AC 2011-1226: PROGRESS REPORT - THE DEVELOPMENT OF HIGH PERFORMANCE CAPSTONE PROJECT TEAMS AND THE SELECTION PROCESS

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Progress Report – The Development of High Performance Capstone Project Teams and the Selection Process

Abstract

The development of high performance Capstone project teams and the team formation process has previously been reported¹ but only provided information regarding initial experience and did not include year-end student project results. This paper is intended to provide a more complete report of the results and the continued evolution of the process and the design program.

A successful Capstone Design program including companion design courses has been developed^{2,3} that has become an integral and important component of the Mechanical Engineering curriculum. A variety of challenging projects are created each year to appeal to student academic and career interests. Students work in teams with the assistance of a faculty advisor to tackle a significant mechanical engineering design project. The formation of student teams can be a challenging and time consuming process that is critical to the success of the design project and the course experience. Attention continues to be focused upon the formation of student teams and the selection process in the hopes of developing high performance student teams.

Successful student teams should include enthusiastic, motivated and engaged students as they must address the project over the academic year of the Fall, Winter and Spring quarters. The student team should also include satisfactory skills, technical or academic expertise required for each project. As previously reported¹, by including student preferences in the team formation process and careful assessment of student strengths and weaknesses, the development of a high performance Capstone project team may be more likely to occur.

This paper will address the experiences and the continued evolution of project team formation and the student selection process. It has now evolved to include an online process that allows the student to identify individual preferred project selections. The process also includes the ability to capture individual student academic and career interests as well as the expertise that may be offered towards the project and team.

Typical class size is between 68 and 110 senior ME students resulting in 14 to 22 projects and teams each year. The Capstone projects include Industry Partnered, Research Partnered, Student Competitions, and Independently created projects. The Capstone projects reflect the technical expertise of the department and faculty including solid mechanics, structures, materials, dynamics, systems and control, robotics, fluid mechanics, thermal sciences, computational science, and nanotechnology. Projects are created each year that vary in the type and the level of technical challenges to be addressed by the student teams.

This selection and team formation process has created a positive environment for high performance teams to flourish. A summary of the first year of experience and the in-progress results for the second year will be presented.

Introduction

Although there is great deal of published business and management literature regarding high performance teams, a review of the published literature indicates that little attention has been given to the development of high performance Capstone Design student project teams. Attention in the academic environment has been focused solely on team formation including random assignment, automating processes, algorithms, and methodologies^{4,5,6,7,8}. The characteristics of “good” student teams and assessments have been presented^{9,10} but provide little guidance. A function-based approach has been introduced in terms of team member selection and qualitative assessment^{11,12} with no quantitative results presented.

An attempt has been made to create students teams that should be more engaged and motivated based upon student project preferences. Additional efforts have been incorporated to ensure a proper mix of skills and expertise with mutual accountability among the student team members. As previously reported¹, an online process of student project selections has been developed that is coupled with self-assessment forms and proposed team submittals. Initial experience with this process yielded a 97% overall success rate in meeting at least one of three student preferences and a 67% success rate in meeting the student’s first preference regarding project selection. Approximately 50% of the teams going forward were proposed by the students (Student Formed) with some assigned team members. Approximately 50% of the teams were created by the course instructor (Instructor Formed) with assignment based upon the complete process.

The project selection and team selection process has previously been described in greater detail¹. This paper will focus upon further observations and a review of the results of this process.

The process resulted in the preliminary identification by independent faculty review of four high performance teams prior to project completion. All four teams were Student Formed through the student team submittal process including the addition of students to the teams by the instructor. This paper will provide further examination of these four teams now that the projects have been completed.

Preliminary results prior to projects completion also indicated that team self satisfaction appeared to be very good and team performance appeared to be very good overall for all teams. It was also noted that overall student satisfaction, the absence of significant team conflicts and the elimination of dysfunctional teams may also be important observations. This paper will address these observations now that the projects have been completed.

High Performance Teams

A simple and effective description of a project team has been defined¹² and is applicable for the approach under consideration:

“A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable.”

Using this definition, the driving factors for all project teams have also been described as follows^{13,14}:

- All teams need a sense of purpose and a clear cut mission.
- All teams need the mission to be broken down into meaningful performance goals for each team member to pursue.
- All teams need to develop certain work approaches, procedures and processes to ensure that they accomplish a task efficiently and effectively.
- All teams have to support the common mission and take their individual responsibility seriously to do their part in accomplishing a task.
- All teams need a mix of skills, experience, and expertise, in order to meet the challenges of the team task.

To further differentiate the qualities of high performance team^{12,13} as compared with average teams:

- A deeper sense of purpose
- Relatively more ambitious performance goals
- Better work approaches and outcomes
- Mutual accountability
- Complementary skills and expertise

Based upon these understandings, if the driving factors for all teams and the qualities of a high performance team are desirable for a student Capstone project team, randomly assigning students is clearly inappropriate and must be avoided. By including student preferences in the team formation process and careful assessment of student strengths and weaknesses, the development of a high performance Capstone project team may be more likely to occur.

Team Dysfunction

Prior experience with student team formation had resulted in some problematic teams and has included:

- A team with no fabrication experience and no desire to actually build their project
- Some teams that have lacked the proper level of technical expertise
- Some teams that were a group of friends or roommates with poor motivation and work processes that resulted in poor performance
- A team that revolted over a dictatorial team leader with a near altercation

The preliminary results that were previously reported¹ with the current process of team formation noted an observation regarding the absence of dysfunctional teams in terms of performance and team dynamics. However no clear definition of team dysfunction was previously presented.

A popular description of the five dysfunctions of a team has been described¹⁵:

- Absence of trust
- Fear of conflict
- Lack of commitment
- Avoidance of accountability
- Inattention to results

Although these actions may clearly impact team performance and team dynamics, they are more descriptive of “under performing” teams as opposed to a dysfunctional team in the context of Capstone design teams. For the purpose of this paper, a dysfunctional team is a team that is prevented from performing or completing expected activities due to conflict or behavior on the team by one or more team members. This should be evident by assessment of poor team dynamics and poor overall team performance in terms of project and course deliverables.

Student Project Selection

The incoming senior students are aware that the project list will be posted prior to the start of school and are also alerted by email. The students may identify and select their top three preferences. An online process has been created and may be accessed from the course web site. This online process is limited to enrolled students and is password controlled. The selection table provides a link for each project name to the project description.

The students are not guaranteed to be placed onto a team within their top three preferences.

Team Selection

The final team selection process is completed during the second week of school. The students have been required to provide their top three project preferences and a self assessment form for accountability. Interested students have also proposed their own teams for consideration. In addition to the provided student information, a review of academic records is conducted by the instructor to better ensure that student expertise matches the expected technical challenges for their project selections.

The students may also propose their own project team based upon the online student selections. The online process allows visibility for all interested students. The students may propose a team with a minimum of three and a maximum of five team members. They are advised that proposed teams with less than five members may have students added to the team by the instructor.

The students are advised at the start of the course that to excel, they must excel as a team. Individual performance alone will not be satisfactory. Due to the complexities of the projects and the complexities of the course deliverables, only high performing functional teams will excel. Average teams in terms of performance will reflect average grades. Dysfunctional teams will be problematic and will encounter difficulties in meeting the course deliverables and project deliverables.

The student teams are responsible for completing their engineering efforts each quarter and ultimately completing their project. These engineering efforts are generally characterized for the students as Prototyping, Testing, Modeling and Analysis for the purposes of the academic course experience.

The focus for final team selection is a proper mix of student skills, experience, and expertise, in order to meet the expected challenges of the engineering efforts. The team members should have identified a preference for the expected project challenges, possess the necessary skills, and have been made accountable for their roles and responsibilities in terms of Prototyping, Testing, Modeling, and Analysis.

Results

The 2009/2010 academic year was the first year that has incorporated a mandatory online project selection process, use of self assessment, required team skills for engineering efforts and review of academic records for final team selections. The 2010/11 academic year used the same selection process. The results of student placement regarding the student preferences may be reviewed in Table 1. The results of team formation may be reviewed in Table 2.

Year	Total Students	Total Teams	Total 1st preference	Total 2nd preference	Total 3rd preference	Total preferred placement
2009/10	73	15	49 (67%)	10 (14%)	12 (16%)	71 (97%)
2010/11	68	14	52 (76%)	12 (18%)	1 (2%)	65 (96%)

Table 1. Student Placement Results

Year	Total Teams	Student Formed	Instructor Formed
2009/10	15	7 (47%)	8 (53%)
2010/11	14	8 (57%)	6 (43%)

Table 2. Team Formation Results

The selection process continued to be very successful with 71 of 73 (97%) the first year and 65 of 68 (96%) of students being placed on a preferred project selection. It should also be noted that 67% of students were placed with their first selection the first year and 76% the following year. No students requested a change of placement.

The students are allowed to also propose their own teams with the understanding that the team should have a complementary mix of skills, experience, and expertise to meet the anticipated challenges presented by the selected projects. A team submittal needed to have a minimum of three members with the understanding that additional members may then be added. Results for both years indicate that approximately 50% of the teams are formed by the students with the understanding that additional students may be added.

The entire process of review and team determinations was completed during the second week of the quarter. It is estimated that this process required about 20 hours of instructor time. Time is needed to review all forms, ensure a proper mix of skills and expertise, and academic reviews once the teams are somewhat defined.

In addition to Self Assessment forms, a Team Survey was administered for the 2009/10 students at the end of the Fall, Winter and Spring quarters to assess their team dynamics and performance. Team and self satisfaction appeared to be very good for all teams and students based upon the assessments and surveys. There were no observed team conflicts. All teams indicated that they enjoyed working together and that there was a positive atmosphere on the team.

A Design Review is conducted for all projects and teams as part of the course requirements during the Winter quarter. Design Reviews are attended by three independent faculty members not involved in the team selection process. These faculty provide a scoring for all reviews in terms of the quality of the Design Review, team dynamics, project activities, and the quality of designs. Additionally these faculty were asked to identify perceived high performance teams with a simple Team Assessment scoring rubric. The reviewers were unanimous in their selection of four 2009/10 teams. The Design reviews have not yet been conducted for the 2010/11 teams and high performance teams have not yet been identified.

All four identified 2009/10 high performance teams were originally Student Formed through the student team submittal process. Two of these teams were submitted with five students and no students were added to the team. One team was submitted with four students and one student was added. One team was submitted with three students and two students were added to the team. Three of the four projects were Industry partnered.

The four identified high performance teams were the following:

- an aerospace Industry partnered hinge deployment mechanism project (Figure 1)
- a medical device supplier Industry partnered material dispenser system project (Figure 2)
- a medical device implant Industry partnered surgical instrument project (Figure 3)
- a student Engineers Without Borders water chlorination project (Figure 4)

Abstract

Due to the confining holding bays of launch vehicles, satellites are often designed to be launched in a stowed configuration then deploy into a functioning configuration. The success of the mission depends on the success of the deployment mechanisms. Teamed with Northrop Grumman, this project concentrated on producing a simulative passive deployable hinge mechanism designed to function in a typical satellite mission environment. A design was developed through extensive research, modeling, and prototyping. With analysis and physical testing, our product proved to meet all design requirements set forth by our industry partner.

	Requirement	Verification Method
Stowed & Launch	Stowed Angle = 0°	Inspection
	Min. Stowed Natural Frequency = 30 Hz	Analysis
	Max Fastener Load Impacted on Spacecraft ≤ 5000N (Shear or Pullout)	Analysis/Testing
	Survive & Meet Requirements with Launch G-Load (X,Y,Z) = (+4g, -4g, +13g)	FEA
Deployment & On-Orbit	Min. Deployed Natural Frequency = 3 Hz	Analysis
	Survive & Meet Requirements with Deployment & On-Orbit Loads	FEA
	Deployment Angle (SC Theta X) = 90°	Testing
	Deployment Latch-up Angular Errors = ±1.0-5° Degrees Max Error	Analysis/Testing
	Maximum Latch-up Base Moment Impacted to Spacecraft ≤ 500 N-m	Analysis/Testing
	Overcome Payload Electrical Harness Resistance Torque = 0.2 N-m	Analysis/Testing
	Deployment Torque Margins > 100% Measured Statically at All Points	Analysis/Testing
	Latch Up Torque ≥ 15 N-m	Analysis/Testing
General	Mass ≤ 0.375 Kg	FEA/Testing

Table 1. Project Requirements and Methods of Verification.

Design Approach

The hinge design had to passively achieve the design requirements highlighted in Table 1. After researching existing mechanisms in achieving passive deployment, two design solutions were created: a Pin and Groove design and a Clevis and Boom design. Through conceptual prototyping and analysis, the Clevis and Boom approach was chosen as the pursuant design.

The Clevis and Boom design efficiently and effectively accomplishes the deployment requirements through its locking tooth design:

- Sloped interfacing surfaces eradicates overshooting
- Tapered teeth provide negligible slop and accurate deployment position
- Locking tooth approach surpasses latch-up torque requirements

Figure 1. Tapered Teeth Design.

Figure 2. Prototype Model (left) and Solidworks CAD Model (right).

Analysis

The hinge was modeled using SolidWorks and FEA was performed using COSMOS. Models precisely emulating the physical hinge were developed and launch loads, stowed/deployed loads, and on-orbit loads were applied to simulate actual launch and deployment conditions.

Figure 3. FEA Stress Results and Theoretical Torque Calculations.

Due to the complexity of the design and the explicit and drastic loads experienced during launch and operation, all load requirements were satisfied through FEA, shown in Fig. 3.

Energy calculations were utilized in the sizing of springs during the design phase and also used to complement dynamic physical testing. Vibration analysis was performed to achieve natural frequency requirements.

Testing

In order to properly test our design, a test bench was constructed to offload the gravitational effects of the boom and mass while maintaining their inertial effects. With this test bench, a series of tests were performed that determined the static and dynamic attributes of the hinge.

A load cell was used to calculate latch-up torques, fastener loads, and deployment torque margins. A potentiometer was used to determine the slop of the hinge in the deployed state. Mass was also physically tested using a laboratory scale accurate to 0.001 grams.

Figure 4. Angular Slop Test (top) and Test Bench Set-up (bottom).

Results

Through the testing and analysis performed, we confidently met all requirements. The overall mass was found to be 8 grams under the maximum, torque margins were determined to well exceed the minimum requirements, fastener loads and latch-up base moments were significantly lower than specified, and all margins of safety were positive.

Figure 5. Results of Deployment Torque Testing.

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Figure 1. Aerospace Industry partnered hinge deployment mechanism project

Abstract

Silicone breast prostheses are made from a two part silicone oils mixed at 1:1 ratio by weight. Upon mixing and cooking this mixture the molecules crosslink creating a non-flowable gel. This is necessary to prevent silicone from seeping into body tissue if the prosthetic membrane were to rupture. Currently these oils are measured, mixed, and injected by hand. This process is labor intensive and prone to human error which can result in expensive wasted material. This goal of this project was to create an automated device to improve mixing accuracy, reduce processing time, eliminate the need for skilled labor, and decrease material waste of the breast prosthesis manufacturing process.

Figure 1. Caption in Arial, 28 points, bold.

Requirements

Due to medical device requirements, the device must be made from silicone compatible materials and sealed from environmental contact to reduce contamination.

Design Requirements:

- Batch volume range: 100 to 400cc ± 5cc
- Mixing accuracy: 0.5%
- Output pressure requirement for injection through 16 gauge needle: 250psi
- Full automation with LabVIEW Software

$$\Delta p = \frac{128\mu v_{needle} Q}{\pi D_{needle}^4} + \frac{128\mu v_{mixer} Q}{\pi D_{mixer}^4} + \rho \sum K_L \frac{V_{mixer}^2}{2} + \frac{128\mu v_{pipe} Q}{\pi D_{pipe}^4}$$

Mixing Accuracy defined as:

$$\frac{abs(W_1 - W_2)}{\min(W_1, W_2)} \cdot 100 < 0.5\%$$

Figure 2. Consol model showing necessary pressure of ~250psi for injection through 16 gauge needle.

Design Evolution

The device operates by filling two hydraulic cylinders sequentially with Part A and Part B silicone oils. Linear transducers meter the cylinder volumes while differential weight measurements taken throughout the process verify that the mixing accuracy is met. After verification, the actuator forces the silicone oils simultaneously through a static mixer.

After initially proving the ability to infer weight of the cylinder contents, we proved the feasibility of using a single load cell for both cylinders, while providing the necessary accuracies. This reduced cost, minimized error due to calibration, but forced the process to fill each cylinder sequentially increasing cycle time.

Figure 3. CAD Rendering of Prototype (1) Weighing Cylinders (2) Actuator (3) Load Cell (4) Linear Transducers

We then tested different cylinder configurations: hanging or standing on the load cell. Hanging the cylinders reduced the need for mechanical overload protection of the load cell, and enabled automatic purging air from the system due to the cylinder outlets being located at the top.

We tested metering the volume by using the actuator as a mechanical stop and through using linear transducers. The linear transducers were highly advantageous—both accuracy and repeatability were improved due to elimination of movement during weighing. Processing time was also reduced

Testing Results

We performed extensive preliminary testing that proved the feasibility of weighing the contents of two cylinders with a single load cell, either standing or hanging. Preliminary tests showed that accurate metering was possible through using the actuator as a piston stop during filling. In the final prototype this method proved inconsistent and linear transducers were adopted for metering purposes. Figure 4 shows that the mixing ratio error was consistently below 0.5% over the range of 100 to 400cc. Final Volumes were within the requirement of ± 5cc.

Figure 4. Caption in Arial, 28 points, bold.

The final prototype underwent a pressure test where the system was pressurized and we inspected for leaks, and monitored cylinder volumes which would change in presence of leaks. The results can be seen in Figure 5.

Figure 5. Cylinder volume during pressure test, indicating no leaks

Acknowledgments

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Figure 2. Medical device supplier Industry partnered material dispenser system project

Adjustable DTS guide for ACDF surgical procedure

Andrew Pado, Ryan Pawell, Keith Schetne, Brett Smith, Sarah Stoltz, Wesley Thibault

Introduction

ACDF treats patients with cervical disc disorders by decompressing the nerve roots and spinal cord in the cervical spine. ACDF fuses cervical vertebrae together using a graft, plate and screws. The purpose of this project is to develop a dual-barreled DTS guide with a rotating handle, adjustable guide angle, adjustable drill depth, and plate holding ability to facilitate the installation of bone screws during the procedure.

Figure 1. Anterior Cervical Discectomy and Fusion Procedure

Design Development

The team travelled down to the NuVasive cadaver lab to obtain a surgeon's perspective of the procedure. This hands on experience furthered our understanding of the surgeons limited work space and need for on-the-fly, adjustable mechanisms. The cadaver lab visit resulted in major design changes shown in the first round of rapid prototypes.

Figure 2. Rapid Prototypes and SolidWorks model of Drill Depth Guides

Figure 3. Complete SolidWorks model of DTS guide

Engineering Challenges

Each mechanism evolved over a series of design iterations. In order to maximize effectiveness and minimize tissue damage the DTS guide must be compact and intuitive. This resulted in multiple modeling and manufacturing challenges because three mechanisms were integrated into to 0.194 inch ID stainless steel shaft. The small incrementation resulted in high precision machining and manufacturing. Lastly, micro TIG welding was necessary to assemble the small parts without altering their precise geometries.

Figure 4. MATLAB plot for determining incrementation for the Angle Rotation mechanism

Results

A functional stainless steel prototype was made and tested. Thirteen out of the fourteen performance requirements were met by analyzing the orientation, structural and surgical capabilities of the DTS guide. Due to limited budget the team chose not to get the Drill Depth Guides machined and rather, functional rapid prototypes were made. All other mechanisms, however, were machined and implemented in the final prototype.

Figure 5. Prototyping, testing, modeling and analysis

Conclusion

In conclusion our design efforts resulted in a functional proof of concept, however this device is not surgery-ready. Our deliverables also include a complete drawing package, user manual, assembly manual, comprehensive test reports and 3D model package.

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Figure 3. Medical device implant Industry partnered surgical instrument project

Engineers Without Borders: Water Chlorination Device

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The pictures above show the rural community EWB is partnered with. Left: View of Araypallpa, Peru. Middle: EWB-UCSB members interacting with locals, 2008. Right: Installation of Gray Water Project, 2008.

Introduction

Engineers Without Borders is a non-profit organization that supports community-driven development programs worldwide through the design and implementation of sustainable engineering projects. The EWB-UCSB team works in the Andean highlands of Peru where rural communities are required by the local government to chlorinate their water supply as a means of ensuring safe drinking water. Many rural areas around the world lack proper water sanitation and consumption of this water can cause illness. For this reason, rural areas often depend on chlorine, a low cost, readily available resource that safely and reliably sanitizes water. Unfortunately, the government provides these communities with a crude system that is neither reliable nor accurate at metering chlorine. At times, the chlorine level is too high and not pleasant to drink, which deters community members from chlorinating their water. At other times, the chlorine level is too low to properly disinfect the water, causing increased illness. The project's purpose is to design a reliable chlorination system to sanitize water that maintains appropriate chlorine levels over a range of flow rates to ensure rural communities have a consistent supply of safe drinking water. Through the use of research, modeling, prototyping, testing and analysis, a system has been designed to meet the requirements listed in Table 1.

Table 1: All of the performance requirements were met.

Performance Criteria	Goal	Obtained Value
Maximum Unit Cost of Device	\$200 (\$71 sol)	\$195 (\$57 sol)
Adequate Contact Time for Disinfection	>30 minutes	> 2 hours
Total Chlorine Added to the Water	2.0 – 6.0 mg/L	2.29 – 5.72 mg/L
Interval for Refilling Chlorine Stock Tank	2 weeks	2.37 weeks

Sustainability

For the system to be a success, it also needs to be easy to install and maintain by non-technically trained people, since the community is running the system on their own for the majority of the year.

In addition, it is our ambition for this system to be adaptable to different communities. The system is specifically designed to be implemented in Araypallpa, Peru, but instructions for adjustment are required so that it can work in communities with different needs and requirements.

Design Process

The design process began by researching various methods of introducing chlorine into a water system that would be an improvement to the government-supplied device. From our research and analysis, it was concluded that a venturi injector would be the optimal system due to its accuracy, cost, and simplicity. Once this device was selected, extensive testing was conducted to model various flow rates and characterize the venturi system. We tested a similar system to the venturi chlorination system currently installed in Araypallpa. The test system used can be seen in Figure 2. Various modifications were identified, tested, and verified to improve the system. The chlorination device was placed before the water reservoir to ensure adequate contact time. A constant water-level chlorine solution tank was installed in the injection line to maintain a constant pressure and improve accuracy. A larger venturi was also utilized to make the system less sensitive and meet the minimum refill interval of the chlorine stock tank. These changes are highlighted in red in the system schematic as seen in Figure 1.

Figure 1: Design of Proposed System

Test Methods

In order to verify that the chlorination system performs properly, a test system was developed to accurately model the conditions in Peru. The water source is 3.5 m to 4.5 m above the injection device and the chlorinated water reservoir is 1.8 m above the device. Figure 3 shows the test setup modeling the height differences seen in Peru. Without using chlorine, the injection line and mainline flow rates were measured for the range of possible heights for the water source. Repeatability tests were performed to ensure the consistency of the system. The results are plotted in Figure 4, which show that the chlorine dispensation is within the allowable limits.

Figure 2 (above): Test set-up using pump to drive flow. Used to test operation of device.

Figure 3 (Right): Gravity-fed system. Used to verify flow ranges based off height. Data shown in Figure 4.

Results

The success of the design depends on the ability of the chlorination device to dispense chlorine, while positioned between 3.5 and 4.5 m below the water source, that results in a free residual chlorine level between 0.3 and 1.0 mg/L. The relationship between the total chlorine added to the water and the free residual chlorine depends on what is in the water. Information from previous EWB trips to Peru was used to calculate that the required total chlorine range to produce the desired free residual chlorine is between 2.0 to 6.0 mg/L. The flow rate ratio test results were used to calculate the theoretical chlorine stock solution concentration and the resulting total chlorine concentration range, which was between 2.29 to 5.72 mg/L. Therefore, the system successfully produces free residual chlorine levels within the 0.3 to 1.0 mg/L range.

The entire device can be fabricated for \$195 using locally available materials, making it an affordable solution for rural communities. The minimum chlorine contact time of 30 minutes is achieved by positioning the device before the reservoir, since it stores approximately 2 days of water. The average flow rate ratio and average total water use were used to calculate the refill interval for the chlorine solution tank to be 2.37 weeks, which allows the community water quality lead to spend less time maintaining the system.

Figure 4: The average flow rate ratios exist within the minimum and maximum ratio proving accuracy in dispensing for the three flow ranges.

Discussion

The designed water chlorination system is robust and simple, can be readily manufactured using locally available tools and materials, and reliably meets the dispensing accuracy requirements. While it will be initially installed in Araypallpa Peru, the system is suitable for application in any rural community with similar conditions.

A user manual has been developed, which includes safety, installation, calibration, and maintenance information. Worksheets are also included to take the user through the design process to develop a system for a similar community. Through the characterization of the system and the utilization of the manual, the system can be disseminated to rural communities in need of sanitary drinking water.

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Stephen Laguette, Dave Bothman, Mary Dinh, URCA, past EWB Teams

Figure 4. Student Engineers Without Borders water chlorination project

The four identified high performance teams continued their performance through the completion of the course deliverables and project completion. A year-end poster competition event is held every June to celebrate the completion of the projects. A team of judges comprised of independent faculty and independent industry executives select the Most Innovative Design, Most Marketable Design, and Best Technical Presentation posters at the event. The hinge deployment mechanism and water chlorination projects were selected for awards. The team leader for the material dispenser project was later hired after graduation by the Industry partner and has been instrumental in the eventual commercial release of this system. The surgical instrument project was recognized by its Industry partner for its innovative design features. All four teams received excellent course grades.

A review of team and self assessments for the high performance teams indicates a high degree of team and self satisfaction. Recall that all four teams were formed through student team submittal. Two of the four teams were proposed with all five team members. Team and self satisfaction were very high for these teams. Two of the four teams did require that students were added. A review of year end assessments indicates that one of the added students on each of these teams was never fully integrated in terms of team dynamics. Self satisfaction by these students was

high but peer assessments indicated less than expected performance was demonstrated. It appears that these teams set high expectations for all team members which were not met by the added members.

The selection process and team formation process did not eliminate under performing teams in spite of meeting student project preferences. There were two 2009/10 teams that under performed in terms of year end course deliverables and project deliverables. Both of these teams were Industry partnered and Instructor Formed using student project preferences. A review of these teams indicates that both had very weak team leaders in terms of technical expertise and leadership skills. These teams clearly stumbled in terms of completing their projects. There were no team conflicts observed but team satisfaction scores were noticeably lower than the high performance teams. These under performing teams were, however, not dysfunctional per the previously stated criteria of team conflict or behavior impacting performance. It appears that these teams simply did not put forth the effort to complete their work.

Conclusions

An online process of student project selections has been developed that is coupled with self-assessment forms and proposed team submittals. This process with two years of experience has yielded over 95% overall success rate in meeting at least one of three student project preferences and a 70% success rate in meeting the student's first preference. Approximately 50% of the teams going forward were Student Formed with possible assigned team members added. Approximately 50% of the teams were Instructor Formed with assignment based upon the complete process.

No students requested reassignment and no student were reassigned after team formation. The process has resulted in overall satisfaction in terms of team performance and team dynamics by all teams and all students as captured through student Self Assessments and Team Surveys. The online process is clearly successful in forming teams and should be maintained.

The process resulted in four high performance teams. Three of the four teams were Industry partnered. All four teams were Student Formed through the student team submittal process. However, students were added to two of the teams. Some of these added students were never fully integrated into the team in terms of perceived performance and team dynamics.

There were two under performing teams. Both teams were Industry partnered and both Instructor Formed. These teams could not be characterized as dysfunctional due to the absence of observed team conflict or behavior impacting performance. They suffered from weak team leadership, poor individual and team performance in terms of course and project deliverables.

An attempt has been made to create students teams that should be more engaged and motivated based upon student project preferences. Additional efforts have been incorporated to ensure a proper mix of skills and expertise with mutual accountability among the student team members. Team self satisfaction appears to be very good and team performance appears to be very good overall. The overall student satisfaction, the absence of significant team conflicts and the

elimination of dysfunctional teams may also be important observations but does not eliminate under performing teams.

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