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Building sustainable communities: A project-based learning approach to modify student perceptions of the building industry

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ABSTRACT

The building industry has experienced a paradigm shift with increased use of data for collaboratively designing, building, and operating sustainable, socially conscious, energy-efficient projects; this shift has resulted in a theory called virtual design and construction (VDC).

Secondary education provides students few opportunities to explore these methods. However, project-based learning (PBL) has shown success in VDC education at a graduate level; though scarce in low-income schools due to a discrepancy called the 'opportunity gap.'

The opportunity gap creates a perception that the building industry does not lead to advanced STEM degrees — which students otherwise discover through courses like VDC. That perception forms a resistance to building industry entrance pathways such as building trade apprentice programs. That resistance then hinders achieving the social mandate to include underrepresented demographics such as women in high paying STEM fields such as apprenticed building trades. As a result, it is a male dominated pathway.

Leveraging California Proposition 39 funding, the authors developed a PBL education platform to integrate VDC students from the secondary, apprentice, undergraduate, and graduate levels. The purpose of this research was to discover to what degree underrepresented youth perceive the building industry as a career if given an opportunity to learn VDC through PBL. The VDC curriculum was piloted as a course that encompassed topics of sustainability, environmental justice, and energy efficiency.

A mix of community-based participatory research (CBPR), ethnography, and surveys were utilized to gather content. Data were gathered from three secondary institutions, including an all girls school and an underrepresented community with one tenth the admission rate to top-tier universities of Palo Alto high school (selected as a generic benchmark for comparison).

Through CBPR the authors show that VDC-PBL 1) narrows the opportunity gap 2) teaches virtual design and construction, and 3) explores careers in sustainability and topics of environmental justice.

Introduction

The question directing this research is: *"If given an opportunity to learn virtual design and construction through project-based learning, to what degree do underrepresented youth perceive the building industry as a career?"*

This research builds upon the ACEEE Summer Study paper *"Community scale research-based integrated education experience"* through implementation of an educational platform envisioned by Tarantino (2016). Tarantino et al. (2016) proposed a project-based learning platform that integrates multiple academic institutions both horizontally across secondary education institutions, and vertically with regional apprentice center, community college, state

university, and research universities. That platform emulates the PBL platform developed and taught at Stanford University for the past several decades by Fruchter (2004).

In this paper, we present continued research and a pilot VDC course that was developed, implemented, and validated with high schools in the Silicon Valley region. This research furthers development of Tarantino's proposed educational platform and relates an experience of its benefits. The goal introduced by Tarantino et al. (2016) was to develop a pathway for students to consider careers in the building industry. Our goal then and now is to inspire teachers, policy makers, and unions to rethink the way they prepare youth for future careers. There is a need to foster a culture of career and college readiness.

Project-based learning (PBL) in virtual design and construction (VDC) education has shown success in graduate-level education (Fruchter 2014). We use these definitions of PBL and VDC:

> *Project-based learning (PBL) is an educational process whereby students gain knowledge and skills through long-term, real-world challenges – with an emphasis on multidisciplinary, remote teamwork. (Stanford News 2017).*

> *Virtual design and construction (VDC) is the use of multi-disciplinary performance models of construction projects, including their products (facilities), organizations, and work processes for business objectives. (Fischer et al. 2017).*

The relation between PBL and VDC begins with the project-based profession VDC evolved within. That focus on a project includes a need to adapt to unexpected issues that often do not have a correct answer. In PBL, a VDC role provides students a freedom to explore a domain that has few boundaries. PBL is active learning, which moves the centre of learning from teachers to students and enables teachers to take a supporting role to the learning process. PBL active learning creates an environment for learning-by-doing in which students from different backgrounds apply classroom knowledge and interact with industry mentors to solve design problems (Fruchter 2004).

Despite evidence and excitement for project-based learning, adoption of PBL in low-income schools has been limited due to a discrepancy called the 'opportunity gap' (Ladson-Billings 2013). This gap creates a perception that the building industry does not lead to advanced Science, Technology, Engineering and Math (STEM) degrees nor high-wage in-demand trades (Santa Clara County Economic Forecast 2016), forming resistance to industry entrance pathways such as apprentice programs.

> *If underrepresented secondary school students formally learn about building energy efficiency and sustainability in a classroom setting paired with hands-on industry sponsored experience, then these students can 1) study advanced undergraduate and graduate material 2) become environmentally conscious members of the building industry workforce, and 3) help improve their community's environmental justice. Tarantino et al. (2016)*

An inclusion of environmental justice through PBL education is a widespread movement in education "*so that young people can lead informed, meaningful, and transformative lives"* (Benavot 2014). The PBL topic focused on regional challenges such as poverty and inequality as well as environmental and social insecurities (Benavot 2014). Our inclusion of environmental justice as a topic specifically for those students most affected in an otherwise affluent region is novel. Environmental justice issues are real for students in these communities, environmental

stresses and contaminants have measurable community health impacts (Akom 2011; Bean and McRae 2016, Gee and Paybe-Sturges 2004; Martinez 2017; Massey 2004).

Changing students' perception of their environment leads to students taking ownership and becoming advocates for their neighborhoods. Teaching students VDC methods and opening-up their mindset creates a better built and natural environment, *"[VDC surpasses] the traditional, non-integrated way"* (Kunz and Fischer 2005). These youth are the future protectors of that environment; César Chávez exclaimed: "*Once social change begins, it cannot be reversed. You cannot uneducate the person."* This PBL platform transforms students' perception of not only their career options, but of their potential, self-worth, and role as future leaders of the building industry.

This paper presents a pilot project aimed at supporting a community of educators looking towards 'pathways to prosperity:' increasing student participation in high-skill careers which lead to opportunities to continue to college. It is a formative assessment to determine the performance of PBL in VDC. The authors implemented an educational platform through collaboration with community-based participatory research (CBPR) and measured the efficacy of that platform through ethnography, student perception surveys, and peer review.

Workforce Development Topography

At the secondary-level, vocational education is geared towards attracting students to select an industry in which to continue their education. Globally, vocational education has developed separately beginning with traditions that reach to before the industrial revolution but took on a new form post industrial revolution. The U.S. and German systems are often held as examples. The U.S. construction apprentice system lacks a pathway found in the German system: in Germany those vocationally educated have pathways to reenter academic systems and continue as engineers or managers (Hansen 2011). In the U.S. this type of pathway exists as a fragmented stack of credentials (discussion of educators at S4CA meeting, San José, CA, 2018).

International Example: Germany

The Silicon Valley construction apprentice system is comparable to the German system described by Hansen (2011) (discussion with construction vocational education trustee in Swiss-German dialect region, Basel, CH, 2017). Unlike the German system the Silicon Valley system begins in post-secondary education. However, as a post-secondary system, the Silicon Valley apprentice education centers, like in Germany, have formed a tight integration with industry and the skills follow industry needs. That integration in the German vocational system is due to its development as a separate pathway from secondary education with a separate administration by the trades (Hansen 2011). That closeness to the occupation resulted in skills that more closely match with skills needed (Hansen 2011). That separation of administration is not the case outside the German system.

Silicon Valley, California

In Silicon Valley, California, the vocational education that does exist at the secondary level is at regular full-time high schools. The facilities are on school sites and replicate an occupational environment. The students do not go to a workplace (Hansen 2011). In these programs, the separation from the worksite has had a long-term effect on that education. Without

administration by those from the trades, these programs have not evolved to meet industry skill needs (Hansen 2011). Academic systems tend to form into an overburdened curriculum culture which has perceived an education for sustainable development as a distraction from prioritized exam topics.

Most all vocational education is now in post-secondary education. The push to post-secondary vocational programs is a global trend to lengthen education years (Meyer, Kamens, and Benavot 2017), where a student might have begun a vocational education at fourteen, they now begin that education at eighteen.

There are California State agencies and non-profit organizations that fund, advocate, or implement vocational education. The state-funded California Partnership Academies (CPA) includes fifteen academies specific to the building trades. In the study region are Yerba Buena High's construction technology academy, a part of the East Side Union High School District, and Salinas' sustainable design and construction (SDC) academy in Monterey County.

The partnership academies work with regional workforce development boards appointed by the California Governor. In the study region there are two boards, the North Valley Job Training Consortium (NOVA) and the San Jose - Silicon Valley Work2Future. The industry interaction between the workforce development boards and labor organizations follows similarly to the German system described by Hansen (2011). This shows that there may be more parallels between the U.S. and German construction vocational education than for vocational education as a whole.

These boards have broad appeal. Recently, the Stanford University MediaX illustrated this industry when they held a vocational education conference. Industry and academia partners related their experiences supporting vocational education to teach the technology skills that are needed in Silicon Valley (MediaX: Workforce and learning pathways in a period of dynamic change, Stanford University, October 2017).

Methodology

This research utilized a mix of methods within a community-based participatory research platform. The primary research method is an ethnography. A survey provides a measure of perception shift. With a mixed approach, the ethnographer has support from a community of organizations and with a survey there is a clearer understanding of the ethnographer's observations.

The community-based participants come from those with an interest in vocational education. These organizations come together as the Santa Clara County Construction Careers Association (S4CA) and meet every three months. These meetings include community colleges (Foothill and San José City Colleges), public high school teachers, joint apprentice training centers (pipefitters, electricians, sheetmetal, and carpenters), labor leaders from the building trades council, business leaders from construction companies, and political leaders from the regional government. This community forms the core of this research and provides a base of participants.

Our content and demographic data includes three secondary institutions in East San Jose, California, including an all girls school and a school in an underrepresented community.

- The East Union High School District represents the background population of an underrepresented community which has one tenth the rate of admission to top-tier universities as affluent communities, has a standard shop class size of thirty five students,each school in the district graduates around 500 students per year (10% of Latinx

students are unable to pass the California exit exam), and is predominantly Latino (50%) and lower income (50% of students qualify for free and reduced-price meals) (ed-data 2018).

- An anonymous high performing private catholic all-girls high school represents an elite population within that underrepresented community; this school has a higher (22%) rate of admission as affluent communities to top-tier universities (94% attend a four-year university), has an average class size of ten students, graduates less than two hundred students per year (every student passed the California exit exam), and is predominantly non-Latina (13% Latina) and upper income (no students qualify for free and reduced-price meals) (high school website).

The lead author took on an ethnography role as a high school construction technology education instructor. Last year that author completed an introduction to virtual design and construction course with several colleagues. This academic year, the lead author formed a PBL pilot with a select group of eight high school students to learn VDC knowledge. For an example of construction, a sidewalk provided both a physical component with measurable properties of quality and also a metaphor for social justice from a viewpoint of public policy for civil infrastructure. To prompt the sidewalk as a focus, the students were challenged to complete a safety survey of the routes to their school. The students were then transported to an affluent community where they did another survey. Over six months the students applied VDC methods to their data analysis, made a mid-term presentation for feedback, and at the end of their academic year, a final presentation of their results to industry mentors.

To measure the perception shift outside that perceived by the ethnographer, five groups of students completed a Likert survey. The experiment group was made of students in the PBL-VDC course (N = 6). There were two control groups: Group A are non-PBL students in other construction technology courses (N = 114). This group parallels closely with the experiment group demographic; this group was predominantly male, Latino, and non-university track. Group B was a general population group (N = 166). This group fit the profile of the regional community. Primarily the difference from control Group A is an equal distribution of male and female students as well as including university track students (43% meet state university entrance exam requirements). Finally we surveyed two all girls private institutions (N= 26)

A survey allows benchmarking the East Side Union experimental group with their general population and then to compare the general population across other institutions. To evaluate the survey results a comparison of experiment to control Group A and B provides a measure of shift in perceptions.Comparing their perceptions to high achieving schools allows us to see what discrepancies if any can be ameliorated to facilitate social mobility for our lower socioeconomic students.

Analysis and Findings

The purpose of this research was to discover the degree to which underrepresented youth perceive the building industry as a career if given an opportunity to learn VDC through PBL. There are two institution categories in the survey sample, one is Piedmont Hills high school, and the other is anonymous private all girls schools.

Ethnography Observation

Note to reader: This ethnography section is written in an ethno-style from the perspective of the first author.

An ethnography allowed me to see students participate in a scientific process through three components of project-based learning. First, I saw teamwork as a crucial component of a PBL-VDC curriculum. Second, the students showed me their command of authentic PBL. Last, I perceived real student engagement.

PBL is effective at increasing student engagement in teams. I leveraged that PBL pedagogy effectiveness to increase student engagement. With this engagement, I introduced themes of VDC. Through this pilot course, students improved their ability to work together. I saw my students became leaders of their school and agents of their own change. VDC related to real environmental issues and social justice which helped me to harness my students' frustration and curiosity. I watched as they identified local problems in their community and became empowered to change their lives.

Change was on my students' minds when they started their safe routes to school survey. They picked a typical route to school in their neighborhood. They surveyed that route. Then, they surveyed a route in an affluent neighborhood. Afterwards, they compared their experiences. The students became social scientists and engineers as they analyzed sidewalks. They grappled with both qualitative and quantitative data as they heard, felt, and smelled differences between neighborhoods. Analysis became more than a survey. The sidewalks showed a deep reflection into invisible walls and barriers to their social mobility. They felt like foreigners in the affluent neighborhood. They were afraid and ashamed. This was the point that many students would tune out, the point where youth close off and internalize their inequity. This is where they become what society tells them they are destined to be.

At this crucial point I saw why VDC was important to our youth. Rather than remain in self-sorrow they started using their new VDC terminology to add descriptions to their anger. The sidewalks were no longer just unfair, they were now 'underperforming design criteria.' They were no longer just ugly sidewalks, they had measurable metrics of concrete cracks and slab upheaval. These sidewalk defects were a result of bad construction and a use of poor materials. All of this could be remedied with proper construction and an efficient timeline. The students were empowered to make recommendations and a construction schedule to fix the problem. They added metrics such as square feet and a dollar amount to how much it would cost. Further, students considered where materials would come from, and whether or not it was buildable and sustainable. They felt a call to action. They took initiative and organized a neighborhood clean-up which their mayor attended.

What my students experienced could be written off as anecdotal; the feel-good story of disadvantaged youth. This does not have to be the anecdote. This curriculum could be a step to social equality and environmental justice. Through my ethnography I discovered this PBL-VDC curriculum increased a perception underrepresented youths' have of the building industry as a career. However, it seems to do much more.

In parallel to the students' safe routes survey, the Stanford University Center for Integrated Facility Engineering held a two-day building information model (BIM) boot camp for the East Side students (Figure 1). This was an open boot camp with room for more than just the VDC-PBL course students. At completion of two days the students received a CIFE certificate in BIM to add to their resume or application to an apprentice vocational education program.

No two BIMs the students made were the same (Figure 2). Each student created their own design while listening to the lecturer. It was amazing to see how students responded to a program and concept (BIM) they had never seen before. Students who had a tendency to disengage were excited to learn and express themselves through design. According to the lecturer, the youth performed on par with graduate students (discussion with Glenn, BIM instructor, Stanford, CA 2018).

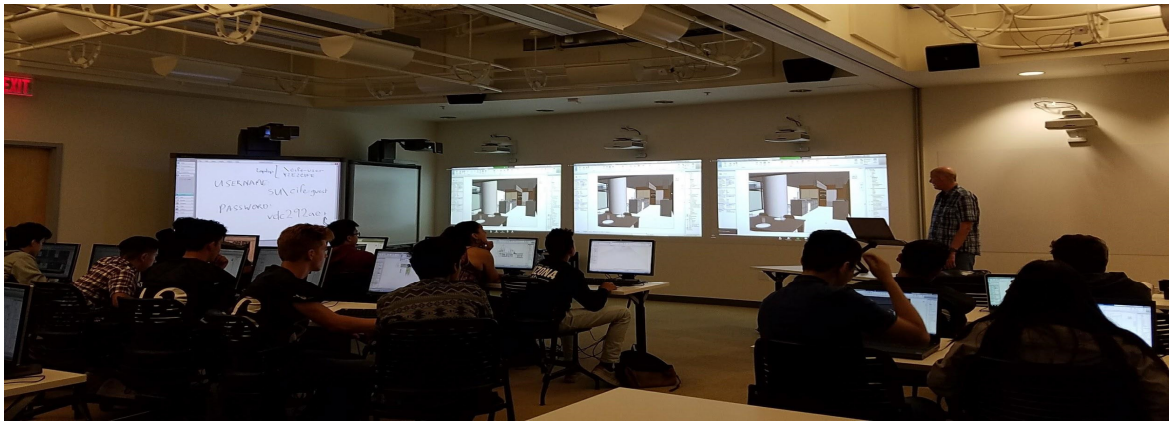

Figure 1. High school students learn to create building information models (BIM) in the Center for Integrated Facility Engineering lab (CIFE).

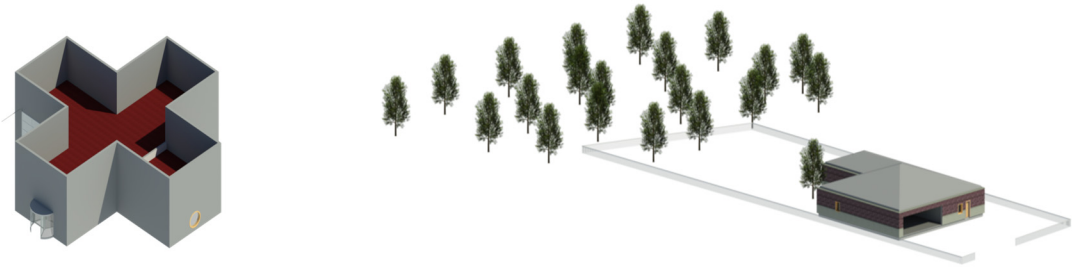

Figure 2. Typical student BIMs after a second day of instruction. These show the students have begun to explore more complex shapes and added landscaping components.

Survey of Perceptions

The survey data showed the degree to which underrepresented youth have shifted their perception of the building industry as a career and pathway to education. Through an ethnography, Montoya shared his observations about PBL-VDC that helped to interest the youth demographic in environmental justice. This section measures if the observed evidence that PBL-VDC engenders environmental justice also motivates students to a building industry career.

Rather than employ pre and post surveys we utilized student perception surveys with different cohorts. We chose Group A as a control to see if VDC curriculum was the cause for change. Group A is a similar class with similar instruction as our intervention group, but no VDC curriculum. We compared to a general population of non-construction students. Two prestigious girls schools formed a comparison group as an exemplar of mainstream education.

Both ethnography and survey detected a shift in student mindset. Students had shed the social stigma of building industry careers. By learning VDC and visiting Stanford University the students realized the rigor and benefits of building industry careers. The survey shows that 44%

of participating VDC students can see themselves working in a building industry career. This represents that with a PBL course, a group of 14-17 year olds successfully saw a career in VDC and participated in that career. This level of career immersion in VDC is unheard of at a high school level.

Inclusion in the built environment is true social justice because the students now feel like participants for change, rather than passive bystanders to inefficiency in their environment. Through PBL and VDC collaboration the built environment is open to public stakeholders.

The survey measured the degree to which the intervention PBL-VDC curriculum achieved our educational platform goal, *"If given an opportunity to learn virtual design and construction through project-based learning, to what degree do underrepresented youth perceive the building industry as a career?"* The survey contains questions on seven topics: knowledge of career opportunity, social mobility, energy efficiency, project-based learning, confidence in capabilities, sustainability, and social justice (Figure 3). Two categories addressed the research question. These are categories: Knowledge of career opportunity and Social mobility.

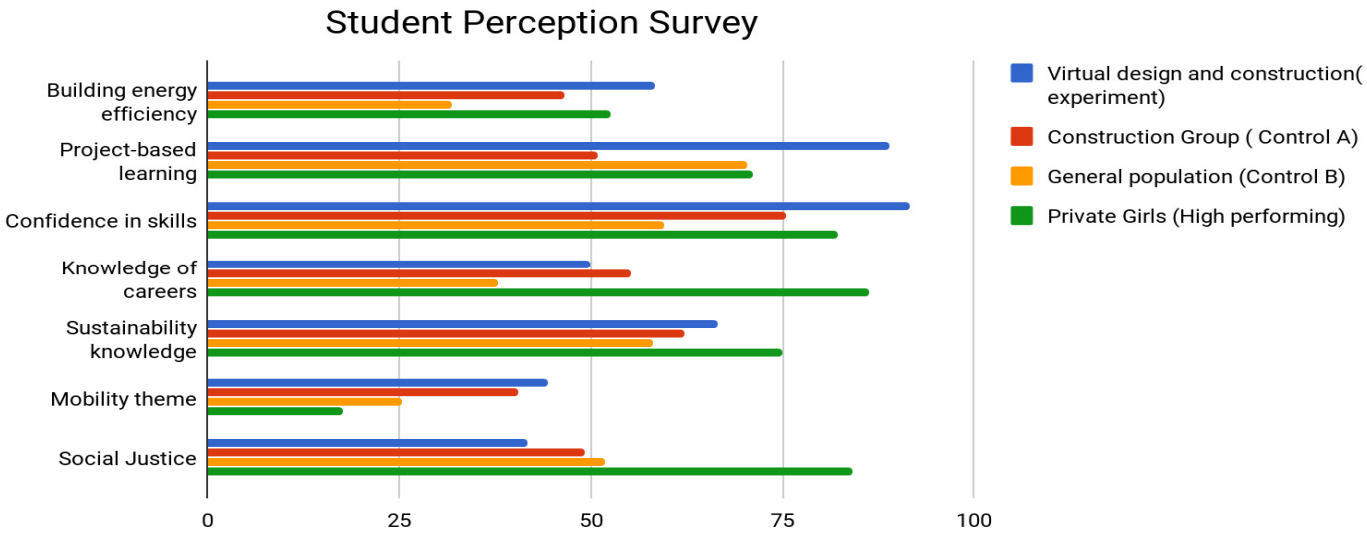

Figure 3. Student perception of construction technology as a pathway. These are percentage of student responses for intervention group (construction PBL-VDC), control group (construction technology), general student population and a private girls school.

Goal 1: Narrow opportunity gap

Knowledge of career opportunity: The survey measured students' knowledge of building industry careers. In order to see themselves in this field they must first know about it. Half the VDC cohort could see themselves following a career in the building industry. This is 12% more than the general population, or four additional students per class. This trails the 86% of private school students who are aware of careers in the building industry.

Social mobility: The survey measured student perceptions of social mobility through the trades. Mobility means students perceive that trades can give them a career with a living wage and is a pathway to higher education. Of the VDC cohort, 44% saw trades as a pathway to success and prosperity. This is 20% more than the general population. Given a standard class size of thirty-five students, a 20% shift in perception translates to seven students per class more than the general population. Looking to the all girls school, 17% saw the trades as a chance for mobility.

Goal 2: Teach virtual design and construction

Energy efficiency: For building energy efficiency, 58% of the VDC cohort answered positively for building energy efficiency. VDC students answered 26% higher than the general population. The VDC curriculum has moved nine more students per class toward understanding building energy efficiency. However when we look at the private girls school we see that 71% had knowledge of energy efficiency.

Project-based learning: The students' satisfaction with project-based learning was high for all cohorts. After participating in project-based learning, 89% of the VDC cohort felt an increased satisfaction with learning. This is 20% more than the general population, representing eight additional students per class. This was also 11% more than the private all girls school.

Confidence in capabilities: The largest impact with PBL-VDC was a change in students' confidence. The VDC cohort answered 91% with positive confidence. That is 30% higher than the general population, and 9% higher than the private all girls school. Utilizing the VDC curriculum increased confidence for ten students per class.

Goal 3: Explore careers in sustainability and topics of environmental justice

Sustainability: The students' perceptions on sustainability. Of the VDC cohort, 66% identified that they knew and valued sustainability practices. That is 8% higher than the general population, or three additional students per class. This is behind the 75% at the all girls school.

Social justice: The VDC curriculum has a social justice component, however, there was not an increase in the students' awareness of social justice. Of the VDC cohort, 41% scored positively on social justice themed questions. This is 10% lower than the general population, that is three students per class. When we look at the 84% positive response from the all girls school, we see that VDC has missed the mark on social justice.

The survey data shows that VDC curriculum increases student confidence, which is important for them to take charge of their future. This class also exposes students to and makes them more likely to choose careers in the building industry. The VDC curriculum provides a pathway for future success for not only the students but the industry as well.

While the perception survey nailed down some concrete quantitative data, the ethnography revealed things that are hard to measure. Observations in the ethnography find that there is a discrepancy in social justice perceptions that needs more research. Is this discrepancy due to a student apathy towards their future, comparable to the apathy of the 'lads' in Willis' (1977) *Learning to Labour*? It would be hard to imagine that we would not find parallels in working class communities.

Discussion and Conclusion

How society perceives their students is as important as changing student's perceptions. Students will often submit to society's expectations of them. Society needs to hold students to high standards while providing both the rigor and scaffolding to achieve that rigor. This contribution by society is crucial for changing students' perceptions of their future and their capabilities.

Through the research presented in this paper, the authors find that learning virtual design and construction methods through project-based learning contributes to virtual design and construction theory with an improved understanding of the role of education in shaping perceptions about the building industry as a career pathway and pathway for higher education.

As an ethnographer, Montoya experienced a role of an educator to understand constructs of students. His ethnography has an added depth, a decade ago he was in the same seat as his students, in the same shop class, looking forward to the same prospects with the same background. Montoya shares his students' constructs. This relation is not so different from the situation of Willis (1977) in the seminal ethnography, *"Learning to labour."* Willis followed a group of British 'lads' as they transitioned from secondary school students to entry level apprentices. In the process the lads disclosed their perception of detachment from their community. This forms a powerful ethnography. Montoya's insights into this demographic are concise and pull from a broad understanding that cannot come from an observational study or survey.

It is that background that brings an understanding to the bigger picture in East San José, this is East Silicon Valley. Ladson-Billings (2013) reminds us, *"There is something deeply un-American about not allowing entire groups of people to participate equitably in an educational system that allegedly provides an opportunity for social and economic advancement."* Those living in the Silicon Valley are privy to some of the greatest advancements in technology. Starting sixty years ago with IBM's Cottle Road campus in South San José, these neighborhoods have transformed from farm lands to start-ups and high rises. Stories of young tech billionaires flood social media and fuel both hopes and dreams for Silicon Valley youth. Young people would normally aim to emulate their favorite sports stars, in this valley more strive to be tech giants than baseball players.

> *As a classroom teacher I used to hear: "I'm the next Kobe Bryant." That narrative has switched focus to creating the next social media app. As educators of low socio-economic youth en loco parentis we struggle to capacitate dreams which seem reserved for the affluent. The poignant truth is that invisible walls exist and continue to develop that ensure disadvantaged youth may never partake in that dream.*

East San José youth bear burdens of social stratification, brownfield neglect, and housing that provides an indoor environment that is either too cold or too hot, one that is never right. Compounding an overall lack of inclusion, in the backyards of these youths they live with a legacy of toxins left by sixty years of Silicon Valley development (Pimentel 2004). This is the toxic wake of a toxic industry. Silicon Valley has the highest concentration of Environmental Protection Agency (EPA) designated Superfund sites (Schlanger 2017). These sites are situated in communities of our student's demographic; *"populations that are poorer, less educated, rent, are linguistically isolated, and predominantly Hispanic"* (Stewart 2014). When Tarantino et al. (2016) recognize with Krieger and Higgins (2002) that *"homes of people with low income are more likely to be too warm or too cool because they are less well insulated, often have relatively expensive forms of heating such as electric baseboards, and frequently lack air conditioning,"* and that, *"occupants often cannot afford to pay for the energy needed to make their homes comfortable,"* they are recognizing the students' reality.

> *The physical boundaries of the tech industry are evident in East Side youths' environment, juxtaposed by the socio-economic boundaries of the community. Eventually, my students will realize they are on the margins of a society and with an industry which fails to provide adequate means for their social mobility. This is the crucial point where students can become agents of change for their future and their environment.*

Youth are: *"drawn to the social justice work because of their desires — perhaps in some cases tied to their families' desires for them — to learn to be in the world as a person from a*

marginalized race, gender, sexual orientation, or any intersection of these" (Akiva 2017). Why then do educators continue to teach? Why do researchers continue to research? These are real questions that authors such as Groeger (2017) explore as a tradition of Deweyan vocational education — a tradition similar to project-based learning.

Possibly a closer reading of Dewey would benefit this research going forward. In a Silicon Valley spirit of innovation, as K-12 career technical educators and civil and environmental engineering researchers, this paper furthers development of an educational platform which aims to disrupt this trend. As conceived by Tarantino et al. (2016), this platform aims to provide students technologies and an education to ameliorate their reality.

What are sustainability challenges in Silicon Valley? This paper has explored equality, access to opportunity, and environmental justice in both energy efficiency in the home and environmental contamination outside the home. This paper has shown that in an affluent region, like Silicon Valley, a sustainable education curriculum as a construction technology course influenced both sustainability and social mobility perceptions. However, as Benavot (2014) noted, this is within an ongoing struggle against a Silicon Valley culture of overburdened curriculum with its focus on prioritized exam topics.

Progress in research has not been without limitations: The VDC pilot course has focused on a single high school and the course developed in Tarantino et al. (2016) anticipated a pilot with three high schools. The limited scope of the pilot has limited the sample size, which limits the generality of our conclusions. In parallel to this paper are ongoing preparations to continue this research. In future research the authors will apply frameworks of measuring environmental justice disparities to better show the constructs of the research (Akom 2011; Gee and Payne-Sturges 2004).

This paper recommends that secondary educators adopt a project-based learning method and begin teaching virtual design and construction as part of the secondary construction technology curriculum. In particular, we encourage both public and private schools to adopt a VDC-PBL curriculum with an emphasis on attracting girls to a trade-based pathway as a step in stacking credentials to a university education. The authors recommend that public policy makers make funding available for such an education and pass resolutions that encourage this education. Through such education, underrepresented youth will perceive the building industry as a pathway to prosperity.

This research used a project-based learning pilot case of safe routes. This topic was selected for environmental justice aspects as well as a practical need for a fail-safe topic (sidewalks are everywhere). As our VDC-PBL curriculum development gains confidence and capacity from pilots, the ambitious Energy Efficiency and Sustainability (EES) curriculum developed in Tarantino et al (2016) will form a new advanced virtual design and construction technology course.

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