Community Scale Research-based Integrated Education Experience

Sergio Tarantino[1], Forest Peterson[1], Alissa Cooperman[1], Neil Struthers[2], and Martin Fischer[1]

[1] Stanford University
[2] International Brotherhood of Electrical Workers (IBEW)

ABSTRACT

The building industry is moving towards increased use of data driven methods for designing, building, and operating sustainable, energy-efficient buildings. The adoption of these methods requires technologically skilled employees and education programs for these skills. The purpose of this paper is to show that by aligning community, education, and industry stakeholders, a data-driven, project-based education platform can be developed that creates a pathway for generating such employees and a platform for investigating building energy efficiency and sustainability. Our methodology for developing this project-based education platform hinges on partnering with stakeholders from community organizations, education, building operations, building energy efficiency, and construction.

We approached the development of the education platform from our standing as researchers in civil and environmental engineering. In order to integrate industry and academia, we partnered with stakeholders who represent construction trades and K-12 education. Together we laid the groundwork for leveraging school district green energy facility projects funded by California Proposition 39 to build an education platform that follows the facilities project process. Then, we began partnering with local K-12 teachers to develop the core of our education platform, a building energy efficiency and sustainability course module. These partnerships with the construction trades, K-12 educators, and affiliated education programs are presently ongoing.

Through the last two decades of work from Stanford University's Project Based Learning (PBL) Lab, we have seen that PBL creates an environment for learning-by-doing in which students from different schools and countries successfully apply classroom knowledge to solve real world design problems, become student mentors, and interact with industry. Additionally, our K-12 collaborators have started using PBL. Thus, we have planned our course modules using PBL to enable multiple levels of education to collaborate within one course.

Overall, we are developing an education platform that (1) uses a real building construction experience to teach energy efficient building design and operation and (2) partners students with industry. Our platform integrates students from the secondary, apprentice, undergraduate, and graduate levels. This platform targets underrepresented communities where environmental justice is an everyday reality, college is often an unrealized path, and opportunities in the construction industry are a pathway to financial security.

Introduction

Communities comprised of historically underrepresented minorities and/or low-income individuals are disproportionately affected by the environmental impacts of buildings. Buildings found in these communities often present unsafe living environments due to lead paint, asbestos, or proximity to brownfields and manufacturing facility pollution. (Younger et al. 2008; Krieger and Higgins 2002; US HUD 2011). For example, one study showed that communities comprised mainly of minority individuals are nine times more likely to reside near toxic facilities and sites

(Massey 2004). Additionally, Krieger and Higgins (2002) report 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. Additionally, occupants often cannot afford to pay for the energy needed to make their homes comfortable."* A recent ACEEE study of 48 metropolitan areas in the U.S. found that low-income households can expend three times as much of their income on energy compared to households with higher incomes (Drehobl and Ross 2016). The impacts of buildings do not stop at the home. A study showed that Southern California schools in the bottom fifth for air quality were composed of 92% minority children (Massey 2004). Underrepresented minorities and/or low-income individuals carry the burden of environmental injustice. This injustice impacts their livelihood.

Presently, neither these impacted communities nor the building sector has a method for rapidly increasing the environmental performance of buildings and thus reducing the negative environmental effects buildings have. If such a method existed, environmental injustice could be combated by an uptake in building energy efficiency and sustainability practices instigated by both community members and the design, construction, and operation segments of the building industry. We believe that this lack can be addressed by creating awareness of building environmental impacts through education and from the community up. We propose to develop a community scale research-based integrated education platform focused on teaching data-driven techniques concerning building energy efficiency and sustainability through project-based learning.

The education platform we are developing integrates secondary school students with vocational trade, undergraduate, and graduate students, community labor related organizations, and industry partners in the building industry. The key goal of our education platform is to create a student body that has an understanding of building energy efficiency and sustainability. Through project-based learning, students from these multiple levels of education and academia will jointly work together to learn about and solve real life community issues of building environmental performance and injustice. Furthermore, the integration with community, education, and industry partners gives all students involved exposure to an industry or academic career path they could eventually pursue. We hypothesize that 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) advance to undergraduate and graduate study, 2) become environmentally conscious members of the building industry workforce, and 3) help improve their community's environmental justice. To accomplish this, our proposed community based education platform partners community, education, and industry stakeholders. Over the course of the last two years we have been collaborating with contractors in the building energy efficiency space, building trade organizations, and community and education stakeholders to develop this platform.

The following paper first describes in detail the proposed education platform and the integrated stakeholder network, outlines the expected benefits for each stakeholder participating in the platform, discusses the education platform's goals, and lastly, details the status of the education platform's current implementation.

Education Platform

Our proposed education platform aims to improve environmental justice through the adoption of energy-efficient and sustainable practices in the building industry by teaching the

future workforce about building energy efficiency and sustainability, i.e., generate a future workforce that is environmentally conscious. The main components of the education platform are 1) building energy efficiency and sustainability project based classes and 2) an integrated community, education, and industry stakeholder network.

Project Based Learning (PBL)

Our platform teaches through learning-by-doing by using project based learning (PBL). PBL is an education approach in which students apply formal classroom knowledge to real world problems (Fruchter 2004). Through PBL students create ties between academic lessons and experience. Thus students understand the utility, relevance, and significance of their formal education. Students learning through PBL lead research efforts, collaborate, make project decisions, review and respond to feedback, create solutions for real world problems, and discuss their findings with peers, teachers and industry mentors. Consequently, students within our education platform will gain skills and behaviors needed for high performance in academia and later in industry.

Integrated Education

In conjunction with PBL, the proposed education platform uses an integrated education framework. In integrated education students from several academic levels participate in the same class. The class content and scope however, are adjusted by academic level. We envision secondary school, building trades training center, community college, undergraduate, and graduate students participating. This integration allows students to learn and mentor, thus students will more fully complete the knowledge gaining cycle.

Building Energy Efficiency and Sustainability (EES) Course Development and Format

The proposed classes will be developed by select graduate school students in collaboration with secondary education, building trades, and industry stakeholders. These classes will center around school facility energy efficiency and sustainability (EES) projects at the participating schools. These projects will be selected from the projects procured and administered by the education stakeholders and supported by a Green Energy Education Agreement[1]. The education platform champion(s) will align project phases with the course modules. In our case, the champions are the graduate students from the research university and leaders of the building trade organizations. Additionally, the industry stakeholders will serve as mentors to the secondary school through graduate school students, and they will provide summer internships for select secondary school students.

We envision the classes spanning a two semester (three quarter) sequence with a summer internship (fourth quarter) on a school facility EES project. This cycle will repeat each year with a new fall class that uses data from the previous summer. Our pilot class will consist of two dozen secondary school students. In later iterations we will include a dozen training center apprentices and an additional two dozen students between the community college, undergraduate, and graduate universities. We envision the students from the preceding year will become mentors and teaching assistants in subsequent years. We believe we can scale and

[1] The Green Energy Education Agreement is a contract provision which we have created in collaboration with the building trades stakeholders. It will be added to the school facilities project contract that binds the general contractor to provide access to the energy related project documents.

replicate this program across secondary schools in a given metropolitan region to include most secondary schools, training centers, and universities.

The class follows a cycle, learn, design, plan, and implement, that aligns with the corresponding industry project in order to emphasize learning-by-doing. Each year the students will receive a school facility EES project to address under the mentorship of their teachers and the partnered design, building, and construction companies. In the fall class, the students will collect actual performance data from their school building. In the winter that data will be included into their energy analysis models and guide their design decisions. In the spring the class will plan the construction for their design. At the conclusion of each course module, the students will present their designs, findings, and conclusions to an expert panel of practitioners and faculty via virtual communication software.

During the summer, the project of focus will be implemented. Select secondary school students will have internships with the project team. This will enable them to practice what they learned and compare the actual process to their class project. Under the mentorship of a university graduate student the summer interns will collect project documents, progress data, and system performance data. This dataset will then form the material for the subsequent fall class.

The high schools we have been collaborating with are underserved and have a high percentage of students that do not progress to the university system. It is important to these schools that we, the platform champions, respect their communities' self-resilience and ability to achieve progress with or without collaboration with outside institutions. Our role is to learn from these communities as their invited guests and we do not see ourselves as 'fixing' their system. The school administrators have guided people from outside their community to be conscious of this when working with students in their community.

Student Benefits from Building EES Course Participation

Through our communication with California Bay Area K-12 educators, we have learned that over the past decades these education districts have lost classes in which students obtain hands on experience. These are the 'shop classes' such as woodshop, metalshop, and autoshop (Frey 2014; CalPADS 2014; Benavot 1983). These vocational classes provide the foundation for the fundamental skills in construction (Clinton and Levitt 1980). They also provide an introduction to engineering. Students who participate in our education platform will regain these hands on experiences that are essential to futures in vocational and engineering careers.

This education platform forms a foundation for applying to the university system. Additionally, due to the coursework component and building trade collaboration, high school students will have the opportunity to choose the apprentice training center, which is a pathway that offers a living wage, supports environmental justice, and provides a technical skillset that builds on their path to completing a university education and continuing to graduate study. Students from the building trades training centers, community colleges, undergraduate universities, and graduate schools will learn the collaboration skills they will use throughout their professional careers from participating in the integrated education framework of our proposed education platform. Lastly, students will gain an awareness of the environmental justice and injustice within their community and the communities within their metropolitan region.

Community Benefits from Building EES Course Participation

The students from the targeted school district will have the opportunity to learn data driven techniques and technologies used at the forefront of construction engineering practice. Consequently, these students will be able to create environmental justice for themselves and their

families as members of the eligible local workforce. Additionally, the community participants will be connected to career and academic pathways to which they may not otherwise be privy.

Industry Benefits from Building EES Course Participation

The project-based class component of the proposed education platform brings awareness of environmental (in)justice to the partnered architecture, engineering, and construction (AEC), building industries, and community labor organizations. Furthermore, the collaboration on school facility energy efficiency and sustainability projects allows the industry partners to begin addressing environmental justice in practice. It also enables them to impact the creation of a future eligible workforce with skills needed to rapidly increase environmental justice within the building sector. Consequently, the education platform will create an eligible workforce that has the skills to improve environmental justice within the building sector.

Integrated Community, Education, and Industry Stakeholder Network

Our education platform leverages stakeholder integration because we believe that collaboration across personnel in design, construction, and operation, will increase the adoption of energy-efficient and/or sustainable practices that can improve a building's environmental performance. A study conducted by our research colleagues shows that AEC project teams who have used the collaborative working processes of Virtual Design and Construction (VDC) reported that the collaborative method of working helped them achieve LEED Platinum in one project and also helped save over $1M in costs on another project (Kam et al. 2013). We believe that if this concept of cross disciplinary collaboration is applied to design, construction, and operation disciplines within the building industry and is used to link these stakeholders to education and academia, then (1) the adoption of energy-efficient and sustainable practices would increase in the building sector and help drive down buildings' environmental impact and (2) by creating collaboration among this group of stakeholders the environmentally conscious workforce needed to propel building environmental performance forward would be created. Finally, by focusing these efforts from the "community up" we can target underrepresented communities that are the most impacted by building environmental performance. Consequently, these community members will be able to improve the environmental impacts of buildings around them and be able to join a growing and prosperous workforce (Fischer 2006).

Stakeholders in the Education Platform

Our proposed community scale research-based integrated education platform joins (1) community, (2) education, and (3) industry stakeholders, as shown in Table 1 and Figure 1. We build on the success of both the VDC methods that improve project performance by integrating construction project stakeholders across the design and build phases of a project, and on the success of Stanford's PBL Lab's global teamwork class in which students from across the world collaboratively create a design solution for a building problem. In order to reach our key stakeholders, the students and their families, we extend the integration of education and industry stakeholders into the community sphere. To develop and implement the education platform these stakeholders are joined together into an integrated stakeholder network by the platform's champion(s). The champion(s) then organize meetings across stakeholder groups to identify each participant's goals and investment abilities. The champion(s) also attend relevant internal meetings per stakeholder group to pitch the idea of the education platform and request the needed resources.

Table 1 Stakeholder Overview

Stakeholder Type		
Community	Education	Industry
Community members Students' families Non-profit organizations Government legislatures	K-12 school districts Vocational training centers Community colleges Undergraduate universities Graduate universities	Design firms Construction firms Facilities operation firms Building trade unions

These three types of stakeholders are needed to (1) develop and implement the education platform, (2) source real life building projects, (3) provide access to students at multiple levels of education, (4) connect the students to community, education, and industry practitioners, and (5) connect students across multiple levels of education.

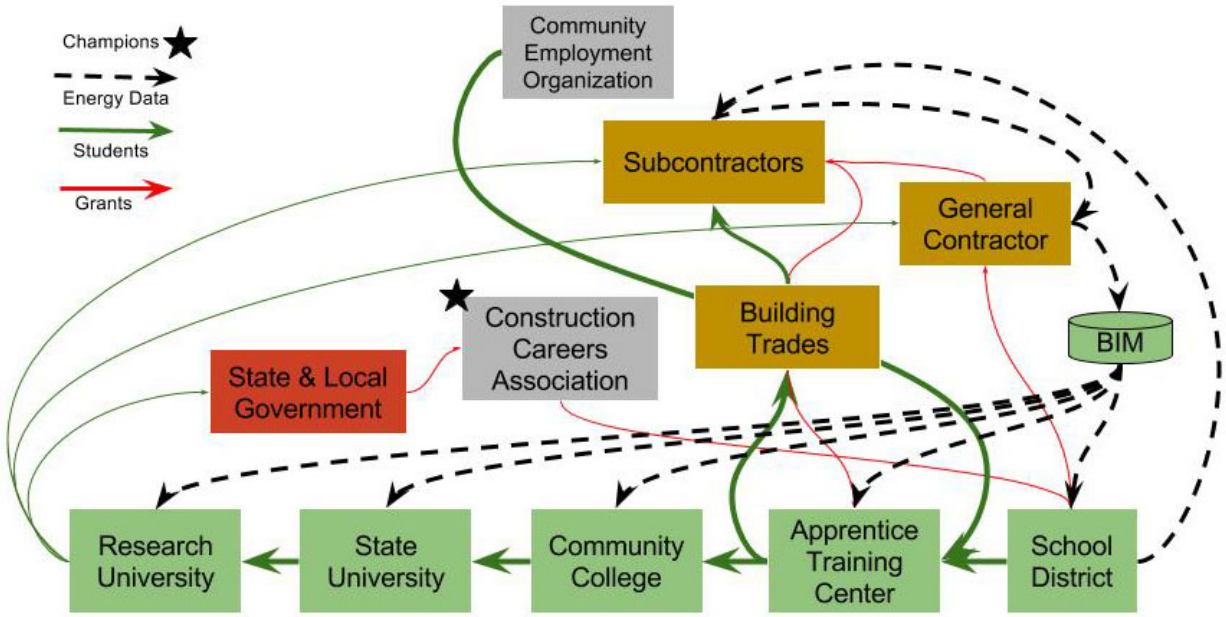

Figure 1 Stakeholders interactions within the community scale research-based integrated education experience. The champions pragmatically are from the research university but they assume a role within the Construction Careers Association as an extension of that association.

Stakeholders Roles, Responsibilities, and Benefits from Integrated Stakeholder Network

While, each stakeholder group will invest resources into the education platform, each group will also benefit from the integrated way of working prescribed by our proposed education platform. As seen in the practice of VDC, the benefits from integrated work surpass those gained from the traditional, non-integrated way of working (Kunz and Fischer 2012). These expected benefits are accrued because the integrated way of working prescribed by both VDC and our proposed education platform enables problem solving that leverages multiple perspectives. The investments and benefits per stakeholder are detailed in Table 2.

Table 2: Involved Stakeholder

Stakeholder	Benefit	Investment	Difference from Traditional Education Framework
Community Stakeholder			
Community Employment Organization	Provide living wage jobs that lead to higher education and professional occupations	1. Write grant applications 2. Coordinate the stakeholder network	Students have a pathway to living wage jobs rather than finding their own way through several low paying jobs
Construction Careers Association	Bring students into the construction industry through mentors and university supported STEM courses		Industry resources pooled for themed education rather than leaving the next generation to chance
Elected State & Local Government officials	1. Support students' education and community 2. Integrate community, industry, and education organizations	Legislate funding grants and directives to agencies and departments[2]	Direct communication of community needs to government rather than individually lobbying
Industry Stakeholders			
General Contractor	Gain: 1. Contract opportunity with participating schools 2. Entry to new market to develop relationships and confidence through performance on school contracts 3. Access to a skilled employee applicant pool	1. Lead design and construction of EES projects Provide: 2. Project data and building system data 3. Access to building sites 4. Internships for students 5. Funding for program management 6. Mentors	Contractually provide access to energy design rather than no access for students and researchers
Specialty Subcontractor			Provide project data and access to building site for educational purposes, this forms a steady supply of site access rather than looking to professional acquaintances for permission to visit sites.
Building Trades	1. Acquire living wages for construction workers 2. Gain visibility for construction as a career option	1. Coordinate access to project data 2. Establish labs with the University	Currently low performing students are encouraged to join the trades.

[2] Example of workforce development through education: The California Clean Energy Jobs Act (Proposition 39 (K-12) Program) http://www.energy.ca.gov/2014publications/CEC-400-2014-022/CEC-400-2014-022-CMF.pdf

Stakeholder	Benefit	Investment	Difference from Traditional Education Framework
	for STEM path K-12 students	Provide: 3. Access to their training centers 4. Mentors 5. Funding for program management	Trades gain: 1: Visibility with K-12 STEM students 2. Visibility with university students 3. Impact on university research
Education Stakeholders			
Graduate School	Gain: 1. School facilities as an experiment platform for energy efficiency design 2. Access to facilities energy data and construction documents	Provide: 1. Two full-time researchers 2. Programmatic design and implementation 3. Provide point of contact for the stakeholder network	Direct connection to community and industry for grounded research – as opposed to systemic ivory tower syndrome
Under-graduate School	1. Establish education sharing with Graduate School Engineering dept. 2. Gain K-12 STEM student applications 3. Gain trade school STEM student applications	1. Provide resources to support the cross school class participation 2. Help design project-based course 3. Mentoring support	Currently the university education is siloed into topics and taught in a traditional lecture format with minimal contact between students at other education centers. Expands the academic program to include: 1. Integrated project-based class format 2. Connection to integrated building sector practitioners
Community College	1. Gain trade school STEM students 2. Establish connection with undergraduate and graduate institutions		
Apprentice Training Center	1. Gain STEM path K-12 student applications 2. Establish transfer pathway with undergraduate institution 3. Gain connection to graduate institutions		
School District (K-12)	Gain 1. Access to funding[2] 2. Community Benefit Agreements (CBA) 3. Connections with continued academic and building career	1. Protect interests of the district 2. Provide resources to support the cross school class participation 3. Guide mentors in	Pathways from the K-12 to the trades and university engineering programs is not a closed path, there are gaps the students must navigate.

Stakeholder	Benefit	Investment	Difference from Traditional Education Framework
	pathways 4. Advanced energy efficiency STEM curriculum support 5. Hands on lab to explore environmental justice	respecting their community and understanding their struggles. 4. Help design project-based course	Expands the K-12 program to include: 1. Integrated project-based class format 2. Connection to integrated local building sector practitioners

Goals of the Proposed Education Platform

The key goal of our education platform is to create an aware student body across middle school, high school, vocational training center, and university that has an understanding of building energy efficiency and sustainability, and how their built environment impacts their environmental justice. As a consequence, our proposed education platform creates a way to scale the environmental consciousness of the building sector workforce by creating an eligible workforce with the requisite skill set.

Table 3 Stakeholder Integration and Education Platform Process

	Product Community scale research-based integrated education platform	Organization Integrated stakeholder consortium	Process Collaboration among building industry, education, and academia
Form	Co-designed project-based learning strategies grounded in the topic of sustainability integrated across academic levels	Integrated consortium of stakeholders from the community, education, and industry	1. Community identified need 2. Industry and Academia identified gaps in practice 3. Identified gaps addressed through proven PBL strategies 4. Industry sponsored projects
Function	1. Increase environmental consciousness in the building sector workforce 2. Create career pathways in construction for students from underrepresented communities 3. Increase the environmental performance of the building sector 4. Link academia with data	1. Integrate and interface with stakeholder organizations 2. Develop, coordinate and execute PBL integrated academic level class 3. Elucidate prevalent community issues to address through PBL	Focuses the resources provided by each stakeholder into addressing a community problem through PBL, research, and industry collaboration

	Product Community scale research-based integrated education platform	Organization Integrated stakeholder consortium	Process Collaboration among building industry, education, and academia
	producing real world projects		
Behavior	Students exhibit increased competency and understanding of building environmental performance Students view construction or academia as a viable career path	1. Platform's resource needs are met in a timely fashion 2. Yearly projects are secured	Resources are concentrated on community problems more consistently and with greater accuracy than otherwise found using traditional methods in each stakeholder's sector

Ideally, our education platform will:

- Create a pathway from K-12 education into local building industry jobs that support environmental justice for underrepresented communities
- Enable students from a variety of backgrounds to enter the AEC industries
- Support public schools' vision of a student body prepared for college and careers in architecture, construction, research, and academia
- Create connections among the participating AEC and building industry, community, and education stakeholders that increase environmental justice

The primary purpose of the proposed education platform is to provide students from underserved schools and/or communities with the skills and connections needed to succeed in the building industry, to improve their environmental justice, and to improve the environmental performance of the buildings they use.

Education Platform Development Status and Conclusion

Limiting the resources for shop classes limits students' access to the construction industry. This affects more than vocational students, potential engineering students lose a project-based environment to learn the mechanisms of engineering. Our education platform will be a means of reviving this through building EES projects. Furthermore, a technological vocational program is a community resource where students learn the mechanics of engineering, vocational job skills, and if given the opportunity, the exploration of environmental justice topics. Our education platform will enable vocational students to obtain the technical skills to work with the technology rapidly entering the construction field as well as provide them with the skills to continue their education if desired.

Through communications with the different organizations involved in our education platform, we partnered with a school district in California's Santa Clara County and related community, education, and industry organizations. This community has a historically under-represented population that has struggled to enter the college-career pipeline and construction management field (SJSU 2016). The planned deployment of our project begins with high school classes on building energy modeling and energy efficient building design. This is our envisioned

first step towards instituting a construction career and academic study pathway for these underrepresented youth. To-date we have outlined the EES curriculum and are creating course modules in partnership with the K-12 and EES contractor stakeholders. Additionally, we are developing teacher training modules since PBL is new to many of the teachers with whom we are working. We have given guest lectures at a partnered high school, we did observational site visits at one of the partnered middle schools, and students from this middle school participated in EES seminars at Stanford University. Building from these efforts we are developing a pilot high school class. Based on the success of the pilot high school class we will expand into the integrated education model by incorporating other educational institutions. We project it will take three years to begin including additional education institutions and implement the virtual classroom presence needed to tie these institutions together into a single class.

We have worked closely with the administrators of a historically underserved school district. The members of this community have struggled with cultural loss, forced cultural assimilation, and/or being a first generation university student when pursuing college and industry career pathways. One goal of our education program is to increase the representation of underrepresented individuals in academia and industry. We see a pipeline growing for students who want to move from training centers and community colleges and into the university system. Through teaching building energy efficiency and sustainability, our education platform will engender environmental justice by providing school facilities that are energy efficient and sustainably designed.

Acknowledgement

We thank Dr. Renate Fruchter for her guidance, encouragement, and involvement. Her Project Based Learning Lab for global students is the basis for the virtual classroom component and is inspiration for the collaboration focus of our proposed platform. We are thankful to the Santa Clara County Construction Careers Association (S4CA) and in particular to the support and encouragement from both Brenda Childress and Dr. Ingrid Thompson. The Alum Rock School District has been pivotal in providing us support and mentoring, we are thankful to Dolores Marquez for her constant encouragement and for her focus on the students. We are thankful to OpTerra Construction for their collaboration and participation during the development of this research. Our collaboration with the Santa Clara education community has been supported by several graduate students within our program, specifically we thank Anthony Kinslow II.

References

Benavot, A. 1983. “The Rise and Decline of Vocational Education,” American Sociological Association Sociology of Education, Vol. 56, No. 2, pp. 63-76. http://www.jstor.org/stable/2112655

Career Technical Education Leadership and Instructional Support Office, California Department of Education. 2014. “CalPADS Enrollment Trends in Career Technical Education in California: 1992 – Present.” https://assets.documentcloud.org/documents/1009332/cte-enrollment-trends-2012-13-1.pdf

Clinton B.C., and Levitt, R.E. 1980. “Union and Open Shop Construction: Compensation, Work Practices, and Labor Markets,” Lexington Books, D. C. Heath and Co., Lexington, MA.

Drehobl, A. and Ross, L. 2016. “Lifting the High Energy Burden in America’s Largest Cities: How Energy Efficiency Can Improve Low Income and Underserved Communities” ACEEE. http://aceee.org/sites/default/files/publications/researchreports/u1602.pdf

Fischer, M. 2006. “Formalizing Construction Knowledge for Concurrent Performance-Based Design.” Intelligent Computing in Engineering and Architecture. p186-205.

Frey, S. 2014. “New report fuels fears of decline of regional occupational programs,” Ed Source, Accessed 5/7/3016. http://edsource.org/2014/new-report-fuels-fears-of-decline-of-regional-occupational-programs/56617

Fruchter, R. 2004. Global teamwork: cross-disciplinary, collaborative, geographically distributed e-learning environment. Collaborative design and learning: competence building for innovation. Quorum Books/Greenwood Publishing Group, Inc., New York, pp.265-297.

Kam, C., Senaratna, D., Xiao, Y. and McKinney, B. 2013. “The VDC Scorecard: Evaluation of AEC Projects and Industry Trends” Stanford CIFE Technical Report. http://cife.stanford.edu/sites/default/files/WP136.pdf

Krieger, J and Higgins, D.L. 2002. “Housing and Health: Time Again for Public Health Action.” American Journal of Public Health. 92(5): 758–768. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1447157/pdf/0920758.pdf

Kunz, J. and Fischer, M. 2005. “Virtual Design and Construction: Themes, Case Studies and Implementation Suggestions” Stanford CIFE Working Paper #097. http://cife.stanford.edu/sites/default/files/WP097_0.pdf

Massey, R. 2004. “Environmental Justice, Income, Race, and Health” Global Development And Environment Institute, Tufts University. http://www.ase.tufts.edu/gdae/education_materials/modules/Environmental_Justice.pdf

SJSU. San Jose State University. 2016. College Readiness. Accessed on June 8, 2016. http://www.sjsu.edu/provost/academic_plan/college_readiness/

U.S. Department of Housing and Urban Development. 2011. “FY 2011 Budget.” Accessed on March 11, 2016. http://portal.hud.gov/hudportal/HUD?src=/fy2011budget/signature_initiatives/transforming_rental_assistance/faqs/energy_efficiency_faqs

U.S. Environmental Protection Agency (EPA). 2012. “Sources of Greenhouse Gas Emissions.” Accessed March 10, 2016. http://www3.epa.gov/climatechange/ghgemissions/sources/commercialresidential.html

Younger, M, Morrow-Almeida, H.R., Vindigni, S.M., and Dannenberg, A.L. 2008. “The Built Environment, Climate Change, and Health: Opportunities for Co-Benefits.” American Journal of Preventive Medicine. 35(5): 517–526.