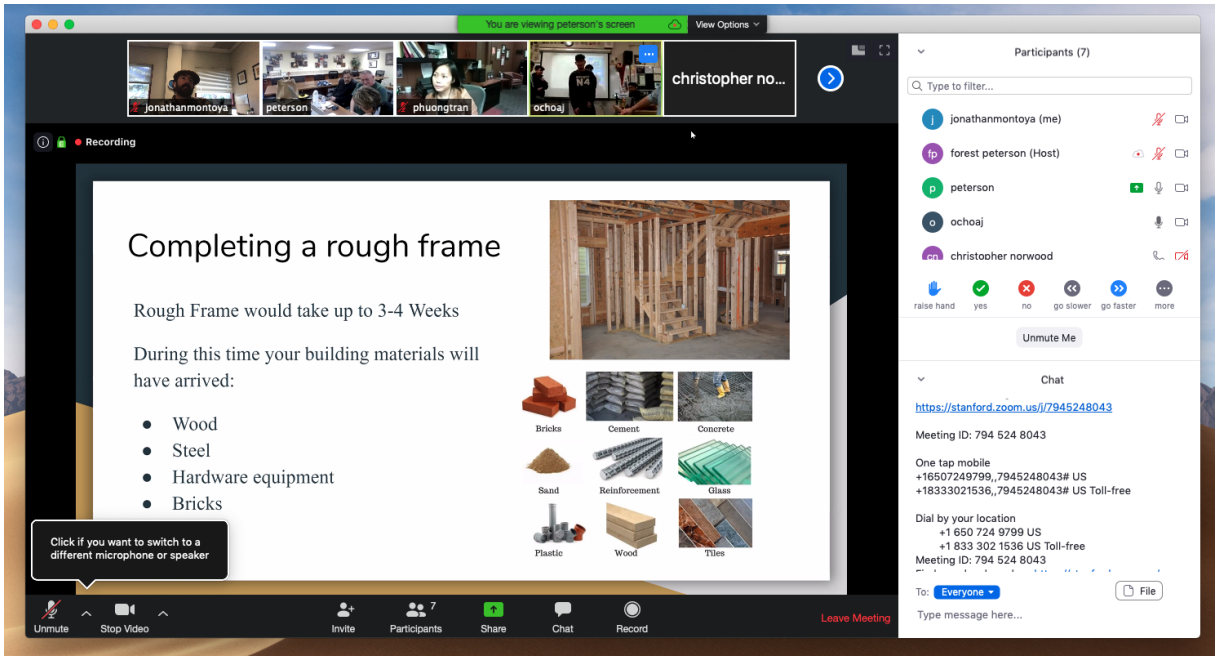

Figure 4: An example of the virtual call format with a mentor panel of practitioners pulled from the collaborating community of practitioners.

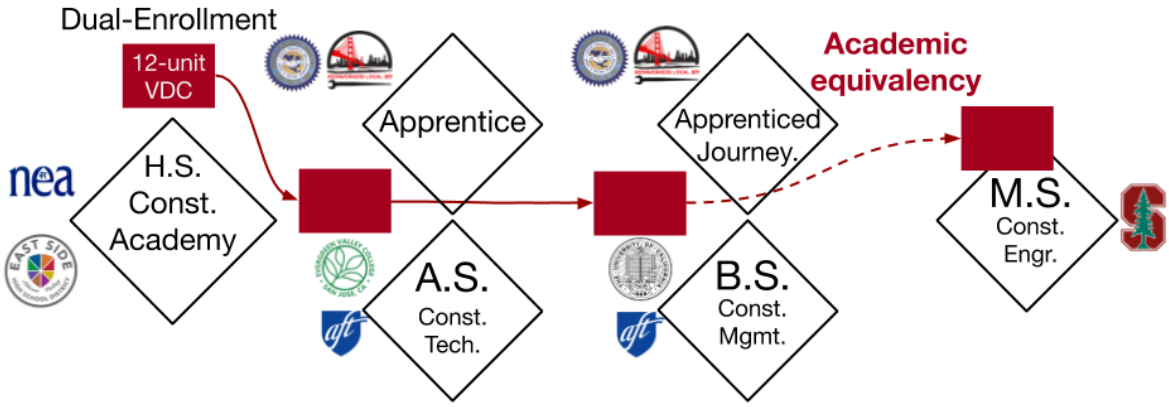

Figure 5: Comparable college pathways through trades and traditional college preparatory.

Figure 6: At the March Dryrun presentations, two months prior to final presentations, students are looking at their presentation slides.

Figure 7: At the March Dryrun, mentor feedback on presentation skills and construction technical details.

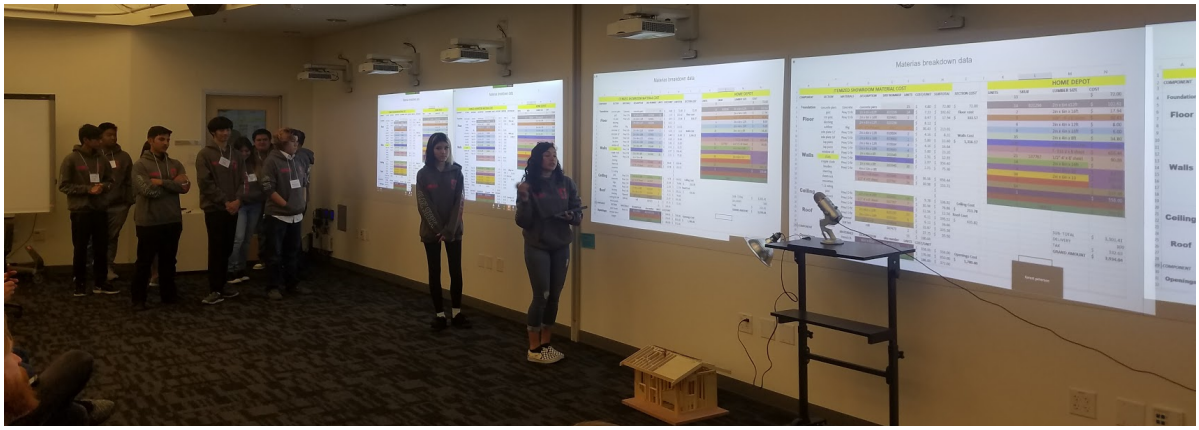

Figure 8: After two more months of project development and virtual mentoring calls, the students return for a May final presentation. The presentation, social, and technical skills are now equivalent to the university level.

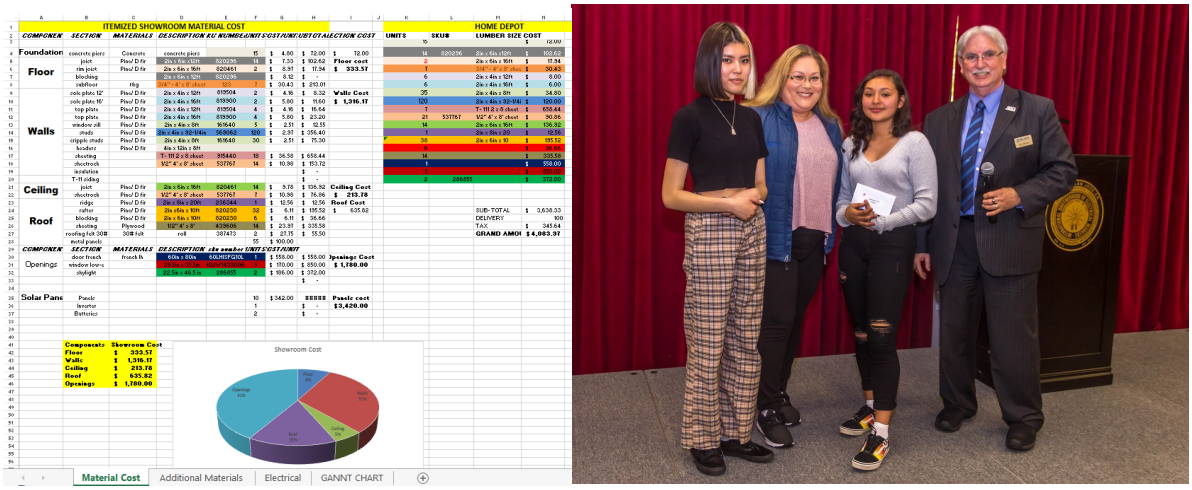

Figure 9: The cost estimating spreadsheet developed together by the two young women. They received a construction skills fair award for their project; they are flanked by a business leader and a labor union representative—the event is held at a building trades labor union hall (IBEW).

Figure 10: Young women have been quick to embrace social justice topics, such as homelessness. That is key to the Workforce VDC program. Students propose and develop solutions using approaches and technology tools that are used for traditional construction problems, therefore, learning those skills through an alternative narrative.

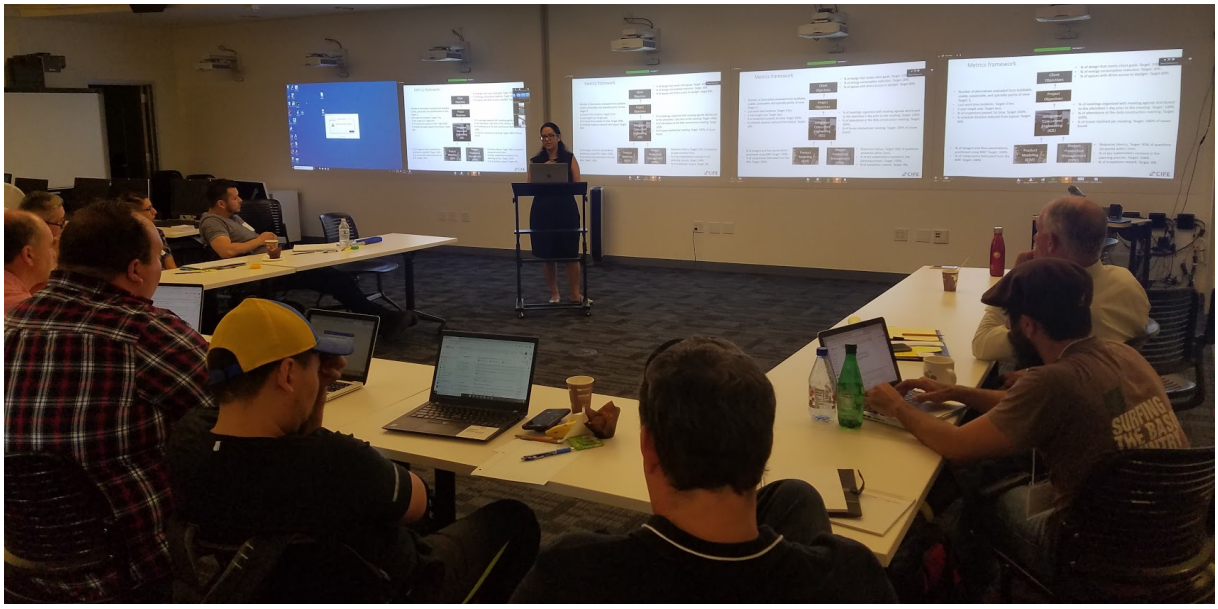

Figure 11: The teaching cohort is predominantly male; the only woman is the doctoral student lecturing on construction theory.

Figure 12: Growing a network of education leaders includes the labor union apprenticeship education system; we have good progress, seven current or recently retired union labor leaders and union apprenticeship educators attended the final presentations (building trades leadership, pipe trades, pipe trades education, ironworkers, carpenters education, and service workers); standing in the back is the president of the Stanford campus higher education workers—the executive director of the higher education workers is giving a keynote opening guest lecture.