It's Simply Different There! Studying Abroad to Advance Engineering Problem Solving while Cultivating Engineering Leadership

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The University of Dayton

School of Engineering

Dayton, Ohio

Introduction

The University of Dayton (UD) has increasingly embraced the importance of providing global learning and cultivating an appreciation of cultural diversity in its undergraduates. Since 2006, UD's School of Engineering has responded to this commitment by sponsoring a month-long, summer study abroad program in Italy, with the first iteration taking place in Ancona, and the next four in Florence. This program focuses on engineering problem solving and leadership development in an international cultural context. The program has four interrelated objectives: (1) to develop skills in observation, data collection, and analysis, (2) to apply engineering problem solving techniques to real life situations, (3) to cultivate an understanding of how a specific culture addresses technical challenges, and (4) to investigate how different models of leadership improve team building and design solutions in an international environment. These objectives are pursued through faculty-mentored, team-based assignments that focus on identified opportunities or challenges posed by the contemporary urban environment in Italy. Student teams define and refine a given problem over the entire span of the program while applying basic problem solving approaches to produce a solution. Interaction among the teams is encouraged and closely mentored and monitored by a faculty team typically composed of two engineering professors and a professor of art history. Each team makes a formal presentation in a symposium at the end of the program.

UD's engineering program in Italy has engaged with the larger global phenomenon of urbanization. More than half of the world's population now lives in urban or densely populated locations. By 2025, it is expected that more than 60% will do so.[1] The advantages of such densely populated areas include easy and rapid exchange of ideas, access to the means of economic development, and the availability of jobs. In addition, availability of medical care, education and other social services characterizes urban environments. On the other hand, dense, urban populations occupy less than 2% of the world's land mass while consuming more than 75% of the world's resources. Cities are constantly at risk of being unable to provide sufficient food, water, and other resources necessary to support their growing populations.[2] The effective management of the urban infrastructure that supports large cities requires personnel with highly refined technical and analytical skills as well as insight into leadership models that can guide and promote the changes required to implement sound resource management.

Five primary challenges to the urban environment are[3]:

- the demographic challenge of a dynamic, rapidly growing population;
- the socioeconomic challenge associated with the effects of social and economic inequalities of resource distribution;
- the technological challenge associated with the increased complexity associated with both existing and new infrastructure management systems;
- the environmental challenge associated with pollution and climate change;
- the financial challenge of gathering sufficient financial support to implement necessary infrastructure change.

In view of these challenges, the University of Dayton program addresses technical problems confronting cities like Florence that must preserve their pre-modern histories and monuments while providing a full array of modern services and amenities. The overarching challenge posed to students in the program is how urban planners answer the following questions:

(1) What is required to achieve optimum use of renewable and sustainable resources in what is both an historic and contemporary environment?"
(2) How can urban leaders drive progress while achieving an optimum use of renewable and sustainable resources?

In view of these questions, the UD program addresses technical problems confronting cities. Florence, Italy is large enough to qualify as an urban environment, but it is culturally distinct and small enough to afford students the opportunity to assimilate the impact of the challenges mentioned above within the duration of the program.

Program Structure

The UD program is organized into three segments: pre-departure preparation, onsite investigation and reporting, and debriefing once back in the United States at the home campus.

Pre-departure Preparation

Students meet in late winter in a classroom setting on the UD campus in a required orientation course. Over a seven-week period, students get to know each other as well as the program faculty who will be traveling and working with them in Italy. This course prepares students to take part in an integrated learning and living experience in Florence that is focused on the question of engineering leadership and problem solving in a global context. In addition to receiving orientation to the specific engineering goals of the program, students explore and clarify broad academic and personal expectations and goals prior to departure. Program faculty and staff from UD's Center for International Programs work with students towards:

- knowing their fellow students, and creating an integrated learning and living community;
- setting personal and collective goals that will be acted and reflected upon while abroad;
- researching and discussing aspects of Florence to be explored and studied as students of engineering;
- learning practical information about the program (housing, classroom logistics, packing, health and safety guidelines, cultural norms, and program policies and procedures while abroad);
- learning specific information related to class schedules and content;
- discussing how to integrate the study abroad experience into academic majors and career goals.

During this pre-departure course, students are required to view William Whyte's documentary, *The Social Life of Small Urban Spaces*[4], and read John Stilgoe's *Outside Lies Magic: Regaining History and Awareness in Everyday Places*[5]. These two works address the interrelated acts and skills of observation, documentation, and analysis, essential research tools that are at the core of the on-site engineering experience in Florence. Students also view and discuss Bill Moyers' documentary on Florence, *The Power of the Past*[6], in the interest of developing a broad understanding of the history and culture of the Italian site of their engineering explorations. In addition to these elements, faculty compare the engineering challenges that students will observe and study in Florence to similar challenges faced in the United States past and present. For example, in preparation for the 2016 program, students learned about the 1913 flood of the Great Miami River in Ohio and the engineering solutions and engineering leadership models that were developed in response to that disaster. This instruction took place in anticipation of teaching the students in Florence about how the city famously grappled with the disastrous flood of the Arno River in 1966.

The theme of leadership is interwoven throughout the program from the pre-departure course through the program on site. Each student is assigned a separate book-length study on the topic of leadership (with emphases well beyond the field of engineering), and individually they report on the respective approach of a given author on this topic. In addition to educating students about different approaches to leadership, the goal of this assignment is to encourage the groups once in Florence to adopt and experiment with these various approaches to leadership as they investigate key engineering challenges in the city.

In Florence, the students are organized into six groups of 5-6 students in each group. In developing these groups, the faculty take into consideration age of the students, technical experience, G.P.A., engineering discipline, and gender so as to assure a balance within and across the groups. In 2016 the program had 19 mechanical engineering students, 4 electrical and computer engineering students, and 9 chemical engineering students. The task therefore of balancing the engineering disciplines in the groups was important so as to provide a variety of engineering heuristics that would be brought to bear on the various projects. With the above student distribution composed of 22 men and 10 women, mixed groups had at least two women; two groups were comprised of five men only. The 12 upper class students were expected to mentor the younger, first and second year students.

In Florence Groups are tasked to develop and implement a group leadership structure for the purpose of team building and successful project development, research, and analysis.[7] Each group then establishes roles for its activities in the city. These roles are:

- a leader who organizes and directs the work of the group.
- a secretary (sometimes described as a scribe or recorder) who keeps the records of the group.
- a person whose job is to keep the group on task, often called a “sergeant-at-arms”.
- a “devil’s advocate” who performs the role of challenging the group’s assumptions and conclusions.
- a problem solver who works to arrive at both technical and interpersonal solutions.
- an outreach communicator who is tasked with being the liaison to the other groups.

On campus, before the program begins, students read Bruce Tuckman’s description of teambuilding [8] to aid in developing highly effective team dynamic upon their arrival in Florence.

Once in Florence, two peer reviews are performed to help students evaluate how effectively their groups are performing as cohesive research units

All groups are initially given the task of viewing Florence in light of six major elements of a city's infrastructure:

- water
- transportation
- waste management
- communications
- energy
- housing

Before departure, each team is required to submit a team response to the question, "What is meant by sustainable and renewable resources in an historic urban environment?" It has been found that even though sustainability per se is not typically the focus of the program or any individual group project, asking students to engage in this question conditions them effectively as individuals and groups for an elaborated engineering problem solving process in Florence where both resources and options for design solutions are notably limited.

Onsite: Initial Week

Upon arrival in Florence, students are tasked to engage in an intensive "deep dive" familiarization with the city. They meet early, before the city develops its full daily rhythm, and then walk and explore the entirety of the city from morning until late into the evening. The faculty meet with the students at various points during the day and at night's end for debriefing. While exhausting, this experience provides an opportunity for students to learn the city quickly and for faculty to begin assessing students' skills and coming needs in researching the Florence site.

Figure 1: Florence, Baptistery of S. Giovanni: The program begins with an all-day site exploration.

After the "deep dive" city exploration and an additional four days of directed site investigation and orientation, each group is assigned one of the aforementioned infrastructure elements, and for the duration of the program that group is tasked with a problem-solving process[9] of:

- defining an engineering challenge related to that element,
- investigating that element by developing experiments,
- collecting data,
- drawing conclusions
- proposing a recommendation for improving that element of the city's infrastructure.

Group Project

The group project, and the exchange among group projects, is the core learning experience of the program. In the 2016 program, the six groups chose the following problems to address:

- improving waste collection during high tourist times.
- improving the drinkability of tap water.
- regulating traffic control and reduce pollution.
- modifying the building code of Florence to foster adequate housing while maintaining the Renaissance character of the city,
- providing sustainable energy resources while retaining the Renaissance character of the city
- designing a reliable, accessible, and sustainable public wi-fi system.

Focusing on one of the six infrastructure elements in the interest of defining a key engineering challenge faced by the city, each group applies the fundamentals of engineering problem solving[6] as it begins to make observations and gather data on a given problem. The subsequent steps of problem solving, i.e. generating, selecting, and evaluating solutions, are then applied and the results presented. As expected, the most challenging portion of this process is defining a specific problem from the more general elements of urban infrastructure. The exploration of these problems is always challenging and the recommendations are often and inevitably speculative, but exploration and establishing concludes are generally performed effectively, and through mentored engagement with faculty, the students steadily begin to demonstrate skills in practicing the field they have chosen to study. Moreover, each group is tasked to present to the faculty and to their peers a definition of the problem it has selected to investigate by the end of the first week. At midterm (after week 2), each group provides to the faculty and the other student groups a status report on its progress towards a solution. In the last week, each group (with all members participating) presents a multi-format (oral presentation accompanied by PowerPoint images and data) report to faculty and peers. This report is supplemented with a full written report and a two-page executive summary. Appendix B includes the executive summaries of the six projects and provide insight as to the depth and scope of the student efforts.

Figure 2: In Rome, discussing Roman engineering near the Vittorio Emanuele monument

Journal

Throughout the program, each student participates in maintain her or his group's research journal as well as maintaining a personal engineering journal, the purpose of which is to aid in developing an ability to:

- observe,
- question observations,
- form hypothesize about observations,
- develop "experiments' to test these hypotheses
- speculate about innovations and improvement to the city's engineering infrastructure.

The journal is distinct from a diary, though it is expected that students will keep a daily log of their research activities. Principally the journal is both a growing record and archive of sketches, diagrams, observations, and experiments in support of that student's contributions to a given group project. The journal is discussed and shared among peers and evaluated periodically by the faculty who look closely at the nature and quality of a student's observations, sketches, and engineering diagrams that have been produced in the course of both broad individual and group exploration of Florence and specific investigation of the given infrastructure element that that student and her/his group is addressing. Students and their groups are regularly encouraged to pose hypotheses about what they observe and even to generate finite, time-specific experiments to validate these hypotheses in aid of their group research.

Excursions in Italy for Comparative Purposes

In addition to focusing on Florence, the program visits sites important to the history of engineering past and present such as Vinci, the hometown of artist, inventor, and engineer Leonardo da Vinci, Pisa, the site of the famous Leaning Tower with its issues related to soil and structural engineering, Assisi, with its recent history of earthquake damage, and Rome, with its vast and influential history of engineering in the ancient world. These are not in any way standard tours of these famous destinations. Rather, at each location students are there as investigators and they are tasked to use their developing engineering expertise of on-site investigation and problem solving techniques to provide "back of the envelope" solutions to on-the-spot challenges posed by the locality being visited.

The first of these visits is to Pisa and Vinci. At Pisa, the students receive instruction on the ground and soil conditions upon which the campanile, that is the famous Leaning Tower, was constructed. The student groups are tasked to estimate the current angle of tipping, then they estimate how much tipping would result in catastrophe failure.

Figure 3: Assisi: How Earthquakes Damaged the Upper Church of S. Francesco

At Vinci, students are asked to observe the engineering drawings and machines of Leonardo da Vinci and to identify the important attributes of innovation that Leonardo demonstrated in the specific projects and across the entire breadth of his work. But all is not engineering, or at least in a conventional sense. So at Leonardo's birthplace, several kilometers outside of Vinci and in a stunning location surrounded by nature, students are encouraged to "hear" and "see" the environment in which young Leonardo grew by asking them to stand, first with eyes wide open and then with closed eyes, seeing closely and listening deeply to the sights and sounds of nature. All of the students are astounded by this experience and readily comment that it teaches them extraordinary powers of observation useful for their engineering work.

Another excursion includes two days in Rome, with a stop at Assisi on the return to Florence. In Rome, the students receive instruction on concrete engineering, and specifically its use in the design and construction of the Pantheon, one of the oldest, continuously-used domed structures in the world. For an engineering problem with some limiting approximations, the student groups are tasked to estimate the amount of concrete used in the building's construction. Finally, in

Assisi, the birthplace of St. Francis of Assisi, the students are introduced to engineering responses to earthquakes in view of the recent earthquakes that Assisi and this region of Italy are increasingly experiencing in the modern era.

Daily Structure

After the initial week, the groups begin work on their assigned projects, employing the engineering problem-solving process described above. The weekly structure includes meeting each day at 9:00 A.M. in a classroom setting for approximately 3 hours. During this time, groups develop a plan for the remainder of the working day and meet with faculty for guidance. Individual reviews of students' leadership books are also typically given during this time with general discussion about the various leadership models represented by the different authors and the ways in which these given leadership models can be applied to the students' work in Florence. Students then head out into the city to continue their investigations, and later faculty meet with students at dinner to recap the work performed by the students that day and prepare them for the next day.

Grading

All students are evaluated on the basis of the group work and their individual maintenance of an engineering journal. Each group presents a midterm progress report as well as a final symposium presentation. The midterm report is typically informal and is intended to aid the groups in focusing the problems that are being addressed, to assess progress being made, and to establish research plans for the remainder of the program. The final symposium provides each group an opportunity to present its problem and solution, to reflect on the different engineering leadership models experimented with and employed over the course of its research, and to offer recommendations for how the city of Florence might go forward in relation to that group's particular infrastructure element.

Each group presentation is multimedia in nature and is typically of an hour in duration, including 15-20 minutes for questions and discussion among the students and faculty. In this presentation, students define the problem they addressed, the evolution of the problem definition, and the process by which they arrived at a solution or recommendation. They specifically describe the implementation of individual steps in the problem solving process, including how observations led to the development of "experiments" to create and test their hypotheses. All group members are required to participate in the symposium presentations. After the symposium, each group then submits an Executive Summary of the group's findings and recommendations, a task designed to give students the experience of effectively summarizing and communicating their engineering work. In addition to receiving a group grade, students are assigned individual grades on their engineering journals and an evaluation of their overall participation and contribution to the program.

Figure 4: Fiesole (near Florence): Student groups deliver on-site progress reports at the Roman theater

Program Results

Results for the program are assessed objectively against the goals set forth above:

1) To develop skills in observation, data collection, and analysis

Individual student engineering journals are the primary source of evaluation of a student's ability to demonstrate this skill development. Each team also demonstrates a collective development of this skill development in the application of the engineering problem solving skills to a given project. Many students are uncomfortable initially with the task of maintaining a journal, as opposed to a diary, but they quickly adapt to the concept very effectively.

Late in the program, individual and team art contests are included to add additional variety and team-building dimensions to the living learning aspect of the program. Students are asked to draw the single most impressive sight they have seen throughout the program. Teams select the best drawing from their group to put forward as a team drawing. Individual drawings are judged by professors. An example is shown in Figure 5.

(2) To apply engineering problem solving techniques to real life situations

Across the board, students and their groups demonstrate growth in their proficiency to take very general topics and define specific problems that are within the scope of each group's ability to apply engineering problem solving. While the students learn these problem solving skills in their first year of engineering study on campus, the application of this skill set to ill-defined problems of broader scope at a site abroad greatly enhances the usefulness of the problem solving skill set.

Blending members from each engineering discipline in the program groups provides multiple and varied views of the challenges faced by each group when addressing its group project.

Balancing the opposing views enhances the value of the leadership (and team building) skills that are introduced to and practiced by the different program groups.

(3) To cultivate an understanding of how a specific culture addresses engineering challenges

Interaction with the Italian culture is a daily experience that requires students to secure information for their projects as well as adapt personally to different living requirements, e.g. grocery shopping, dining, transportation and entertainment. In a post program evaluation many students indicate that their interactions with host country nationals often leads to conscious thought about cultural differences that they directly applied to their projects.

(4) To investigate how different models of leadership improve team building and resulting design solutions in an international environment.

It is clear from the final project presentations, students give considerable thought not only to their respective projects, but also to the smooth operation of their groups. Additionally, peer reviews accentuate the importance of leadership within the group.

Recommendations for Future Study Abroad Programs

Some recommendations for improvement include:

- introducing more stand-alone problems, similar to those performed in Pisa, Vinci, Rome, and Assisi. This has proved to be a very good learning and team-building exercise and could be expanded upon throughout the program and especially in Florence.
- introducing a weekly rotation of leadership roles within each group and instigating a dedicated period of reflection and goal setting for the changing leadership in each group. Exploring leadership models in the program has proven a valuable asset to student learning that could be augmented with the direct application of this learning to the appointment of new student leaders periodically accompanied by dedicated reflection and setting of goals by each new set of group leaders.
- working to engage more formally local technical experts and officials responsible for the city's infrastructure as consultants to the program. To date this has been accomplished on a relatively adhoc basis, as in engaging an expert in Ancona to discuss landslide engineering or interviewing the manager of the waste water treatment plant in Florence.
- instituting some degree of Italian language training for the students both before and during the program. This would improve their engagement with the host country and aid in students' work with locals and consultants to the various team projects.

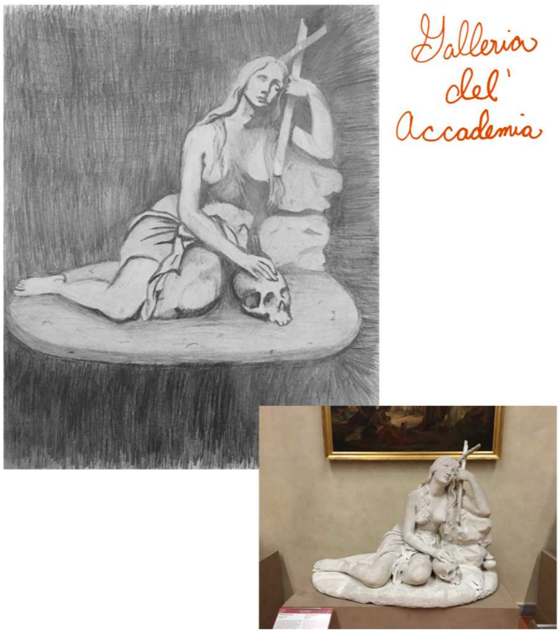

Figure 5: Florence: Statue of Mary Magdalene
as seen and drawn by an engineering student

Conclusions

In the post-program review, students respond to a question regarding the importance of this study abroad experience to them if asked about its relevance to their engineering education in a job interview. While responses vary, all are very positive and affirming of the value of the program.

Some students find the experience of comparing and contrasting cultures very informative, allowing them to identify what is good and what requires work in their own culture. This comparative reflection affords each student an opportunity to grow in cultural sensitivity, historical perspective, and in knowledge of different cultural approaches to engineering challenges.

Student responses include:

The opportunity to “travel and see classroom engineering principles in action was truly breathtaking,” and “I learned to apply multiple perspectives and bring unique solutions to (engineering) problems presented to me.”

Some students recognize that cultural differences can be stressful, requiring unique solutions. One student commented: “Above all, it taught me adaptability in new and uncomfortable situations.” Another: “Study abroad … is where you get outside your comfort zone…” and “it turns you into someone who isn’t afraid of the differences of culture, but cherishes them.”

Finally, this study abroad experience made for students, as one student expressed “a very fun and invigorating class that will prepare me to be an engineer in the modern world.”

Figure 5: Florence, Piazza S. Pancrazio: After a post-dinner recap of the day’s activity

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Appendix A: Leadership Titles for the study abroad program, 2016

1. *Good to Great*, by Jim Collins
2. *Leadership: The Challenge*, by James M. Kouzes & Barry Z. Posner
3. *The 48 Laws of Power*, by Robert Greene
4. *The 7 Habits of Highly Effective People*, by Stephen Covey
5. *Developing the Leaders Around You*, by John Maxwell
6. *How to Win Friends and Influence People*, by Dale Carnegie
7. *Leadership and Self Deception: Getting Out of the Box*, by Arbinger Institute
8. *Next Generation Leader: 5 Essentials for Those Who Will Shape the Future*, by Andy Stanley
9. *Listening Leader The Ten Golden Rules to Listen, Lead, and Succeed*, by Lyman K. Stiel & Richard K. Bommelje
10. *Sun Tsu the Art of Business*, by Mark McNeilly
11. *Empires of the Mind*, by Denis Waitley
12. *The 21 Irrefutable Laws of Leadership*, by John C. Maxwell
13. *Whale Done!*, by Blanchard, Lacinak, Tompkins, Ballard
14. *A Passion for Excellence*, by Tom Peters
15. *Leadership is an Art*, by Max De Pree
16. *The Servant Leader*, by Blanchard and Hodges
17. *Lincoln on Leadership*, by Donald T. Phillips
18. *The West Point Way of Leadership*, by Larry Donnithorne
19. *The Functions of the Executive*, by Chester Irving Bernard
20. *Leadership: Theory and Practice*, by Peter G. Northouse
21. *Primal Leadership: Learning to Lead with Emotional Intelligence*, by Goleman, Boyatzis, & McKee
22. *What Leaders Really Do*, by John Kotter
23. *The Leader's Companion: Insights on Leadership Through the Ages*, by J. Thomas Wren
24. *The Rules of Work*, by Richard Templar
25. *The Seven Signs of Ethical Collapse*, by Marianne Jennings
26. *Leaders: Strategies for Taking Charge*, by Warren G. Bennis, Burt Nanus
27. *First, Break All The Rules*, by Buckingham & Coffman
28. *Improving Performance*, by Rummler/Brache
29. *A Force for Change How Leadership Differs from Management*, by John Kotter
30. *The Ascent of a Leader: How Ordinary Relationships Develop Extraordinary Character and Influence*, by Thrall, McNicol, & McElrath
31. *True Leaders*, by Betty Price & George Ritcheske
32. *The Extraordinary Leader Turning Good Managers into Great Leaders*, by Zenger & Folkman
33. *Principle-Centered Leadership*, by Stephen R. Covey
34. *The Servant: A Simple Story About the True Essence of Leadership*, by James C. Hunter

Appendix B

Brown Team: Improve the drinkability of tap water

Tasked with improving the sustainability of water use in Florence, we immediately stepped out onto the cobblestone and headed whatever direction our observations would lead us. We were confused and concerned by the lack of fire hydrants in the streets, but found our answer hidden in the sides of buildings. We grew concerned that the street drains would be too small to drain a flood or torrential rain, but we knew too little about the city's relationship with flooding in the post-1966 era to go further by observation. We found ourselves fascinated by Florence's dependence on disposable water bottles, but we deemed it a cultural oddity rather than a pressing issue, and moved on with our city-wide investigation. Our initial impressions of the city left us with interesting questions, but none represented any pressing issues. Our next step was the city's history. Coming from another city molded by a catastrophic flood, we hoped to find our problem tucked away in the Arno. Unfortunately for our project (although fortunate for the Florentines), the construction of the Bilancino dam in 1984 had largely mitigated any threat of another flood.

Just a day into the program, our group was gifted with a tremendous problem quite literally spouting open before our eyes. When we took a detour from the British Institute that morning to see the carnage caused by the water main break, the team was quick to note that we were looking at something of massive significance to our project. This realization grew tenfold while researching the cause of the break as two vital pieces of information arose. First, many articles said things along the lines of, "yet another water main break in Florence," which lead us toward the city's ongoing piping issue. The second came in discussing the break with a geologist investigating the site. She mentioned that they had come to realize that the rupture was caused by decay in old pipes rather than any sort of seismic activity or irregular shifting of the Earth.

Curious about the state of pipes in Florence after repeated water main breaks, we pursued topic further at the British Institute, the Florence Public Library, and on the Internet. Although the first two helped largely in studying the past, online research led us Italy's National Statistics website, which housed quite a bit of information about the country's issues with drinking water. Most interestingly, we learned that 36.9% of Italy's drinking water (3.1 billion cubic meters) was lost in 2014. We also learned that Italy is globally the second highest consumer of plastic water bottles per capita. 12.4 billion water bottles are produced here, and only 33% of the polyethylene used is recycled. With this knowledge, we had our question: where is all the drinking water going, and why is no one drinking it once it arrives? The answer to the former question was quite easily found online; the lost water throughout Italy is largely due to the country's outdated piping systems. With a history of water usage that spans back over two millennia, the piping is now wildly inefficient and largely outdated. In order to resolve the second half of the question, we decided it was time to fully get into contact with the Florentine locals.

We drafted up a short survey consisting of three questions: Do you drink the tap water? Why or why not? If no, what could be done to make you drink it? We had expected a fair mix of yes and no when asking the first question, but we were told repeatedly that, "No, I don't drink the tap water, but I'm sure that most people do." At first, we just found this bit of information interesting, and then moved on. When the third consecutive person mentioned an assurance that others drank the water but admitted to not drinking from the tap herself, we knew there was something odd about the situation. We found this situation to be a bizarre extension of the bystander effect, where everyone is certain that others are taking the right steps towards environmental consciousness, but no one is actually performing these steps themselves.

Hearing interviewees explain why they refused to drink the water yielded some similarly interesting, and far more troubling, responses. We quickly learned that Florentines share a general fear of the harmful chemicals found in their pipes. Although they trust the water that is being pumped from the aqueducts, they have a serious mistrust for the outdated pipes bringing water into their homes. The common knowledge of an arsenic contamination in Rome's water and of the occasional asbestos concrete pipes in Florence has left many Florentines reliant on the inexpensive and undoubtedly harmless bottled water so readily available throughout the city.

With this knowledge in hand, the team set forth looking to solve the two-part issue. First, the city's pipes needed to be made safe and efficient. Second, public perception of tap water needed to be reworked into a more favorable light. The team scoured the libraries and the web for information, and the resulting solution came in two large parts: long-term and intermediate.

The long-term goal demands a complete overhaul of the city's piping system. The current pipes are simply far too inefficient and hazardous to remain as they are. Anything short of a full reworking would simply be a "band-aid solution" that ignores the true problem at hand. First, the city's pipes are to be explored by tiny robotic probes often used in piping. These will allow us to determine which pipes are repairable and which simply are not. From there, the repairable pipes will be lined with a sleeve like the ones made by Insituform, which will give the pipe additional years of life until we have handled the irreparable pipes. For these, we decided to utilize a method known as trenchless piping, where a pulley drags along a new pipe, which shatters the old pipe and leaves the new one in its place. Once all the unsafe pipes have been handled, the sleeved pipes can then be replaced as well, leaving the city with a fully functional set of new pipes. Both of these methods are heavily recommended for Florence as they are minimally intrusive; the city will remain functional and beautiful throughout the construction process.

While these processes are ongoing, we will work to improve Florence's cultural issues with water. First, we would expand the current fountain system by the local water company, Publiacqua. They currently have eight drinking fountains in the city, but we want to expand that program and bring free water into heavily foot-trafficked areas. We also want to bring two ideas into the city we saw during our travels. In Rome, we utilized kiosks where the user selected mineral or sparkling water of varying sizes. Given Florence's need for safe and free drinking water (and Italians' general love for the sparkling frizzante) these kiosks would be a welcome addition. A few team members spent a weekend in Lugano, Switzerland, where they saw a fascinating variation on traditional water fountains. The city's lakefront featured wonderful pieces of modern art, all of which incorporated drinkable water. We feel that this mix between art and daily life captures the essence of Florence, and would love to see the government commission a series of artistic fountains to be placed around the city. In order to cut into Florence's perception of water, we would distribute water testing kits to Florentine homes, in order to let people collect their own data and see first-hand how safe their drinking water now is. After ensuring that people in the city have access to safe water, we would institute a tax on plastic water bottles similar to that on cigarettes. From personal to environmental health, both are similarly unsustainable. By taxing water bottles, the team hopes to push Florentines toward the safe drinking water they now have readily available.

Our project hinges on the inherent morality of engineering. By imposing these measures, we will cut massively into Italy's thriving bottled water industry, and force many to accept change they might not immediately want. While it will be met with a strong push-back from these companies, we feel that engineering implies the leadership and conscience that steps in and pushes towards safety and sustainability, even at times when it is far from the easiest path.

Blue Team: Improve waste collection during high tourist times

Florence is faced with many infrastructural concerns pertaining to sustainability. One of these concerns involves the effectiveness and efficiency of waste handling within the city of Florence generated by both tourist and local populations. The waste generated consists of trash and sewage and depending on how both are handled could positively or negatively affect other forms of infrastructure within the city.

The effectiveness and efficiency of waste handling could be observed through the everyday activities of local residents, tourists, and members of the waste management company. Many key observations were made in order to build an understanding and formulate a problem definition. The observations made centered around themes of waste retrieval methods, times of trash collections and street cleaning, waste bin styles, required vehicles and personnel, as well as how the population interacted with the waste containment and retrieval processes. In addition to the observations made, additional research was done to answer questions which could not be answered through observations. Constructing a solid foundation of observations and research provided substantial information to determine which waste management aspects were affecting the results and construct a clear problem definition.

Through observations and research, it was found that Florence's waste containment and removal issues are caused by a fluctuating tourist population, environmental aspects, inconsistent styles of trash cans, and cultural variations which will be addressed using a consistent and universal process to build sustainability. The problem definition guided various outlooks, such as waste bin styles, the collection process, recycling, street cleaning, and sewage, which aimed towards improving Florence's waste management system to become more sustainable. Many ideas stemmed from these outlooks, but as the list grew it became apparent that not all the ideas could be evaluated. Through the combination and strengthening of ideas, three concepts were decided upon to be evaluated. Concept 1 was an underground waste bin, similar to the ones already used in Florence, which would increase the volume of waste containment in the tourist region of Florence while also altering the black waste bins to use as the above ground section, keeping consistent with the city's aesthetics. Concept 2 was an aesthetically pleasing polypropylene waste collection bin consisting of four compartments: organic, glass, plastic, and nonrecyclable, which would encourage the separation of waste and recycling within the tourist region of Florence. Concept 3 would make use of the current waste bins and place a sensor under the lid to monitor the amount of waste in each bin and communicate the information back to the waste management headquarters to map efficient routes for collection of full waste bins, avoiding bins with minimal waste.

The concepts were evaluated using design criteria and a numerical value system in a design matrix to fairly evaluate each concept based on the needs for a sustainable waste solution. The design criteria with the weight pertaining to their importance are: Impact on other team challenges (9), Aesthetics (8), Environmental impact (8), Durability (7), Cost (6), Universalizing/Consistency (5), Physical implementation (5), Communication of change (4), and Fluctuating population (3). Each concept was ranked individually on the design criteria using the

3-5-7-9 method of evaluation, with 9 being the highest, in order to spread out the results creating a clear cut decision of the best solution. Concept 3 scored a total of 380 points while Concept 1 and Concept 2 scored 350 and 300 points, respectively.
Concept 3 was given high scores in Aesthetics, Environmental Impact, Physical Implementation, Communication of Change, and Fluctuating population while only receiving a low score in Cost.

The highly durable sensors produced by Enevo weigh 1 pound with the dimensions of 3.7 inches in diameter and 2.4 inches thick. Three screws attach the sensor to the lid of the desired waste bin and can be installed quickly by any waste management employee. Powered by a lithium battery with a lifespan of 10 years, the sensor optically scans the waste bin and relays the information back to headquarters using 3G communication where workers can view an optimal route for pickup. The sensors cost $8-$25 per sensor depending on the amount purchased and will cost $10,000 for the 500 sensors needed to cover the most populated tourist areas and will be regained within a few years through the reduced collection costs (Manning). The cities and universities, Waterdam, The Netherlands and Duke University which have incorporated these sensors, are examples of the current and future benefits created through data collection and forecasting. The most important aspect of implementing the sensor is how it will benefit the other infrastructure concerns while building and efficient and sustainable waste management process. The sensor will create more efficient communication throughout the city for the waste management company by setting up a network to efficiently communicate information from the waste bins to headquarters then to the employees. This will decrease the amount of transportation on the streets resulting in a reduction of energy needed and emissions created thus building a more sustainable city. By creating more efficient routes, the waste bins will be picked up in a timely manner avoiding waste overflowing into the streets and multiple associated environmental concerns, including contamination of waterways.

In order to build a sustainable system, a beneficial solution needs to be paired with a successful implementation. The sensors will be installed during the end of October and early November, coinciding with the tourist offseason and warmer weather to reduce any increased population or cold weather issues. During this time, the tourist region of Florence will be broken into seven sectors where the installation will occur. First, a team of workers will physical install all the sensors in Sector 1 and upon completion move to Sector 2. As the physical installation is completed, a communication team will bring the sensors online. Breaking the tourist region into sectors will allow the implementation teams to address any issue on a smaller scale and prevent reoccurrence in future sectors. To implement this solution and address any issues that occur, there must be a leader involved with the right skills. This leader must be able to visualize the process and set goals which can be communicated to the team in order to implement the solution by the deadline of the next tourist season. Building synergy and flexibility within the entire team will help create a transparent environment allowing the teams to address any issues that arise. In order to solve these issues, the leader must be patient and understand what each team member's role is. An efficient process combined with the correct leader will allow for a successful implementation.

The process's success will be evaluated by comparing data, including energy usage and man hours required for collection, from before and after the implementation. The evaluation of applied work hours to the job can help to steer the waste management company what to do next with personnel decisions and where to move jobs to. Visual evaluation can also be used in order to see if the process is working by observing the waste bins for any signs of inefficient collection, including overflowing.

Moving forward, the knowledge gained from this project is not limited to this single project, but can be used in multiple other applications as well as revision of the original problem definition to read Florence is faced with issues pertaining to waste containment and removal caused by a fluctuating tourist population, environmental aspects, non-consistent styles of trash cans, and cultural variations which will be addressed by utilizing forms of infrastructure that interact with waste management. The new problem definition can be used in Florence's tourist locations as well as other surrounding areas to create other sustainable waste solutions. The knowledge gained of waste sustainability will be beneficial to evaluate the waste management process in the United States and other sustainable solutions in future projects.

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Team Gold: Regulate traffic control and reduce pollution.

Florence has struggled with extremely high pollution levels recently. As of 2011, it is the most polluted city in Italy [1]. In addition to the health risks this poses, it is also damaging to the buildings and artwork that make Florence such a popular tourist destination. Continued damage will decrease the important tourism income that the city brings in, as the structures will lose the splendor and beauty that originally drew people to them. The current system of transportation contributes to the pollution levels and also poses an immediate threat to the safety of pedestrians, tourists, and the operators of motor vehicles themselves. Due to these factors, while focusing on transportation methods, a solution must be implemented to reduce pollution in the city and protect the lives of those who travel throughout the city of Florence.

In order to generate a solution, Team Gold used a specific process where each team member generated three to five different ideas; the process was called freeform brainstorming. Once the individual designs were set, the concepts were shared with the team. From the selection of ideas, the team then organized them into five concise solutions. The first idea included the idea of tramway system, to replace the public transportation and cars in the city with a public tramway. The tramway would be an effective mode of transportation; however, the tramway would destroy the historical atmosphere of Florence. The second idea was to only allow electric cars by banning gasoline powered cars in the city. Electric cars would be difficult to implement into the city however. The third idea was absolutely no cars in the city within the set boundaries and to place parking garages throughout the city for public parking. This would be difficult to convince the public to remove their personal vehicles from the area. The fourth idea Team Gold came up with was the idea of creating an underground railway system that would replace the need for cars and public transportation. This would be costly and destroy the historical atmosphere. The fifth and final idea being only bikes allowed within the city, no cars or public transportation of any kind. This poses a problem for the large families who are trying to move from one place to another. As engineering leaders it is our job to choose a solution we see best for our community, but as leaders it is our job to explain our process of how the team came to the solution team gold did, thus as leaders team gold explained the brainstorming process.

Once the brainstorming ceased, the team determined to choose the restricted car zone. Comparison, data collection, and a design matrix were used to determine the final solution. The team compared Florence to the cities of Rome and Venice in terms of traffic and size. By completing this comparison, it helped justify our solution. Data collection was done by counting cars, bikes, motorbikes, and buses along two different streets. The results of this data collection showed that cars and taxis were the most abundant transportation vehicles a majority of the time. The design matrix included a 'MUSTS' and 'WANTS' section in order to determine the most favorable and feasible solution. The 'MUSTS' section was based off of red blocks and green blocks depending on whether or not the 'MUST' was fulfilled while the 'WANTS' section had a ranking system for each 'WANT'.

After the generation of the solution, the team discussed the implementation methods. To implement the solution, five main tasks were generated. The first of these five tasks is to inform the public to the upcoming changes to the traffic system. The public must be constantly informed of the decisions that are being implemented. The second is to change the traffic laws and implement the restricted access zone. There are special exceptions for Emergency Service Vehicles, policemen and delivery trucks. The third task is to obtain the technology necessary to the success of this solution. This step involved choosing an automatic bollard as well as controllers to give the service vehicles so they have unlimited access. The fourth step is to calculate the costs accrued through this solution, and the final step is to generate a construction timeline. The final two steps are crucial to the feasibility of the final solution. As engineering leaders it is our job to discuss with the community and get feedback, not to ignore the reality that our decision affected the lives of these individuals. Thus as leaders it is our job to get feedback from the citizens about how our solution impacted their lives as a whole.

There are several means of evaluating the effectiveness of the solution. One way to estimate the effectiveness of the solution would be to investigate commute times. Based off observation and experience, commute time across the city is only slightly longer to walk than it is to drive, and biking is often the quickest of all. With the aid of public transportation, hopefully commute time would not be too negatively affected, if at all, especially given the fact that motorcycles, mopeds and bicycles would still be permitted. Nevertheless, the commute time in Italy is only 23 minutes (and likely lower in Florence due to its compactness) [2]. Another means of evaluating the solution would be to estimate reduced CO_2 emissions from the car ban. Given Florence's population of 374,500 and an estimate that 52% of people in Florence have cars, there are about 195,000 cars in Florence [3, 4]. Assuming an average emission of 150 g CO_2/km, 29.3 metric tons of CO_2 per kilometer driven by every car in the city would be eliminated [5]. Though this estimate sounds good on paper, and there would hopefully be reduced pollution in Florence as a result of the ban, the team must consider other effects of the proposed solution. It would be difficult to quantitatively evaluate effects, so instead the group proposes various metrics to evaluate the solution. The team would monitor any changes in tourism levels by paying attention to museum attendance and business sales. Hospitals would be monitored for any change in breathing problems as a result of the expected lower air pollution levels. The residents would be given a survey of their thoughts on the ban--feeling of safety as a pedestrian or biker, convenience, preservation of the city's history and changes in commute time. The team would also note the likely increase in public transportation. As a result of examining the effectiveness of the car ban, the group would take any appropriate action to increase the positive effects and minimize its negative effects.

As the project drew to a close, the team has some recommendations to improve the analysis of Florence transportation. The areas include more communication with the city, such as asking residents and government officials, as they would be the ones living with the changes. The team would also advise gathering more information on the number of cars traveling in areas closer to the heart of the city because they only have data from one location. On top of that, the team's idea to build parking garages could work, but talking to a contractor would be advisable in order to determine costs and feasibility. The team recognized that exceptions would need to be made in order to accommodate for the needs of the citizens. Ultimately, for this solution to pass, a citizen vote would need to take place. The team knows this idea is very idealistic, but feels by presenting it to the public and making them aware of the severe pollution issue surrounding Florence it is in the team's best leadership interest. A leader, as stated in the book, Good to Great, one must be able to confront the brutal facts [6]. The team recognizes the severity of air pollution in Florence and the large amount transportation vehicles contribute. As good leaders, they would like to bring this issue more to the forefront by proposing an unrealistic dramatic change.

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Green Team: Modify the building code of Florence to foster adequate housing while maintaining the Renaissance character of the city

Housing and land management urban infrastructure is defined as the infrastructure in which people live as well as the provision of adequate housing and employment for all individuals while maintaining a high standard of quality of life. With that definition in mind, the green team walked the streets of Florence making observations on the housing and job quality of Florentine citizens. After walking about the city center and outskirts, living in the city, and researching Florence's culture, the team came to the conclusion: Florence is approximately two thousand years old and time has taken its toll on the buildings, leaving the majority in various states of deterioration and in need of repair. Taking into consideration that Florentines are proud of their rich history and culture, as well as the impact of tourism on the economy, any repairs to the buildings must fit into the traditional façade.
Ideally any repairs must also be sustainable and increase the standard of life.

While attempting to find a solution for the housing infrastructure problems, the green team thought of many possible solutions. An initial solution, which was soon decided impractical, was a sky city where everyone walked along bridges connecting the buildings, attempting to solve the issue of walking on small sidewalks amongst the heavy traffic in Florence. A similar solution was to build an underground parking garage where all the cars traveled below the city and pedestrians traveled safely above the ground, again determined to be impractical. After experiencing the lack of air conditioning, the team thought the addition of an air conditioning system to residences could improve the quality of life. However, this system would require some insulation work to be done prior to implementation. Expanding on the air conditioning idea, the team then thought of creating a building code for permanent repairs for buildings in the city allowing for the incorporation of social issues. Building more housing and moving residents to the outskirts of the city was also considered. Lastly, after seeing a slum outside the Firenze Rifredi train station, small houses on wheels and portable, collapsible shelters were considered. Through the use of a decision matrix, the building code was chosen by the team. Cost, practicality, sustainability, and the common good were taken into consideration in the matrix. The categories were ranked on a scale from one to five, with five being the best for that category. The building code received the highest total score of 16, followed by building outside the city with a score of 13, leading the team to choose the building code solution.

The building code was broken down into five categories, including interior structure, exterior structure, energy, water usage, and building usage. The interior structure section included a major focus on insulation. Buildings currently lose an excess of heat and energy, but through the use of insulation and energy star-rated windows, energy would be saved. The key component of the section on exterior structure was to maintain the traditional façade of the buildings in Florence while using better, more sustainable materials for repair. Since residential energy constitutes 27% of all energy used in the world, the energy section focused on using energy efficient appliances and sustainable sources. Since Italy is currently under water stress, along with much of Europe, it becomes important to use water in the most efficient ways possible. The water component focuses on the use of water efficient appliances, maintaining water cleanliness through corrosion free pipes, and allowing for the collection of water to be more sustainable. The final category, building usage, ensure the proper usage of residential buildings, as well as taking into account issues of accessibility that are faced in Florence every day.

The building code would be implemented by the government with the inclusion of a grandfather clause. This would ensure that any renovations or construction of new buildings after submission of the building code would have to follow the regulations without necessitating that all buildings immediately change to meet the regulations. Leadership would play a role in the implementation through the delegation of workers and incentives. Task forces would be comprised of a small group of leaders in various categories such as energy, materials, accessibility, and water to ensure that the regulations of each aspect are being met when buildings are built or renovated. This ensures that all proposed regulations are feasible and that future inspections can be done by experts in each field. In addition, incentives including tax write-offs for building owners whose properties have received certification through the building code, would be included. If aspects of the code are not met, there is also potential for a fine.

Overall the building code seems to solve most problems regarding the deterioration of buildings within the city, making buildings more sustainable, and providing more housing for Florentine residents. The new code however did not cover as much of a social aspect as originally planned and could have been approached better. The current building code for Florence was not able to be found through research so the team had to rely on articles about the code. In response to the lack of accessibility, the code created by the team would have to be clearly communicated to the city as a whole and be easily found by any individual looking to explore the current regulations. The team struggled when creating a code for the interior of buildings due to lack of experiences within various buildings in the city. Elements comprising the interior part of the code were based off of experiences within the residence at Via Cavour 85 and Hotel Bonifacio. This section could have been improved with broader experiences within residences. Lastly, difficulties could arise during implementation of the code since laws would need to be passed and there would be a time delay before the code would fully come into effect. Citizens might also be unhappy to change their lifestyles for what the team considers to be improvements. If implementation of the new code goes through and citizens receive the code well, the code would most likely be successful. The effectiveness and success of the project could be measured based on how many residences receive certification in specified time spans.

If the project were to continue, Italy's law system would have to be investigated and understood. The research would be necessary in order to know how to implement the new building code in the Florentine government. More observations within the interior of buildings would also be necessary to perfect the interior structure component of the building code. In addition, more research could also be done in order to set benchmarks for implementation of the code, for example, ensuring that a certain percentage of buildings receive certification within a specified time span. The benchmarks would allow the team to determine the progress of implementation. If the green team revisited the housing issue in the future, there would need to be two different focuses-the deterioration of buildings and the socio-economic aspect of homelessness and low employment rates. After splitting the problem, the team could have had two strong solutions instead of one which was unable to fully solve both issues. The green team selected a broad problem statement, resulting in a difficult time when finding a solution.

Red Team: Provide sustainable energy resources while retaining the Renaissance character of the city

As a group we researched five types of Renewable Energy: Thermoelectric, Hydroelectric, Wind Power, Biomass, and Solar Power. As a group we each investigated the process and availability of each renewable energy in Florence. Our priority for our research was to find an aesthetically pleasing technology to keep the Renaissance appeal in the city. We wanted to hide the energy so when tourists visit the top of the Duomo or Piazza Michelangelo they saw the city without any changes. We understood the city of Florence depends on tourism, and if the city views were altered in anyway it would have a negative impact on the industry. Our next important criteria was the efficiency of the technology and the environment that Florence is in.

Our initial idea was to use Thermoelectricity and install sheets of metal underneath the rooftop shingles. We believed this would be the most aesthetically pleasing idea. After doing some research our group discovered the cost and inefficiency made thermoelectricity a terrible resolution for the city. Within the Tuscany region Wind Power is unreliable due to the low winds in the region. For this reason there are only four Windmills in the Tuscany region. As result our group concluded the Wind Power is not reliable for the city of Florence, and dropped the idea. Florence is obviously in a river valley, and after the flood of 1966 a dam was developed to regulate the flow of the Arno. It wasn't until 2004 that they installed a hydro turbine in the dam. From this we realized that the hydro power in Florence has already been implemented and had to look into other renewable energy.

As a group we decided the best renewable energy sources to install and develop are Solar Power and Biomass within Florence and the Tuscany region. At the present time, there is a biomass plant in Bondeno which provides energy for about 10,000 houses while also producing zero emission of harmful carbon dioxide. While having these benefits in Bondeno, there is not a clear transition when taking it to Florence. Ruining the aesthetics of this rustic city while also not being the most efficient choice drags biomass below solar energy. We decided to pursue solar power because there is a lot of room for improvement and it is aesthetically pleasing to the city.

Through our research we found that SRS Energy developed a Solar Shingle in 2008 that was colored blue. They partnered with US tile to improve the design and market their product. In California the product received a lot of attention when it first came out, although the company had gone out of business. One of the reasons that SRS Energy went out of business was due to poor marketing, affordability, and efficiency. As a team we believed that the Solar Shingle would be the most aesthetically pleasing renewable energy in Florence, although there is still a need to develop this technology.

We continued to play with the idea of Solar Shingles and brainstormed how to make the shingle efficient and aesthetically pleasing in Florence. There was no possibility to create a shingle that was only clay color, because it would not attract sunlight as well. After doing some more Research on the Solar Shingle we found a prototype solar shingle that was a solar panel enclosed by a clear region to let sunlight in, and a clay on the sides to blend the panel. This was our best option due to the easy installation, aesthetic appeal, and efficiency. The new design would use smaller solar tiles that are 14.9% more efficient than SRS energy tiles. Current solar tiles produced by Dow Powerhouse are at an efficiency rating of 19.9%, while the SRS Energy tiles maxed at 5%. With solar power being our top option we chose to pair it with the Tesla Powerwall. The Powerwall works great with solar panels because it allows the owner to go completely off the grid if they would like to be self-sustainable. With this the battery can charge all day when it is sunny and then the power can be utilized at night when there is no sun. Overall we think they complement each other well and are a viable option to eliminate the ugly wires that take away from the aesthetics of the city.

Decision Analysis

Decision Analysis		Thermoelectric		Hydroelectric		Wind Power		Biomass		Solar Power	
Characteristics	Weight	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Economics	9	1	9	9	81	8	72	9	81	8	72
Aesthetics	9	1	9	4	36	6	36	5	45	10	90
Technology	10	2	20	7	70	9	90	9	90	5	50
Environment	10	9	90	4	40	1	10	9	90	10	100
Efficiency	10	1	10	10	100	8	80	6	60	4	40
Room for Growth	7	6	42	3	21	4	28	4	28	8	56
Durability	7	10	70	10	70	7	49	10	70	9	63
Environmental Safety	8	8	64	5	40	7	56	10	80	10	80
Totals	630		314		458		421		544		551

The plan to get the Solar Shingles into the economy is a business proposal to ENEL. ENEL, headquarters in Rome and offices in Florence. It is a company that owns 86 percent of power distribution to all of Italy and 25.4 percent of power generation. We believe that ENEL would be interested in our solar shingles because it would increase their generation of power, and possibly distribution. Our proposal is that we would partner with ENEL to receive funding to develop this prototype. Our company would then provide them our shingles and give them negotiable shares of our company. We also have ideas for how ENEL could convince building owners to allow them to install the shingles. Once the efficiency and installation costs were determined, ENEL could offer the building owners a certain amount of years for free or discounted energy to use their roof space. We believe that many small party consumers are focused on the short term benefits, thus providing them with a quick benefit. Then after the contract between the building owners and ENEL is up, they could take ownership of energy generated by the Solar Shingles, and sell it back to the building owners. We determine this to be a 10 year investment, with at least another 10 years of free power generation for ENEL.

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Orange Team: Design a reliable, accessible, and sustainable public wi-fi system

Five undergraduate students pursuing various Bachelor of Science degrees from the University of Dayton Engineering Department were tasked to collaborate on generating a project that rectifies a communication-related problem in the city of Florence. The students resided in the city for a month in order to discover the interactions between communication and engineering in the Italian community. Throughout the course of that period the team was able to define a problem, generate a solution with alternatives, evaluate the chosen resolution, and present the entire process to a panel of their mentors and peers.

The problem the team focused on was how to design a reliable, accessible, and sustainable public wi-fi system. The process of defining this problem was a bipartite method of research and discussion. Initially the team conducted an eleven-hour intensive exploration of the city, in which they covered over sixteen miles of roads discovering the various methods of communication, as well as discussing potential issues. By factoring in connection to engineering, importance to the population in Florence, and individual interest, the team determined that the human communication of wi-fi was to be studied. Online research on the nature of wi-fi was conducted, as well as explanations from one electrical engineering student who has experience in technical terms of it. Then the team discussed the issue of wi-fi quality as each team member individually had experienced unreliable connections in public plazas. In order to corroborate these wi-fi quality issues, the team conducted an experiment to determine the speed of the connection, as well as map out the distance the network reaches. The results of the described experiment are pictured in the figures below. Figure 2. is a qualitative representation of the experiment, while Figure 1. presents the quantitative data for effective wi-fi distance. With this knowledge the team was able understand the current system. As a result, the team determined a more efficient system could be put in place and thus, the focus would be on public wi-fi system design.

The current hardware being used by the public wifi services in Florence is insufficient for the public system they are attempting to offer. Their hardware is designed for small businesses or offices, not massive public piazzas. Our team's hardware suggestion is to install industrial routers designed for high loads of data transfer. The team would also like to look into data logs from the routers in place to determine if physically changing the location of the routers/emitters will improve wifi signal in the public piazzas.

The team broke up the design of a public wi-fi system into five main components: knowledge of current wi-fi quality, appropriate hardware, funding, location, and means of implementation. These components were derived from consolidating concepts of discussion during team meetings. Inspiration for brainstorms/ideas on how to design each component arose from individual research and previous knowledge of the subject. Based on these areas, the team decided there were three potential ways to design a public wi-fi system for Florence: keep the current one and make no changes, update the current one, or replace the current one. Cost-wise to replace the current one would be tricky, as well as potentially irrelevant as wi-fi is an ever evolving technology and new models emerge frequently. To keep the same design would mean the only means of bettering it would be to eliminate the flow of people utilizing the system, which goes directly against the value of tourism existent in the city. Therefore the solution we chose was to update the current system.

To develop an all-encompassing solution, the team created a distinct system of upgrades and implementation that would serve the dual purpose of simplifying and upgrading an undefined complex system. In addition to the new hardware recommendations, there must be a system put in place for making said changes. The team created a system of implementation that breaks up roles into three sectors: governmental, technical, and experimental. The overall efficiency of the system relies on smooth communication between the three separate departments. Initially, government administration dictates whether or not to upgrade the system. Following the initial decision, the technical side covers actual router evaluation and installation. The installation of new hardware precedes an experimental period, covered by research teams. These teams would evaluate the effectiveness of the new hardware over a six or 12 month period, and then report their findings back to the government for a full review of the new system. If it is determined that the upgrade and changes were effective, then the system could be implemented in other piazzas and public spaces. The old hardware would be recycled to ensure the project is carried out in a sustainable manner to insure that no environmental degradation from harmful substances in the router occurs as a result of the project. Overall, the result of the team's research and collaboration is a smooth system that effectively implements a changing public wi-fi system, while providing key outlets for communication between involved departments.

There are many benefits to this new faster wi-fi system, the first of which is it will allow for tourists to access the internet faster, allowing for tourists to spend more time in the city. The public wi-fi system will also allow the people of Florence a way to access the internet in a country where only 59% of the people have access to the internet. Furthermore, the recycling program will prevent waste from reaching the landfill. Therefore this new system will positively benefit Florentine society as well as the surrounding environment.

A month-long period of study in the city of Florence provided a unique environment that fostered the curiosity of five undergraduate students of engineering. Tasked with exploring the engineering of communication throughout the city, the team first examined all observable aspects of communication, including cellular devices, emergency signals, signage, and print media, before finally narrowing the focus to wi-fi usage. The team began the engineering process by defining the problem. Public Firenze Wi-Fi, offered in most Florentine piazzas, was observably unreliable and inefficient. After experimentation and research, it was determined that the team's focus should be on improving this free public system by developing an improved system, consisting of better hardware, better router locations, and an improved system of implementation. It is through these recommendations that the team plans to improve the overall quality and effectiveness of public Firenze Wi-Fi. Taking into account the societal, environmental, and tourist benefits, the new smart implementation of wi-fi proposed by the team could effectively update the currently antiquated wi-fi system.

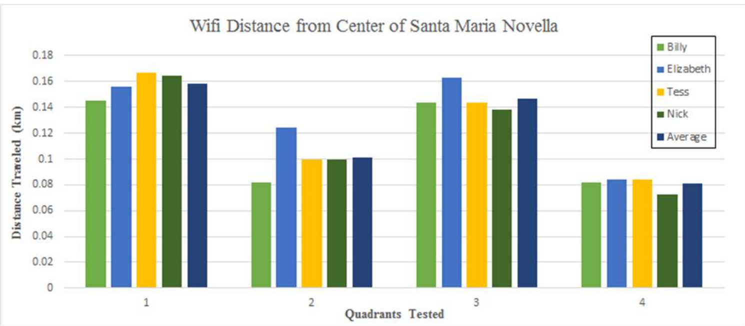

Figure 1.

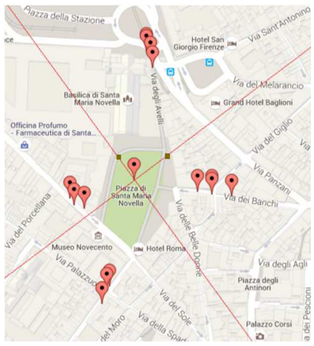

Figure 2.