Teaching Engineering, Teamwork & Tolerance by Bringing Multi-discipline, Multicultural Students Together via a Project of Common Interest; Vertical, Hydroponic, Smart Garden With Global and Universal (Space) Applications (Student Poster-Paper)

Mr. Miguel Rafael Ruiz-Carpio
Mr. Cyrus Safai, SLCC

Cyrus is an undergraduate student majoring in Mechanical Engineering at Salt Lake Community College (SLCC). Cyrus has teamed up and worked with a group of four other students from Mechanical, Civil, Electrical, and Computer engineering departments on the Vertical, Hydroponic, Smart Garden With Global and Universal (Space) Applications. He has worked at the SLCC Slick Science Summer Camp for the past 7 years.

Mr. Arafat Djobo
Mr. Ivan Gaichuk
Dr. Nick M. Safai, Salt Lake Community College

Dr. Nick M. Safai has been an ASEE officer and member for the past 24 years. He has been the six-time elected as the Program Chair of the ASEE International Division for approximately the past 13 years. Nick has had a major role in development and expansion of the division. Under his term as the International Division Program Chair the international division expanded, broadened in topics, and the number of sessions increased from a few technical sessions to over eighteen sessions in the recent years. The ASEE International Division by votes, has recognized Nick's years of service through several awards over the past years. Nick has been the recipient of multiple Service awards (examples: 2010, 2006, 2004, 1996), Global Engineering Educators award (example: 2007, 2005), Best Paper award (examples: 2010, 2005, 2004, 1995) and other awards from the International Division for exceptional contribution to the international division of the American Society for Engineering Education. Examples of some Awards from other Professional Organizations: • American Society of Civil Engineers (ASCE): Engineering Educator of the Year Award 2004. • Utah Engineers Council, UEC: Engineering Educator of the Year 2005 award, in recognition of outstanding achievements in the field of engineering and for service to society. • SLC Foundation; Salt lake City, Utah: Teaching Excellence Award 2004. • American Society of Civil Engineers (ASCE): Chapter faculty Advisor recognition award 2002. • Computational Sciences and Education; recognition for outstanding contributions and for exemplary work in helping the division achieve its goals1998. • Engineering Division; recognition for outstanding contributions and for exemplary work in helping the division achieves its goals 1995. • Science and Humanities; recognition for outstanding contributions and for exemplary work in helping the fields achieve its May 1994. • Math & Physical Sciences; appreciation for academic expertise February 1994.

Academics: Nick Safai received his PhD degree in engineering from the Princeton University, Princeton, New Jersey in 1979. He also did a one year post-doctoral at Princeton University after receiving his degrees from Princeton University. His areas of interest, research topics, and some of the research studies have been; • Multi-Phase Flow through Porous Media • Wave propagation in Filamentary Composite Materials • Vertical and Horizontal Land Deformation in a De-saturating Porous Medium • Stress Concentration in Filamentary Composites with Broken Fibers • Aviation; Developments of New Crashworthiness Evaluation Strategy for Advanced General Aviation • Pattern Recognition of Biological Photomicrographs Using Coherent Optical Techniques Nick also received his four masters; in Aerospace Engineering, Civil Engineering, Operation Research, and Mechanical Engineering all from Princeton University during the years from 1973 through 1976. He received his bachelor's degree in Mechanical engineering, with minor in Mathematics from Michigan State. Nick has served and held positions in Administration (Civil, Chemical, Computer Engineering, Electrical, Environmental, Mechanical, Manufacturing, Bioengineering, Material Science), and as Faculty in the engineering department for the past twenty seven years.

Industry experience: Consulting; since 1987; Had major or partial role in: I) performing research for industry, DOE and NSF, and II) in several oil industry or government (DOE, DOD, and NSF) proposals. Performed various consulting tasks from USA for several oil companies (Jawaby Oil Service Co., WAHA Oil and Oasis Co., London, England). The responsibilities included production planning, forecasting and reservoir maintenance. This production planning and forecasting consisted of history matching and prediction based on selected drilling. The reservoir maintenance included: water/gas injection and gas lift for selected wells to optimize reservoir production plateau and prolonging well's economic life.

Terra Tek, Inc., Salt Lake City, UT, 1985-1987; Director of Reservoir Engineering; Responsible of conducting research for reservoir engineering projects, multiphase flow, well testing, in situ stress measurements, SCA, hydraulic fracturing and other assigned research programs. In addition, as a group director have been responsible for all management and administrative duties, budgeting, and marketing of the services, codes and products.

Standard oil Co. (Sohio Petroleum Company), San Francisco, California, 1983-85; Senior Reservoir Engineer; Performed various tasks related to Lisburne reservoir project; reservoir simulation (3 phase flow), budgeting, proposal review and recommendation, fund authorizations (AFE) and supporting documents, computer usage forecasting, equipment purchase/lease justification (PC, IBM-XT, Printer, etc.), selection/justification and award of contract to service companies, lease evaluation, economics, reservoir description and modeling, lift curves, pressure maintenance (gas injection analysis, micellar-flooding, and water-flooding), Special Core Analysis (SCA), PVT correlations, petrophysics and water saturation mapping.

Performed reservoir description and modeling, material balance analysis. Recovery factors for the reservoir. Administrative; coordination and organization of 2 and 6 week workplans, 1982 and 1983 annual specific objectives, monthly reports, recommendation of courses and training program for the group. Chevron Oil Company, 1979- 1983; Chevron Overseas Petroleum Inc. (COPI), San Francisco, California 1981-1983. Project Leader/Reservoir Engineer, Conducted reservoir and some production engineering work using the in-house multiphase model/simulators. Evaluation/development, budgeting and planning for international fields; Rio Zulia field – Columbia, Pennington Field – Offshore Nigeria, Valenginan, Grauliegend and Rothliegend Reservoir – Netherlands. Also represented COPI as appropriate when necessary.

Chevron Geo-Sciences Company, Houston, TX, 1979-1980 Reservoir Engineer Applications, Performed reservoir simulation studies, history matching and performance forecasting, water-flooding for additional recovery (Rangeley Field – Colorado, Windalia Field – Australia), steam-flooding performances (Kern River, Bakersfield, California), gas blowdown and injection (Eugene Island Offshore Louisiana) on domestic and foreign fields where Chevron had an interest, using Chevron's CRS3D, SIS and Steam Tube simulator programs.

Chevron Oil Field Research Co. (COFRC), La Habra 1978-1979, California. Research Engineer, Worked with Three-Phase, Three-Dimensional Black Oil Reservoir Simulator, Steam Injection Simulator, Pipeflow #2. Also performed history matching and 20-year production forecast including gas lift and desalination plants for Hanifa Reservoir, Abu Hadriya Field (ARAMCO).

Teaching Engineering, Teamwork & Tolerance by Bringing Multi-discipline, Multicultural Students Together via a Project of Common Interest;
Vertical, Hydroponic, Smart Garden With Global and Universal (Space) Applications

Miguel Carpio (Electrical Engineering),
Cyrus A. Safai (Mechanical Engineering),
Arafat Djobo (Civil Engineering)
Nixon Wong (Computer Engineering)
Ivan Gaichuk (Electrical Engineering),

Engineering Students
Salt Lake Community College

and

Dr. Nick M. Safai (Professor)

Abstract:
A group of multicultural students from different engineering disciples teamed up to do a study of common interest. The idea was to bring together these students of various backgrounds and ethnicities and increase tolerance, better cultural understanding amongst them, and increase team work and comradery. The project which was of common interest among the students was a smart garden, vertical, hydroponic, with applications to global and universal, even in space. A hydroponic system solves / removes the need for a mass consumption of water, and or the need for a specific soil. An indoor smart system where the environment is controlled means that any crop can grow anywhere and is not constrained to a particular region for growing. Educating and teaching the population in third world communities would definitely have a significant positive impact on those people. In brief the study will address;

1. What: (Multinational Student Project, Vertical Garden, Hydroponic, Smart (Digital & Automated).)

2. How: (Vertical structures, Water Tank, Irrigation System to each tank, Sensors and robots, Controlled environment)

3. Why: (Less land, Vertical), No soil (Hydroponic), Less water (Hydroponic), No pesticides (Smart), Higher food yield per crop (Smart), Year round food yield (Smart), Yield even outside of native environment (Smart), Global and Universal Applications, Faster food yield (Smart), Higher food quality (Smart).

The plant growing process is digitized/made smart by incorporating multiple sensors to monitor every aspect of the plant's growth, as well as having climate control in the environment under which the plant is growing. All of these techniques are implemented to battle the challenges that the world is currently facing. Less land becomes available to farms with a growing population, water scarcity, people moving to cities, and therefore larger cities and increased apartment living. This problem can be solved by vertical farming. A lot of water is presently used to grow food and not all soil or environments are fit for growing certain crops, or in some cases any crops at all.

Background:

Motivating and promoting interest in teaching engineering subjects is always a challenge for undergraduate engineering students especially for junior and lower level students. To solve this issue we brought social awareness to members of the group, as well as tolerance and responsibility with this approach. It also emphasized to the students a tolerant and an open-minded world, now and forevermore. A group of multidiscipline, multinational, multicultural undergraduate students at Salt Lake Community College, majoring in Civil, Mechanical, Electrical and Computer engineering are working on a project involving vertical farming, hydroponic watering, and making the plant growing process smart.

Food and its availability is of major concern in all nations, especially the underdeveloped communities. Students get exposed to different engineering disciplines, and learn how to work in a multicultural team and become socially responsible in an ever increasing connected world. Each student also becomes a teacher to other students at times discussing his specialty and field of engineering.

To grow a vertical farm sound structures hold multiple growing pots for plants one on top of another. A hydroponic method is utilized to water plants and provide plants with the necessary nutrients. That is; nutrient solution is funneled through pipes in order to deliver water and nutrients directly to the plants without the use of soil. Nutrients can also be provided via certain biological living organs and /or fish in the tank.

Introduction

As students begin to learn more about engineering it becomes apparent that students have more specialized skills and interests than from some of their peers. Within freshman to junior levels this disparity is especially apparent amongst peers working in entry level classes such as calculus and physics. While the students are working on increasing their base skills their special skills diverge as students build specialized skills for their fields. This program can benefit students of multidisciplinary fields within engineering. This program, utilizes the skills and expertise of electrical, mechanical, civil amongst many other engineering disciplines that can work together to solve one of the important challenges of the 21st century: eradicating world hunger. Many technical skills are required to face this challenge, however intercultural and global communication are required in order to solve this problem world wide. Social awareness, tolerance, and a sense of responsibility for our communities and our world are also equally important to be able to solve this issue.

Hunger Statistics (Why this Program is Important):
Today, according to the World Food Programme, the world produces enough food to feed everyone, and nevertheless there are still individuals going to bed hungry. According to the food aid foundation, worldwide “795 million people in the world do not have enough food to lead a healthy active life”. The vast majority of this population exists within developing communities where about 13% of the population is undernourished. Hunger causes societal problems; approximately 3 million children die each due to poor nutrition, 100 million children are underweight and 1 in 4 children are stunted due to a poor nutrition. This is a crucial issue which needs immediate solving if we want humankind to stop suffering and dying due to hunger, a problem where we have all of the needed technology and resources to solve.

If lack of availability is not the issue to helping the world have enough food to feed everyone, then what is? According to the Sustainable Table Food Program the primary areas of concern for food security or, “access by all people at all times to enough food for an active, healthy life.” (United States Department of Agriculture), are food distribution, political-agricultural practices, and environmental factors.

Due to these challenges we developed this proposed system. The proposed system would help environmental problems, as well as the distribution of food to be managed. This system would not expose crops directly to outside climate, and be able to be sustained in locations where poor soil, poor levels of water, as well as lack of room are an issue; thus alleviating the problems caused by problems such as climate change, floods, and droughts, as well as lack of room for growth in urban areas. Addressing this issue will be the primary focus emphasis of this project, however there is a potential for this project to address food distribution as well. Future research is required to determine the success of this project with regards to food distribution.

Other potential benefits from this style of farming according to *Dickson* are;
1. Supply enough food in a sustainable fashion to comfortably feed all of humankind for the foreseeable future;
2. Allow large tracts of land to revert to the natural landscape restoring ecosystem functions and services;
3. Safely and efficiently use the organic portion of human and agricultural waste to produce energy through methane generation, and at the same time significantly reduce populations of vermin (e.g., rats, cockroaches);

4. Remediate black water creating a much needed new strategy for the conservation of drinking water;
5. Take advantage of abandoned and unused urban spaces;
6. Break the transmission cycle of agents of disease associated with a focally-contaminated environment;
7. Allow year-round food production without loss of yields due to climate change or weather-related events;
8. Eliminate the need for large-scale use of pesticides and herbicides;
9. Provide a major new role for agrochemical industries (i.e., designing and producing safe, chemically-defined diets for a wide variety of commercially viable plant species;
10. Create an environment that encourages sustainable urban life, promoting a state of good health for all those who choose to live in cities."

Technical Discussion and Methods:

Part 1: Tolerance, and Teamwork Measurements:

In order to measure the tolerance levels that students had while working together in this project several factors were taken into account such as the frequency that students decided to hold meetings per month, the dates were recorded, and the amount of time that students spend together was also measured. A pre team project and mid project analysis was also conducted in September 2017 when the project begun, and in January 2018 where students were asked their tolerance levels towards peers of other cultures. The survey was anonymous to encourage full honesty. The questionnaire is shown below

Example of Survey Questionnaire

SURVEY QUESTION 1

On a scale from 1 to 5, 5 being 'Very Open' and 1 being 'Not Open At All,' how open are you to learning from peers of other cultures from your own?

1 2 3 4 5

SURVEY QUESTION 2

On a scale from 1 to 5, 5 being 'Gets Along Excellently' and 1 being 'Does Not Gets Along At All' how well do you get with peers of other cultures from your own?

1 2 3 4 5

SURVEY QUESTION 3

On a scale from 1 to 5, 5 being 'Very Comfortable' and 1 being 'Not Comfortable At All,' how comfortable are you around peers of other cultures from your own?

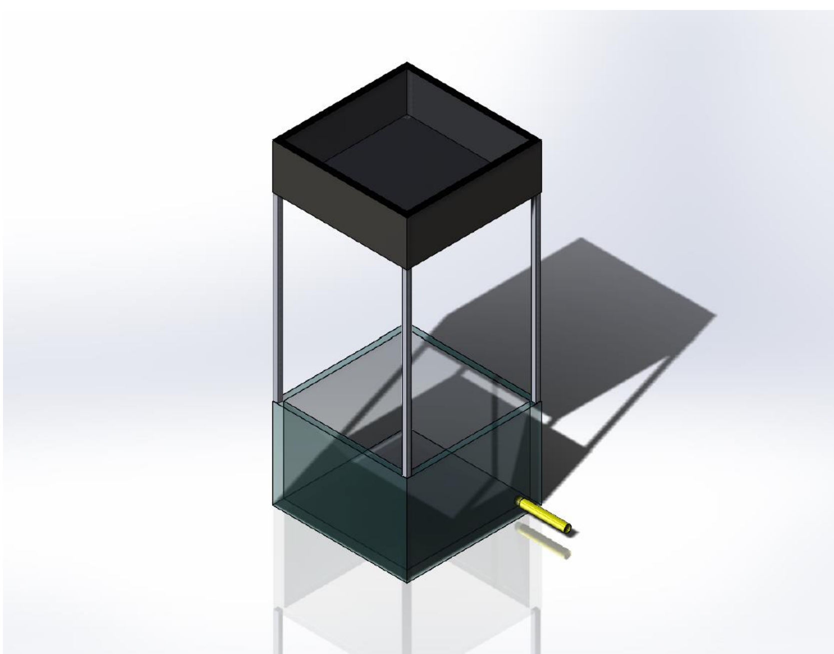
1 2 3 4 5

Part 2: Technical Project Methods:

To implement the following project three main technologies must be intertwined in order to be able to have a successful project. Mainly, vertical farming, hydroponic watering, and making the growing process smart through embedded systems, and machine learning. Because of these 3 diverse technologies civil, mechanical, and electrical engineers can work together, with mechanical and civil focusing on the vertical structures and the hydroponic system, and electrical engineers implementing embedded systems into the entire process.

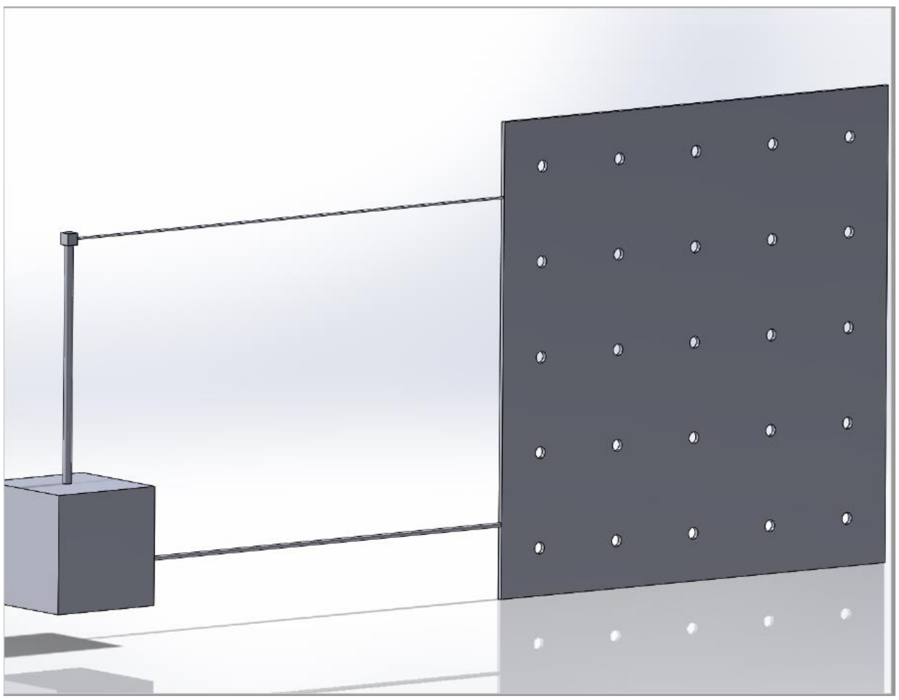
However these are not the only types of engineers that can work on this project, for it is a multidisciplinary project. For example, chemical engineers can examine the water solutions found in hydroponic system to determine what would be the optimal levels of nutrients for the plants to grow, a bio-engineer can make sure that the overall growing process is successful and carried in the right conditions for the plants to grow, a computer engineer can optimize the embedded systems along with the electrical engineer. We will explain these technologies more in depth.

There are multiple ways for the structures utilized to be built vertically. One method is to stack another plot of growing section on top of another, and continue making this stacking for multiple times. Drawing 1 illustrates a Solidworks schematic of basics of the planned hydroponic model.



Drawing 1: Schematic of basics of the planned hydroponic model

Another method to build these structures is to take the horizontal growth space and tilt it vertically then stack multiple of these vertical growth walls as close together as possible horizontally. With this method it is possible to grow food on both sides of the structure increasing the yield of food even further. Multiple levels of this style of farming can increase the yield of crop per square meter, sometimes as much as 30 times more as is the case of strawberries grown in this manner. This system must be strong enough to hold the stress of multiple levels of crops one of top of another. The need for soil to hold plants is solved with this system as the vertical system is designed to be able to hold the plants in place. Drawing 2 shows the vertically tilted wall that can be used to grow food on both sides.



Drawing 2: Tilted wall example of schematic of basics of the planned hydroponic model.

Within a hydroponic system the plants are grown in other material to hold the roots of the crops. A drip irrigation system is then developed to deliver the plant solution to the roots of the plants directly. All of the water that is not utilized by the plants returns to the tank system. Other variations of this irrigation system can be implemented, such as aeroponics where a fine mist of the substance solution are delivered to the roots of the plants. Due to a direct delivery of minerals and nutrients to the plant the water consumption is decreased from conventional methods of farming. Likewise the need for soil to deliver nutrients is solved with this system. This irrigation system combined with vertical farming ensure that the need for a particular type of soil, and land is not used.

Embedded systems on the growth plots as well as with the climate controls of the ancon closed room ensure that the crops are grown to the best qualities. Using Arduino is one of the methods to monitors solution's flow rate and pH value, light intensity, tank's solution level, solution temperature sensor an embedded system expands on environment control as well as crop analysis. The sensors within the plots of growth analyze constantly the conditions of the plants. This can lead to a higher crop yield, and pest control reduction. The constant control of climate sensors will also help to learn what the optimal conditions are, and recreate that particular climate constantly. This increases the growth process and crop production, regardless of the native environment of the crop. Due to this advantage to grow crops in this style it is our hypothesis that if this system is able to be recreated in a space station in outer space or in a different planet where we are able to build this indoor system we will be able to have multiple crops native to planet Earth wherever we may send humans in the future. This system thus needs to be integrated to our modern day agricultural techniques in order to be perfected and thus implemented in outer space missions were human beings are involved.

Results:

Multicultural interactions within engineering is a topic rarely covered in conventional classes, along with an ethical class with regards to engineering benefitting the entire community. According to Martin, "The main idea is that migrants go through fairly predictable phases in adapting to a new cultural situation. They first experience excitement and anticipation, followed by a period of shock and disorientation. "This can be shown by the interactions experienced by the students participating in this project.

At first the students experienced a level of culture shock experiencing the different cultures of their peers, however as the students worked through the initial culture shock a higher level of mutual understanding and tolerance for the differences in between the group occurred. When initiating this project, on June 2017 the average number of team meetings was 1 a month. By December 2017 the average number had grown to 5 a month, more than doubling in team meetings. Within this meetings the average time spent together was 30 minutes, by December 2017 the average time spent together working on this project per meeting was 1 hour and 15 minutes. Both the frequency of meetings, and length of meetings increased as students worked together.

This model is constant with the U curve model of integration as described by Martin. After culture shock occurs integration takes place over time leading to an integrated individual in a new culture. After integration students have been able to stay longer in team meetings, and host team meetings at a greater frequency. The levels of openness towards peers of other cultures, levels of comfort with peers of other cultures, as well as the overall quality of interactions with peers of other cultures increased over time according to the surveys conducted. The sample size of the subjects is limited however to 20 students. The amount of time taken to survey these students is also limited to 5 months. Further research is needed larger sample sizes, as well as over a longer period of time. However it is our hypothesis that this trend will continue as more students enter multicultural projects. Frequency of team meetings are illustrated in Figure 1 below which as can be seen has increased during the project.

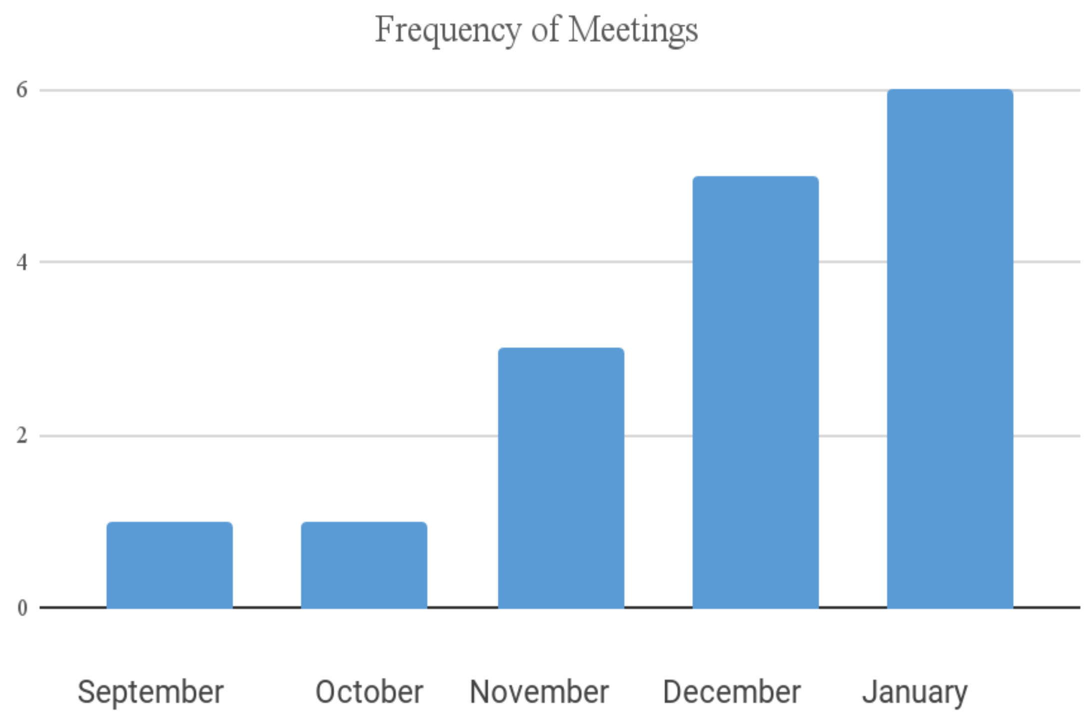


Figure 1: Frequency of team meetings

Both the frequency of meetings, and length of meetings increased as students worked together. This model is constant with the U curve model of integration as described by Martin. After culture shock occurs integration takes place over time leading to an integrated individual in a new culture. After integration students have been able to stay longer in team meetings, and host team meetings at a greater frequency. Average time spent in minutes during meetings is shown in Figure 2, as can be seen below there has been an increase in the time students spent together during each meeting in the course of the project.

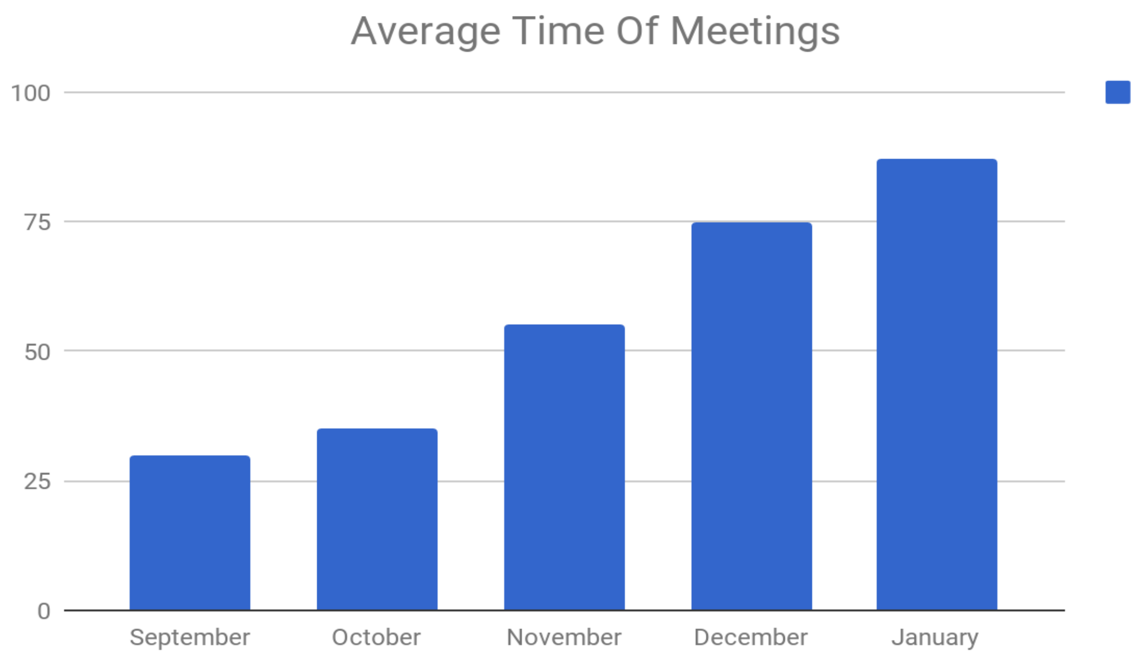


Figure 2: Average time spend during meetings.

The levels of openness towards peers of other cultures, levels of comfort with peers of other cultures, as well as the overall quality of interactions with peers of other cultures increased over time according to the surveys conducted. Openness towards peers of other cultures is illustrated in Figure 3 which can be seen below and is illustrated for the course of the project.

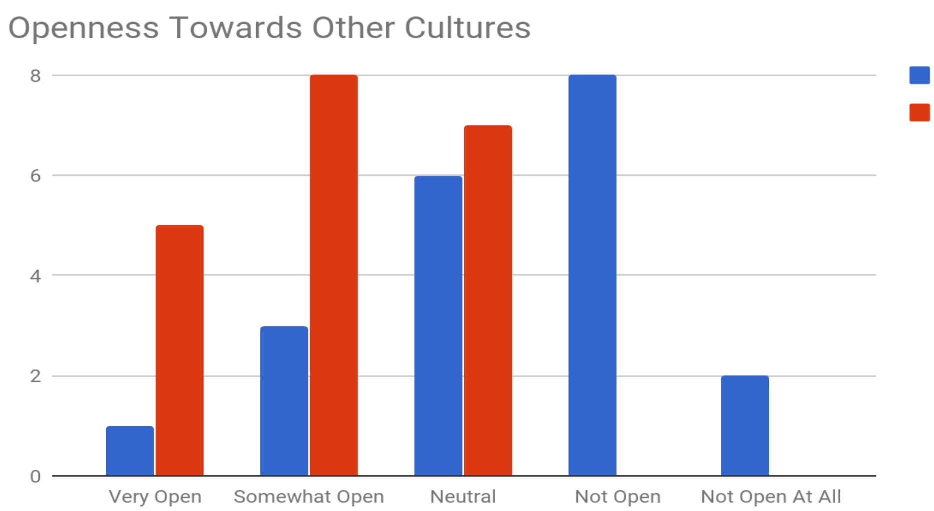


Figure 3: Openness towards peers of other cultures

Legend: Blue is September 2017 and Red is January 2018.

The sample size of the subjects is limited however to 20 students. The amount of time taken to survey these students is also limited to 5 months. Further research is needed with larger sample sizes, as well as over a longer period of time. However it is our hypothesis that this trend will continue as more students enter multicultural projects.

Levels of overall comfort amongst peers of various / other cultures during the meetings or other events is illustrated in Figure 4 as can be seen below:

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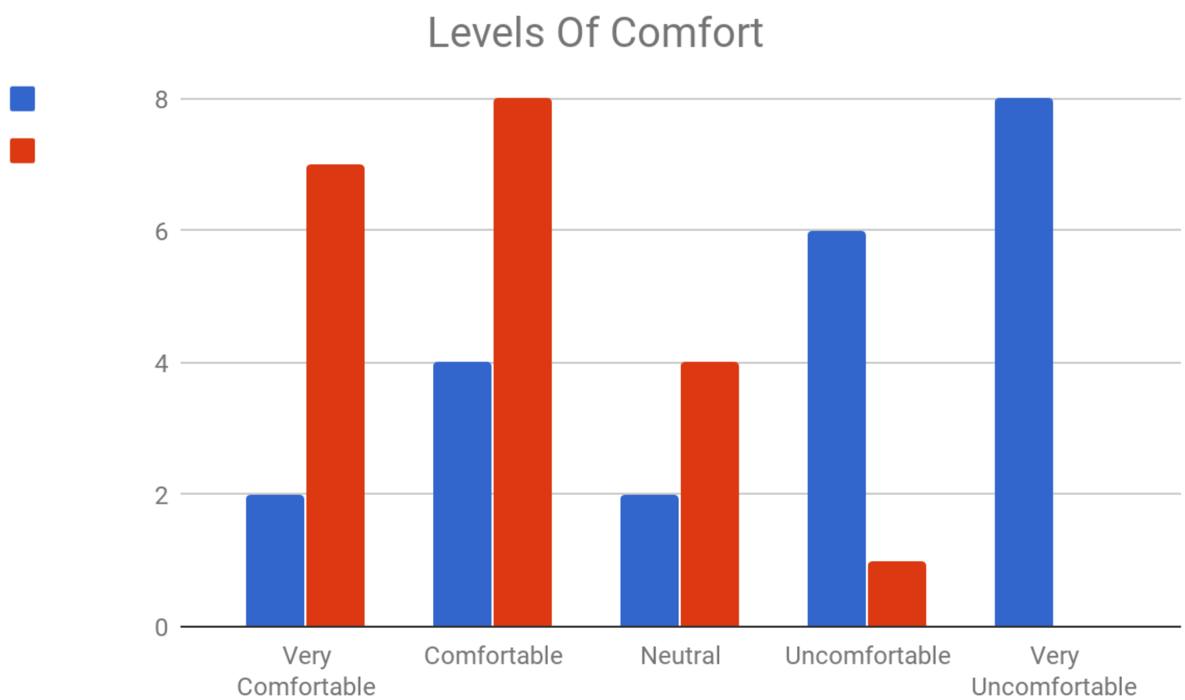

Figure 4: Levels of overall comfort amongst peers of other cultures
Legend: Blue is September 2017 and Red is January 2018.

We also examined the overall quality and the interactions among peers coming from different backgrounds, races, and ethnicities. Overall quality of interactions with peers of other cultures is plotted and illustrated in Figure 5 which can be seen below. The plot clearly shows an increase in interest and being more comfortable in spending time, learning from, and being around peers of other cultures.

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Again the sample size of the subjects was limited however to 20 students. The amount of time taken to survey these students was also limited to 5 months. Further research is needed with larger sample sizes, as well as over a longer period of time. However it is our hypothesis that this trend will continue as more students enter multicultural projects.

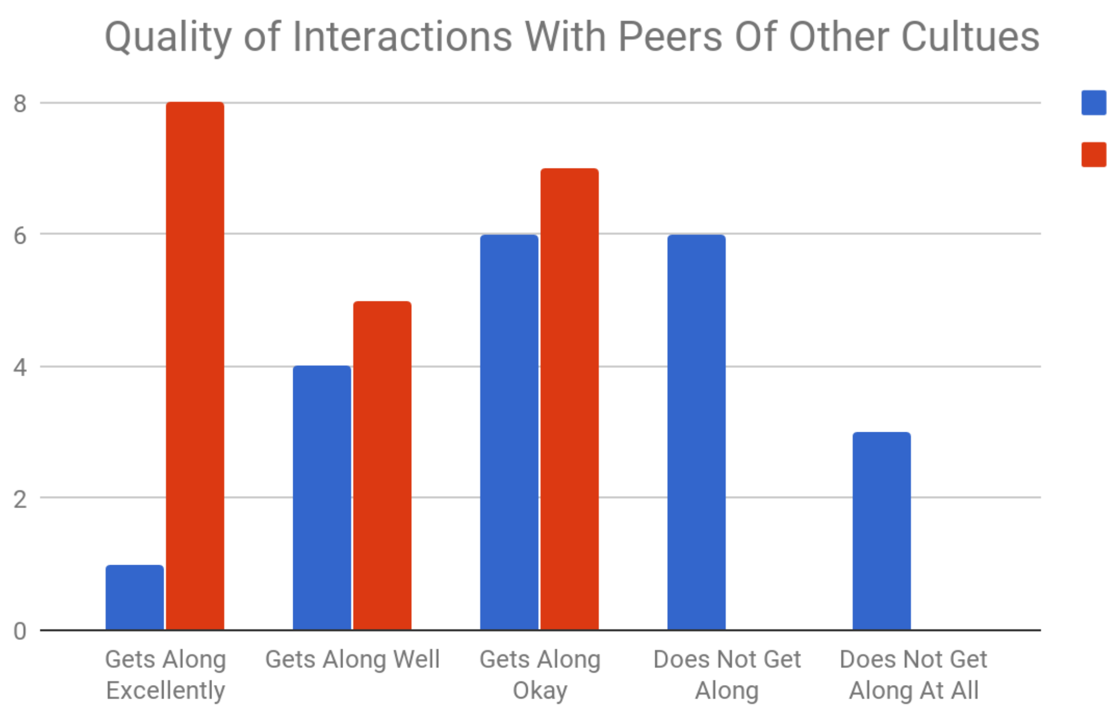

Figure 5: Overall quality of interactions with peers of other cultures
Legend: Blue is September 2017 Red is January 2018

Conclusion and Call to Action:

From this project we have seen that when students are brought together by a common interest into a project the ability to foster tolerance increases, as well as the team work put into play. It is also crucial that multidisciplinary approaches are embedded into different projects in order to solve world wide issues such as world hunger, as well as future problems such as feeding humans in outer space.

As engineers we are the stuarts of the well-being of our planet, and human kind. Because of this reason we implemented this project at our local community college, because this growing process helps to ensure food access a major crisis throughout our planet's history, but one we can solve now that we have the technology, and ability to perfect the technology needed to ensure food access to all.

We can see that with our project there is a trend of mutual tolerance, and increased civility in the quality of our project over a period of 5 months. Again the sample size of the subjects was limited however to 20 students. The amount of time taken to survey these students was also limited to 5 months. Further research would be useful with larger sample sizes, as well as over a longer period of time. However it is our hypothesis that this trend will continue as more students enter multicultural projects.

There must be more extensive research done to measure the increased tolerance and teamwork not only in this project but also in other projects implementing multicultural aspects. It is our hypothesis that this trend of increased teamwork and tolerance will increase overtime in other projects implementing a multicultural aspect.

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Student Bios:

Miguel Ruiz-Carpio, one of the student authors for this paper, is working in an associate degree of electrical engineering at Salt Lake Community College (SLCC). He is working with the Thayne Center as well as with the American Society of Education Engineering student Chapter at SLCC in implementing a garden with the described technologies in this paper to provide food for the local food pantry that the college has to provide marginalized students with access to food. His passions lie in helping humans have access to resources that will improve their overall quality of life. He will be transferring to the University of Utah in Fall of 2017 to obtain a bachelor's degree in electrical engineering with an emphasis in power engineering.

Miguel is interested in learning more about other technologies that can increase the quality of life of marginalized populations, and provide concrete solutions to today's toughest challenges that can create a sustainable future. Ultimately Miguel hopes to earn a Master's degree in power engineering, and a doctorate degree in energy consumption optimization. Miguel hopes to help marginalized communities with his skills and ultimately open a for non-profit organization that tackles challenges affecting the world through engineering philanthropy.

Cyrus Safai is presently attending University of Utah / Salt Lake Community College and is majoring in Mechanical Engineering. He is currently in his sophomore year and has a 4.0 GPA. He has volunteered as an assistant teacher at the Slick Science Summer Camp since 2008 and the UFLL Lego League Competition during fall and early spring semester since 2012. He also works as an engineering tutor for the university.

Cyrus has been involved in various professional engineering and honor societies since his High School days. He serves as an officer, or has a major role in professional engineering societies and clubs on campus. A few examples are listed below:

- He is the president of the American Society of Engineering Education (ASEE student at SLCC).
- He is the vice president of the MESA/STEP club at SLCC.
- He is a member of the American Society for Civil Engineers (ASCE).
- He is a member of the PTK Honors Society.

Cyrus's Awards & Honors:

- Award winner at the 2017 SME Symposium for demonstration on wireless power transfer.
- President's List (completion of 15+ credits with a minimum GPA of 3.8).

Selected Cyrus Publications / Presentations are listed below:

- Cyrus presented (student paper) at the 123rd ASEE annual conference, June 26-29, 2016, held in New Orleans, Louisiana.
- Cyrus Safai, Miguel Ruiz Carpio, and Ivan Gaichuck presented their paper/poster titled: "*Wireless Power Transfer: The Future of Electricity"* on Friday March 24th at the Bruin Brains Conference.
- Cyrus Safai, Miguel Ruiz Carpio, and Ivan Gaichuck paper titled; "*Magic Mirror"* to be presented at the SME symposium on April 11th, 2017.

Arafat Djobo is a student majoring in Civil Engineering. He is presently enrolled at Salt Lake Community College and is planning to continue at University of Utah for his graduate studies in civil engineering.

Nixon Wong is a student majoring in Electrical and Computer Engineering. He is presently enrolled at Salt Lake Community College and is planning to continue at University of Utah for his further studies in electrical and ECE department pursuing his interest in the field of computer engineering.

Ivan Gaichuk is a student majoring in Electrical Engineering. He is presently enrolled at Salt Lake Community College and is planning to continue at University of Utah for his further studies in electrical engineering.