



## Civic Engagement as a Component of Engineering Education

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## **Civic Engagement as a component of engineering education.**

### **Abstract**

Engineers in practice are required to insure their designs meet a variety of civic codes and standards. Often the engineer is required to educate their client on the prevailing codes that affect the project and guide them through the implications of said regulations. Typical course design projects rarely require students to meet with a client, help the client define their actual need, develop a problem statement or determine what codes apply to their given situation.

At Santa Clara University, all students are required to have a civic engagement experience. This is defined as the ability to work with the community, to develop a realization of their vocation, and to develop an understanding of the civic bodies who oversee projects that impact the public. To provide engineering students with a relevant engineering experience and meet the university's civic engagement requirement, the "Engineering Projects for the Community" course was developed and has been taught for the past twelve quarters.

This paper highlights a variety of projects for community clients. The course required students to determine what civic requirements applied to their project and to provide guidance to their clients as they worked with the client from problem definition to project deliverable phases. The civic requirements can have a significant impact on design decisions and project costs. Projects range a wide variety of engineering majors including civil, mechanical, electrical, bio and computer. Through the use of student reflections, this paper attempts to identify the influence of working with civic regulatory bodies on student learning and student perception of their chosen career path. As one group noted, the regulations impacting their project resulted in unforeseen costs but the entities who established these regulations were both purposeful and necessary to protect the environment.

### **Introduction**

Santa Clara University is committed to providing educational opportunities aimed to instill the knowledge, habits of thought and action, and orientation to society that the university believes will best prepare students for life. Towards this goal, the university has a new core education experience<sup>1</sup> that includes requirements in "civic engagement," as well as other more traditional areas. The book *Civic Engagement and Higher Education* defines civic engagement as "working to make a difference in the civic life of our communities and developing the combination of knowledge, skills, values and motivation to make that difference. It means promoting the quality of life in a community, through both political and non-political processes."<sup>2</sup>

At Santa Clara University, the civic engagement requirement specifically intends to develop students' capacities for and commitment to addressing major contemporary social issues raised by scientific and technological advances. This core requirement should also expand students' understanding of the skills needed to effectively participate in contemporary life, including investigation, critical thinking, communication, and collaboration. As such, the university requires that assignments be aligned with the following learning objectives. Students will be able to:

- critically evaluate and express reasoned opinions about the role of public organizations (governmental, non-governmental, multilateral, or international) in civic life through both oral and written work, and
- analyze and evaluate civic issues by engaging in active and collaborative learning with peers and others through one or more of the following: working cooperatively with other students in class, observing and participating in the contemporary ramifications of various types of civic life or civic discourse, or working with civic organizations beyond the walls of the University.

At most universities, the path to meet the civic engagement requirement is often found in service-learning or community service programs organized in the social science or humanities departments. However, as a profession, engineering has incredible potential to promote and improve the quality of life for both individuals and communities. Further, engineering projects are required to meet codes, standards, and regulations set forth by governing bodies. As such, this paper presents a course that was developed to allow students to meet the university's civic engagement requirement, focusing specifically on working with civic organizations and the applicable codes and regulations these organizations impose when developing a relevant engineering project.

## **Engineering Projects for the Community**

### ***Course Description***

In order to meet Santa Clara University's core requirements as well as promote the integration of engineering concepts into service learning projects the course "Engineering Projects for the Community" (ENGR 110) was established in the School of Engineering. Community-based projects are distinguished through an interaction, motivation, and/or impact that involve a community beyond the university. This course, which is available for all students and can be taken multiple times, includes service and civic learning experiences for each of the engineering disciplines; provides interdisciplinary projects of the students' choice; and includes structured reflection as a key course component. A full description of the course, assignment prompts, community partner relationships and typical enrollments can be found in a previous ASEE conference paper<sup>3</sup> and in a special edition of the International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship.<sup>4</sup>

During the ENGR 110 course, students visit several community partners at their sites to understand the operation and needs of each agency. Students self-select into teams that are typically interdisciplinary in order to complete a service project. The interdisciplinary undergraduate student teams design, test, and deploy functional systems to solve engineering-based problems for the benefit of the communities and agencies that serve them. The projects are in fields such as environmental engineering, nature and habitat conservation, health and medical technologies, assistive and rehabilitative technology, web-based services for non-profits, infrastructure development for social programs and educational models.

As part of the course instruction, the basic components of the design process are reviewed and students are required to write the problem statement for their project, identify the project constraints, brainstorm solutions and list possible criteria for judging the initial ideas. This step necessitates students develop their understanding of the project. As it is possible that their understanding is not fully in-line with their client's needs, this assignment is followed by a mandatory client meeting where questions are clarified and the client can comment on the project's development.

Course activities include regular student meetings with faculty advisors and their community partner to elicit specifications for the need, feedback on design choices, and coordination for final deployment of the end-product. The students hold regular design reviews to ensure that the quality of the end result meets the standards of the School of Engineering and the satisfaction of the community partner. By the end of the class, each team completes a comprehensive conceptual design based on creative problem-solving and preliminary impact analysis. Deliverables vary based on the project but should include complete design specifics, development of a significant portion of the hardware/software for the project, and a demonstration of the design along with a design report. A final design review, which is presented to the class, the clients, and invited faculty, occurs during the course's final exam period. The design review presentations must include all regulations that affected the project design. This insures the students are exposed to the wide variety of codes that influence the different projects.

Critical thinking and reflection are important components of the course and the students write narratives that describe their thinking, their observations and experiences, and the connections they make to what they've learned in this course and in prior courses. We ask that their reflections describe their thought process, the factors that were considered, their reasoning, and how they arrived at decisions. In ENGR 110, they write four narrative reflections. In the first reflection, they report back on the community partner and their mission.<sup>3,4</sup> For the second reflection, students are asked to address what civic requirements apply to their project and identify the regulatory bodies that oversee guidelines and rules in the field of their project. In the third reflection, they reflect on the project's impact with respect to factors related to science, technology, and society. The fourth and final reflection asks them to comment on their learning gains from the course and project work done.<sup>3,4</sup>

### ***Project Descriptions***

The "Engineering Projects for the Community" course has partnered with various groups in our community including an outdoor/environmental education school, an adult education center, and a nature conservancy. By working with multiple community partners, who each have different working missions and resulting needs, a wide variety of projects are available to the course students. Descriptions of a few of the partners and example projects for these clients are detailed below.

The Guadalupe River Park Conservancy (GRPC) is a non-profit committed to outdoor awareness and education. The mission of the GRPC is to provide community leadership for the development and active use of the Guadalupe River Park & Gardens through education,

advocacy and stewardship.<sup>5</sup> The GRPC hosts various school groups on field trips. One particular activity of special interest to the ENGR 110 students is an ecology workshop held on the Guadalupe River banks. The ecology workshop involves visitors accessing the river's edge in multiple locations. However, due to steep embankments, approaching the river is challenging and has resulted in several ENGR 110 projects to facilitate this educational program.

The first project with the GRPC focused on improving access to the river at a site where the river's bank had been reinforced with gabions in a tiered system with three levels. The gabions, which are large wire cage "boxes" filled with rocks, are shown in Figure 1. The height of the gabion tiers was difficult for small children to climb up and down and required adults to physically lift children between the tiers to protect them from falling. The GRPC required a solution that would allow children to safely and quickly navigate the tiers.

A team with one mechanical engineering senior and two electrical engineering freshman chose to work on this project. During initial client interviews, the team discovered that the GRPC did not have property rights to the area. Further investigation revealed that a permanent installation would require permits from San Jose's Public Works Department.<sup>6</sup> The budget and time restrictions of developing a permitted, permanent solution led the team to establish the design constraints that the solution needs to be portable, lightweight, easily storable, safe and easy to use.

The final solution consisted of a single assembly for each gabion tier that includes a foldable ladder, drainable ballast tanks, and a wooden chassis. The ladder is the means by which the children will be able to climb up and down the gabions. The use of a folding ladder addresses the need for the assembly to be portable and easily stored. The two ballast tanks per ladder provide lateral stability during operation to enhance safety. The tanks, which were made from five gallon buckets, feature a drain valve to facilitate emptying the ballast after use. Finally, the assembly is attached to a wooden chassis that provides the mounting platform for students at the top of the ladder and a level surface for both the top and bottom ladder supports.



Figure 1: Design solution for Guadalupe River Park Conservancy river access at the location of tiered gabions.

At another entry point to the river used by the ecology workshop, the access is very steep (at a slope of 25% based on ENGR 110 student surveying calculations). The steep slope is prohibitive for field trip students who have physical limitations restricting their access to the river bank and

resulting in their watching the rest of the students from the walkway near the river. The task of developing a portable solution, including initial working drawings, resulted in another ENGR 110 project with the GPRC. As with the previous GRPC project, the solution could not be a permanent installation and required consideration of transportability and storage.

A team with one civil engineering senior and two civil engineering juniors accepted the challenge of designing a safe, portable ramp that abides by American Disability Association (ADA) requirements<sup>7</sup>, is transportable by two people, and provides access to the river for visitors with physical handicaps. Design constraints, developed by this team, included a maximum weight to facilitate portability, durability of any structural components due to exposure to the elements; ADA requirements for the ramp size, slope and ramp landing; and structural code requirements<sup>8</sup> for the loading on the ramp and design of ramp components. Although the student's academic preparation was only in the design of steel members, the prohibitive weight of steel resulted in the team designing the ramp out of aluminum. The ramp was designed per the 2009 International Building Code (IBC)<sup>8</sup> including the required gravity loadings.

A third project with the GRPC resulted due to complaints the GRPC had been receiving regarding a discontinuous section of the riverside trail on the river's east bank. The GRPC contact requested the students develop preliminary design alternatives for a trail connection and options for connecting the riverside trail to street level. These alternatives would be presented to the GRPC Board of Advisors. Two teams of mechanical and civil engineering upper division students worked on this project.

The teams anticipated their need to meet the local structural safety codes enforced by the City of San Jose, along with constraints for pedestrian safety including railing requirements and lane widths; but they quickly learned there were a number of constraints on the project that were outside the scope of anything they had learned in the traditional classroom setting. Both the California Fish and Wildlife Department (CFWD) and the Environmental Protection Agency require that the riparian habitat along the river's banks be undisturbed during construction or restored to its original state with seedlings derived from the local species; a costly alternative. Both teams then considered elevated paths that would have vertical supports in the river bank. However, the CFWD and the Santa Clara Water District both enforce the *Streambed Alteration Act*<sup>9</sup> that requires the designs have no appreciable impact on the river's flow and limited them from having any trail supports in the river. Finally, both teams were unfamiliar with the guidelines of the American Disability Association (ADA) including maximum ramp slopes and minimum turning radius at trail switchbacks.

Two of the proposed designs are shown in Figures 2a – 2d. The left, or west, bank in the river cross-sections drawn in Figures 2a and 2c show an existing west-side trail protected from erosion by gabions. The right, or east, sides of these figures show the cross-section of the team's two proposed solutions for connecting the discontinuous east-side trail sections. Figures 2b and 2d show the corresponding plan view and path of the trails. The solution in Figures 2a and 2b recommends placing concrete piles, with cantilevered horizontal supports to pick of the trail deck system at set intervals along the embankment. Figure 2b indicates the possible location of the piles and horizontal cantilevers. The team's second alternative, shown in Figures 2c and 2d,

recommends spanning the approximate one-quarter mile trail section with an elevated trail supported on four abutments.

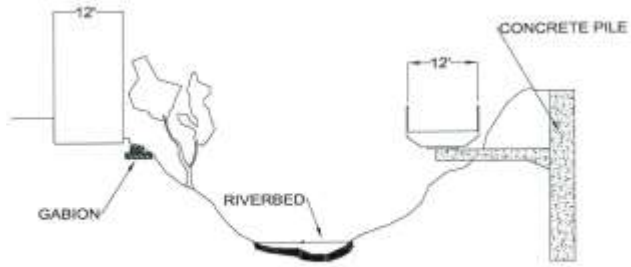


Figure 2(a): River bed cross-section with proposed design solution for the Guadalupe River Park Conservancy trail connector. Solution consists of concrete piles with cantilevered horizontal supports to carry an elevated trail.

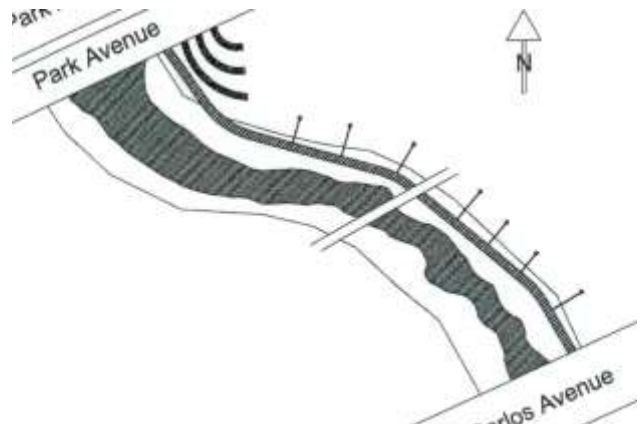


Figure 2(b): Plan view of the proposed design solution for the Guadalupe River Park Conservancy trail connector. Solution consists of concrete piles with cantilevered horizontal supports to carry an elevated trail.

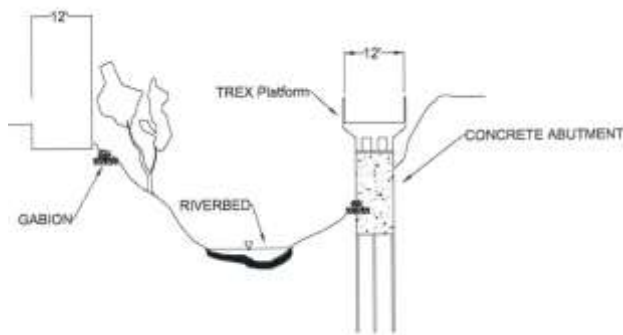


Figure 2(c): River bed cross-section with proposed design solution for the Guadalupe River Park Conservancy trail connector. Solution consists of four concrete abutments to support three spans of an elevated trail.

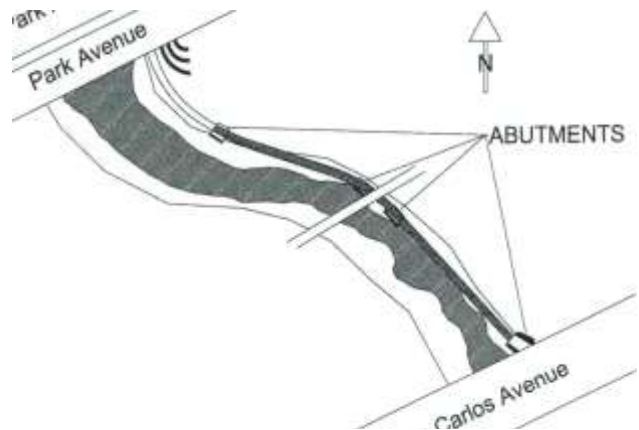


Figure 2(d): Plan view of the proposed design solution for the Guadalupe River Park Conservancy trail connector. Solution consists of four concrete abutments to support three spans of an elevated trail.

In addition to the GRPC, the ENGR 110 course has worked closely with Walden West<sup>10</sup>, a local outdoor school and science camp located in Saratoga, California and operated by the Santa Clara County Office of Education. This center provides hands-on and outdoor experiences for 5th and 6th graders with a mission to immerse them in the world of science and to inspire environmental stewardship. Walden West requires sustainable and eco-friendly systems to meet the operational needs of the school. All engineering systems designed for this community partner need to be cost effective with minimal maintenance. As equally important is the project's environmental

impact, which must be considered in all decisions during the design process. A recent Walden West project to save a dying pond provided a unique opportunity for the students.

Walden West is nestled in the Santa Cruz Mountains and abuts the Sanborn County Park. A pond located on the boundary of the two properties is dying due to stratification, as shown in Figure 3, and an aeration project has been proposed to restore the pond. A team of one mechanical engineering senior and two juniors, both bioengineering, took on this project.



Figure 3: Dying pond on the border of the Walden West school and Sanborn County Park . Picture shows the pond's surface covered in Lemnoideae.

As the pond falls under the jurisdiction of the Santa Clara County Parks and Recreation District (SCCPRD), the aeration system must be designed so it cannot cause any significant damage to the surrounding plants and

wildlife. The team obtained research results that stated that dissolved oxygen concentrations of three parts per million (ppm) will “stress” wildlife that are accustomed to warm water and concentrations below two ppm will kill native wildlife.<sup>11</sup> The students tested the water, surveyed the pond and settled on designing a diffused aeration system to reverse the eutrophication of the pond.

The three main components of the aeration system were an air compressor, special weighted tubing to deliver the air and an air diffuser that disperses the air as bubbles. The students calculated aerating an 894,000 gallon pond would need an air compressor that requires 250 watts of power. The SCCPRD also abides by the National Park Service ordinance 36 CFR Section 2.12 Audio Disturbance that states: “Under this section the following is prohibited: Operating motorized equipment or machinery that exceeds a noise level of 60 decibels measured on the A-weighted scale at 50 feet or, if below that level, nevertheless, makes noise that is unreasonable.”<sup>12</sup> The students’ discovery of this ordinance required them to alter their design and chose an aeration system whose compressor noise measured only 30 decibels at 50 feet. The design also included a sound-insulating, storage housing to ensure that the noise ordinance would not be violated. The increased cost of the quieter compressor and storage housing was unexpected and resulted in the students closely reviewing their design to look for ways to cut costs in other areas. Sound ordinances were not the only regulations that applied to this project and the students determined that the district requires an in-depth permitting process that insures the project meets restrictions set forth by the Wildlife Conservation Board, the California Resource Council and the California Environmental Quality Act<sup>13</sup> plus any requirements of the District and the CFWD. As part of their project, the students included all the required forms and permit applications for the client.



The previously described projects all had obvious governing bodies, with a few surprises, and clear ties to civic engagement. This is not always the case for ENGR 110 projects as some clients' needs do not fall under infrastructure or land restoration. However, any product that will be used by the public must meet a set of standards. The following project designed for Santa Clara Adult Education has been included to highlight projects that have less apparent regulatory organizations but still must meet minimum standards to protect the public or ensure access.

The mission for Santa Clara Adult Education is to “empower adults of all ages and abilities to succeed in an ever-changing world”.<sup>14</sup> Specifically, the independence network at the center works with adults with disabilities to teach them skills to function in day-to-day life. Many people with physical disabilities lack the motor skills to use a multifunctional mouse that is the standard interface for most software.

A recent hardware project developed devices that provided alternative means for generating mouse-clicks. Students at the center with motor-control issues that allow them to squeeze but not effectively click a mouse were using custom made “squeeze clickers” that had a phone plug output. The center's new software only accepted left mouse clicks from a USB mouse as input. A student team designed and built the adapter box shown in Figure 4 to accept the phone jack as an input and then output USB left mouse click data to a computer. The design needed to be affordable, simple, and yet rugged to stand up to tough use by the Adult Education students. The team researched regulations needed for such devices and found that besides the ADA, the device had to meet the Guidelines of the U.S. Consumer Product Safety Commission<sup>15</sup> due to the electrical wiring.



Figure 4: Adapter switch for computer mouse for Santa Clara Adult Education.

ENGR 110 students have also developed computer and mobile device applications for Santa Clara Adult Education and websites for Walden West and other community partners. Some of the organizations that enforce website regulations and provide standards are the World Wide Web Consortium (W3C)<sup>16</sup> and the Internet Engineering Task Force (IETF)<sup>17</sup>. The standards issued by these organizations directly or indirectly affect the makings of a website and can be split into categories of interoperability, accessibility, and usability of web pages. The ADA has developed clear guidelines for providing access to websites, computer programs and applications for the visually and hearing impaired. Student research into the ADA regulations for accessibility identified that ADA compliant websites require: an ability to navigate the website with just the

keyboard; videos have captions for the hearing impaired; reasonable color contrast and text sizes; and the website does not rely on the ability to distinguish color for readability. Additionally, software that stores personal data must meet a minimum standard of safety as defined by the ISO/IEC 27002 *Information technology – Security Techniques – Code of practice for the information security management*, as published by the International Organization for Standards.<sup>18</sup>

### ***Student Reflections***

The experience for undergraduate students to work on a project where they determine and define the constraints based on regulations and client demands is important to their growth as engineers. To help students recognize the value of the experience, they are required to write reflections on Community Partnerships, Civic Engagement, Societal and Ethical Impact, and Overall Learning Gains in reference to their projects. Students are provided a short description on what reflections should contain and what the focus should be. For the reflection on civic engagement students were asked to critically evaluate, and express reasoned opinions about the role of public organizations (governmental, non-governmental, multilateral, or international) in civic life as related to their project. The students were prompted to detail public policies or regulations they had to follow for their project and identify relevant regulatory agencies and/or professional societies that help enforce them.

The following section details reflections from students on how their projects related to civic bodies and what they learned overall about their professions.

On the ladder to access the Guadalupe River, a student reflects:

*“However since our system will not be a permanent installation it will not be regulated by building code. If we had gone the permanent route, we would have had to deal with the GRPC, gotten city building permits and inspections done....The lack of inspections and formal oversight does put the responsibility of ensuring the system works effectively and safely on us.”*

A student on the GRPC Ramp project:

*“... In order to place our safe foundations, we will need to obtain permits from the City of San Jose. ... Another key decision was the decision to use the much lighter weight but also more expensive aluminium columns, platform and ramp because portability of the system was determined to be more important than cost. If steel components had been utilized, they would have been much cheaper but also eight times heavier.”*

Reflecting on the environmental implications of the trail connector for GRPC, a student mentioned that:

*“A policy that plays a direct role in directing where our project direction goes is the protection of the riparian habitat. With the restriction of not harming the surrounding wildlife in the affected area, it makes it difficult to design anything that can use the bank of the river as support for a cantilevered bridge. If we were to implement a cantilevered bridge by putting supports into the bank, the roots of trees that have been growing there may be harmed and ultimately cause the trees to fall down, harming the surrounding wildlife, which we want to avoid at all costs.”*

On the Walden West pond aeration, a student commented:

*“In order to proceed with our project, our team must also follow and understand the rules and regulations of the California Environmental Quality Act (CEQA). According to the rules specified by the CEQA, we are a private agency undertaking an activity defined as a ‘project’ (which may cause either a direct physical change in the environment or a reasonably foreseeable indirect change in the environment). Therefore it is necessary to gain discretionary approval from a government agency. Detailed projections of the oxygenator systems impact on its surrounding environment must be documented in order to gain approval and support before construction begins.... However a project may not be approved as submitted if feasible alternatives or mitigation measures are able to substantially lessen the environmental impacts on the project.”*

Another student said:

*“I have contacted Sabine Sanders from the parks department to ask her about the regulations with altering the pond. She sent me some permits and documentation needed and also told me that the department of fish and wildlife would also have some permits that would be required for the project. This restoration also needs abide by the all of the provisions of The Public Park Preservation Act of 1971.”*

A student working on an electrical interface stated:

*“The consumer product safety commission lists the possible dangers of the device as electric shock, burn and mechanical hazards such as sharp edges and points..... The CPSC’s electrical regulations state that all electrical components must be enclosed.....”*

A student working on website development mentioned that:

*“It is important to realize that these standards are actually recommendations that are not strictly policed. However, there are general guidelines to website creation that are beneficial for the user and other developers.”*

Regardless of the project type, the course students all found that their project was required to meet or follow a minimum set of codes or guidelines. Their reflections clearly indicate the students were able to identify the role that the public or public organizations had in their projects. The student reflection on the Walden West pond aeration project succinctly sums up how regulations can affect the design process when he said:

*“Our comprehension of all the material covered in the CEQA is also pivotal to the design, scheduling, and overall development of the oxygenator system.”*

Even though every student has found some civic regulation or guideline their project should meet, no student has indicated they found these requirements hindered their designs or diminished their interest in their chosen field. Their reflections indicated that this experience helped them apply their classroom knowledge to a practical problem allowing them to reinforce their learning. As one student reflected when working on the handicap ramp for the GRPC:

*“My partners and I will be great for this project because it is within our area of emphasis, civil engineering, and we have a passion for what the mission of this project is... This project also benefited how I view projects. Instead of just viewing it from a technical point of view, there are so many other aspects to consider. These include impact on the community, ethics, customer*

*restraints, and various city codes/ordinances. All these aspects must be considered for the project to be feasible and successful, as well as utilized to its full capacity.”*

A student working on the pond aeration project added:

*“This course actually greatly improved my engineering skills on a professional level. This was the first engineering project I have been given in which no firm guidelines were assigned, therefore expecting us to recall all of our previous engineering studies and apply them to our project needs. Our project involved pond aeration, a subject I had very little background knowledge on, so I gained great experience in researching aeration concepts as well as applying my background knowledge in fluid transport. Working for an actual client rather than being given a hypothetical situation also gave great experience in what it was actually like to be a consulting engineer and cater to the needs of someone else. Client interaction reinforced the importance of being professional and following through on benchmark completion.”*

### **Conclusions**

During the twelve quarters this course has been taught, it has become apparent that civil engineering students are typically well aware of the regulatory constraints in design, while other majors are not as aware of them. The ENGR 110 projects provide an opportunity for all students to gain this awareness. To insure students pay proper attention to any required codes and to structure the course to meet the university’s civic engagement requirement, which it has for the past two years, students complete the reflection assignments described earlier and are required to include descriptions of their civic interactions in their final report and design review presentation. However, the submitted student work, with regards to civic engagement, shows a large discrepancy in the detail given to this topic. This may be due to initial lack of knowledge that codes and regulations exist or because a particular project has less obvious regulations.

To address this discrepancy, the instructor plans to add more references and readings that will increase student awareness of the regulatory agencies that govern civic life. In addition, the preliminary and final design review presentations provide opportunities for discussion and reflection on why some projects may have more code restrictions, whether the student believes these codes and regulations are necessary or useful, and why they are established at all.

This course and the community projects the students complete may be their first real experience in the overall positive effect that engineers can have on the community. For many it is also their first exposure to the rules and regulations engineers must follow to insure their projects do no harm. But no one said engineering would be easy and the codes simply add another layer of complexity as realized by an ENGR 110 student:

*“....the civic issues we are dealing with right now in our project, it makes this project harder, but it is also a nice challenge.”*

### **BIBLIOGRAPHY**

1. “Santa Clara University 2014-15 Core Curriculum Guide”,  
<http://www.scu.edu/provost/ugst/core/upload/Core-Guide-December-2014.pdf>.
2. Ehrlich, T. (Ed.) (2000), *Civic Responsibility and Higher Education*, pg vi, Oryx Press.
3. Krishnan, Shoba and T. L. Nilsson, “Engineering Service Learning: Case Study on preparing students for the global community”, 119<sup>th</sup> American Society of Engineering Education Conference, San Antonio, USA, June 2012

4. Davis, R., Krishnan, S., Nilsson, T., & Fylling Rimland, P., "IDEAS: Interdisciplinary Design Engineering and Service", *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, Special Issue: University Engineering Programs That Impact Communities: Critical Analyses and Reflection, January 2015, pp. 165-179
5. Guadalupe River Park Conservancy, <http://www.grpg.org/the-conservancy/mission>
6. City of San Jose's Public Works Department, <http://www.sanjoseca.gov/publicworks>
7. *2010 ADA Standards for Accessible Design*, Department of Justice, 2010, [http://www.ada.gov/2010ADASTandards\\_index.htm](http://www.ada.gov/2010ADASTandards_index.htm)
8. *2009 International Building Code*, International Conference of Building Officials, 2009, <https://law.resource.org/pub/us/code/ibr/icc.ibr.2009.pdf>
9. *Streambed Alteration Act*, California Department of Fish and Game, <http://www.dfg.ca.gov/habcon/1600/>
10. Walden West Science Center, <http://www.sccoe.k12.ca.us/waldenwest>
11. "Pond Turnover." *Aquaguide Missouri Department of Conservation*, 2004, [http://mdc.mo.gov/sites/default/files/resources/2010/05/4921\\_2870.pdf](http://mdc.mo.gov/sites/default/files/resources/2010/05/4921_2870.pdf)
12. *Soundscape Management Policy 4.9*, National Park Service, 2006, <http://www.nature.nps.gov/sound/policy.cfm>
13. *California Environmental Quality Act (CEQA) Statute and Guidelines*, State of California, 2012, [http://ceres.ca.gov/ceqa/docs/CEQA\\_Handbook\\_2012\\_wo\\_covers.pdf](http://ceres.ca.gov/ceqa/docs/CEQA_Handbook_2012_wo_covers.pdf)
14. Santa Clara Adult Education, [www.santaclaraadulted.org](http://www.santaclaraadulted.org)
15. *Electronic Code of Federal Regulations: Title 16 Commercial Practices*, Consumer Product Safety Commission, Vol 2, [http://www.ecfr.gov/cgi-bin/text-idx?SID=55685c812924258d8b1e7c91edf76f22&c=ecfr&tpl=/ecfrbrowse/Title16/16cfrv2\\_02.tpl](http://www.ecfr.gov/cgi-bin/text-idx?SID=55685c812924258d8b1e7c91edf76f22&c=ecfr&tpl=/ecfrbrowse/Title16/16cfrv2_02.tpl)
16. Craig, J. Editor, Cooper, M. Editor, *Accessible Rich Internet Applications (WAI-ARIA) 1.0*, World Wide Web Consortium, 2014, <http://www.w3.org/>
17. The Internet Engineering Task Force (IETF), <http://www.ietf.org/>
18. *Information technology – Security Techniques – Information security management systems – Requirements, ISO/IEC20071*, Joint Technical Committee ISO/IEC JTC 1 & Subcommittee SC 27, 2013