



A Student Mentored Design Challenge Competition for First Semester Freshmen Engineering Students

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Introduction

Statistics at the University of Hawai'i at Mānoa College of Engineering show that over the past several years, retention rates for incoming engineering freshmen to the second year have been steady at around 50%. At minimum, the college aims to increase retention rates to at least 65%. In 2012, the college began to look at ways to increase retention, beginning with the implementation of a recommended but non-mandatory introduction to engineering course and then followed by a residential living program for engineering freshmen. The average incoming engineering freshmen population is about 200 students. The introduction to engineering course capacity is 40 students and the residential living program serves just about 30 students. Because these programs have limited enrollment compared to the entire population, they only impact less than half of the incoming freshmen. While these engaged experiences have demonstrated some increase in retention, the college's retention rate still remains below the minimum desired 65% from the freshman year to the sophomore year.

This paper summarizes the efforts to introduce a student mentored first semester freshmen engineering design challenge, called the Holmes Hall Freshmen Challenge, with goals to increase retention from first to second year while building community and support for first year freshmen. The challenge is introduced to freshmen at the college orientation, which draws a greater number of students than the previously mentioned programs. Typically over 100 incoming engineering freshmen, participate in the college orientation so the program is offered to over half of the incoming freshmen.

Research has shown that combinations of programs for first year freshmen such as learning communities, peer and faculty mentoring, introductory courses, and team projects,¹ have positive effects on retention. Engaging freshmen in team based design projects²⁻³ and providing mentorship opportunities⁴⁻⁶ have been shown to increase student retention and success. In addition to providing mentorship and a team based project, this program also aims to increase freshmen participation in various engineering society student chapters, begin to identify motivated students and student leaders within the freshmen population, and develop leadership and mentorship skills in the upper division students. The program also helps to keep freshmen connected to engineering during their first year in college. During the first year, the engineering curriculum does not have any mandatory engineering classes so students are typically only taking their math, science, and general education courses. This can easily make the engineering freshmen feel disconnected from the college of engineering. To further connect freshmen to the college, the challenge incorporates the main engineering building, Holmes Hall. All of the above aspects were incorporated into the program to increase students' sense of belonging to the college and engineering community which has been shown to increase the likelihood that a student will stay and ultimately finish in engineering.⁷

As the program is currently in its pilot stage, preliminary results on persistence from first to second semester and the results of the participant and mentor surveys will be presented. The

implementation of the challenge will be discussed, including identified issues and recommendations for future implementation.

Program Overview

The Challenge – The Holmes Hall Freshmen Challenge was a semester long design competition between teams of first year freshmen to solve a problem using the engineering design process under the mentorship of upper division students from the engineering societies (such as IEEE, ASME, ASCE, SWE, etc.). The challenge allowed for the possibility of different multidisciplinary solutions that could introduce freshmen to the different engineering disciplines/majors.

Each team was to design, construct, and test a device or system of devices that could transport a standard tennis ball from a marked location on the 3rd floor of the engineering hall to the marked zones on the 2nd floor of the engineering hall as shown in figures 1 and 2. Each zone as shown in figure 2 was worth a different amount of points as described in the scoring criteria in table 1. The challenge was designed with the idea that delivering the ball to a particular area without a direct line of sight path would be difficult and relate to real life situations in which materials need to be transported in difficult environments. The challenge was also designed to be different from other more popular challenges, like egg drops, trebuchet/launcher, and rockets, to encourage innovative thinking. Since the challenge was not similar to other popular challenges, students would not be able to copy designs from the internet and other sources.

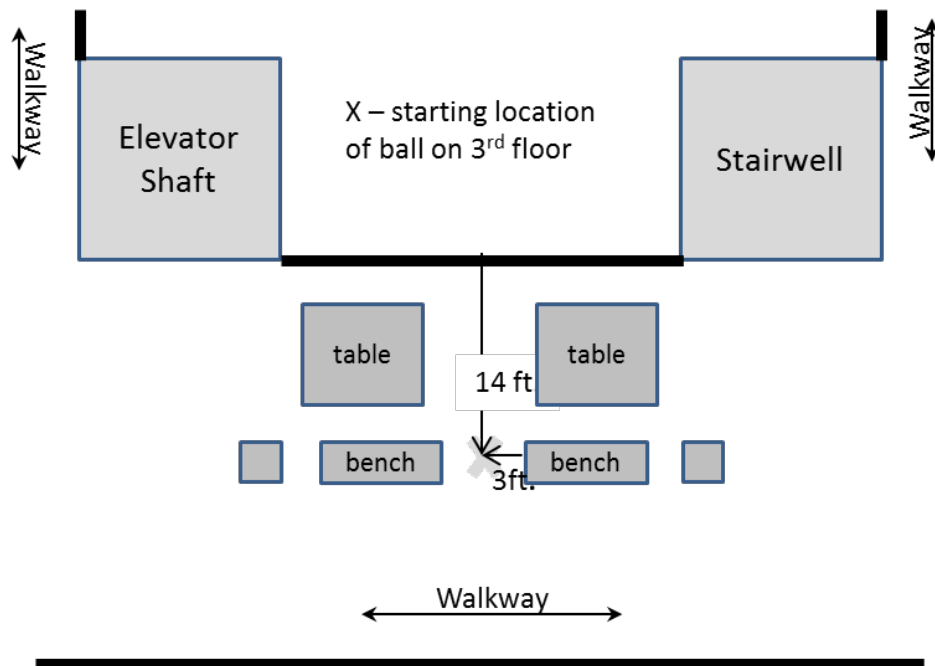


Figure 1. Top down view of 3rd floor with starting point designated with an “x”.

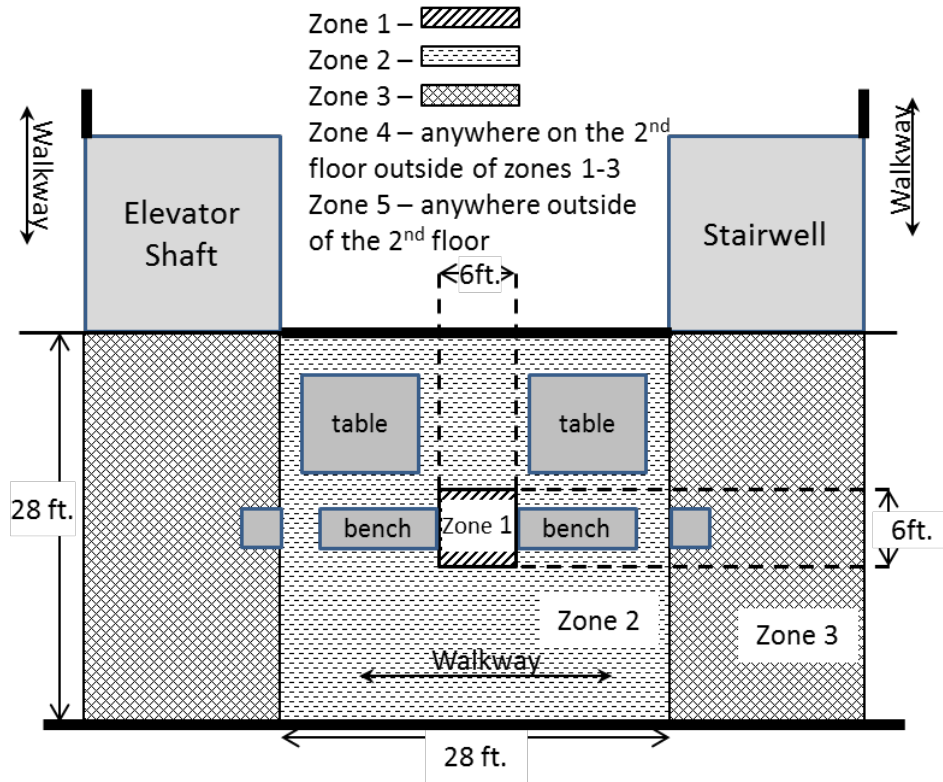


Figure 2. Top down view of 2nd floor with marked zones.

Holmes Hall is an open atrium building and the challenge area included portions of the two floors that were located right above and below each other. Railings border all walkways and so many paths exist to get from the third floor to the second floor, such as over the railings, through the open stairwell, or even by elevator. When the challenge was introduced to the student organization mentors, the mentors of different majors each had ideas of how to accomplish the task with concepts from their disciplines (pulley systems, robotics, track systems, etc.). Discussing the challenge with mentors provided a check that the challenge would be feasible for freshmen and would not give an advantage to any team working with mentors from a particular major/discipline.

Teams were also given the following rules and constraints for their designs/devices.

- Budget limited to \$75 per group
- Use of recycled/reused materials encouraged and do not count towards the budget
- No pre-made kits or toys
- No dangerous materials (explosives, hazardous acids, etc.)
- Device must be free standing
- No handling of ball by person once ball is in motion.
- Device setup should be completed within 5 minutes
- Device and setup should cause NO destruction to the engineering hall

- Personal safety: Set up & operating device should not place anyone in dangerous position.
- Rules/Constraints may be altered should consistent challenges arise amongst all groups and will be determined by program facilitators. Should modifications occur, all groups are to be notified at the same time.

Halfway through the semester, teams asked if they could put parts of their design on the second floor in the target zones. Since it was somewhat late into the semester and most teams had already planned that as part of their designs, the decision was made to allow it. However, allowing students to place parts of their design in the target zones ended up making the challenge too easy and almost all teams created similar solutions.

All but one team created the same design. This design incorporated some kind of tubing that ran from the start point on the third floor over the railing and ended in a box on bag placed in the most favorable zone, zone 1, on the second floor. They inclined the tube so that the ball would naturally roll down from the start point to the end point in zone 1. Because of this, students were able to get around the challenge of controlling the landing of ball reliably into zone 1. The other team that did not have the previous design used a recycled desk fan to pull their tennis ball from the start point to zone 1. They placed their fan into zone 1 and tied a cord to one of the fan blades and the other end of the cord to their tennis ball. When they turned on the fan it pulled their ball over the railing to zone 1 on the second floor.

Allowing teams to modify the zones took out the challenge of controlling the delivery of the ball into the highest point zone reliably as many teams put some kind of physical stopping barrier in that zone. In the future, when using this challenge it is recommended to clearly add to the rules that teams are not allowed to set up anything in the target zones on the second floor. If teams cannot set up or touch anything on the second floor then the answer to reliably delivering the ball to zone 1 is not as clear and would require more innovative thinking and iteration of design.

Teams were required to demonstrate and a present their projects at the end of the semester to a panel of judges. The judges included various engineering faculty, staff and administration, who scored each demonstration and presentation using the criteria in tables 1 and 2. Demonstrations included each team running their device 3 times to show reliability and average speed of delivery. Based on the scoring criteria, the team and mentor organization with the highest score would win the competition and have their team and organization names engraved onto the challenge perpetual plaque, which would hang in the engineering student lounge/study area.

Table 1. Scoring Criteria for Demonstration

Scoring Criteria	Details	Points
Completion of Task	Deliver the tennis ball from the 3 rd floor to the 2 nd floor in a marked zone at least once. Highest point zone will be counted.	8 points – Zone 1 5 points – Zone 2 3 points – Zone 3 1 point – Zone 4
Reliability/	Deliver the tennis ball to the	5 points for 3 times to

Repeatability	same zone repeatedly	same zone 2 points for 2 times to same zone 0 point for not reaching the same zone
Speed	Average time of all 3 runs from start of the device to the tennis ball landing	3 points for fastest team average 2 points for second fastest 1 point for third fastest
Creativity	Creative use of materials, mechanisms	Possible 5 points
Contact	If a team member must touch or adjust the ball after the run has started	-1 points for each infraction
Teamwork	Team members must be present at all monthly meetings. Each member should be involved in presentation or answering of questions at Final presentations.	-1 point for each member missing monthly meeting -.5 point for any member not included in final presentation
Final Presentations	See Presentation Evaluation for details	Possible 10 points for Final

Table 2. Criteria for Final Presentations

Presentation Criteria	Details
Introduction	Introduce each team member and what the team will be covering in the presentation
Clarity & Content	Ideas and descriptions should be easy to understand and clearly conveyed through either oral or visual means Should include initial design idea and challenges that you faced and how you overcame them
Teamwork	Each team member should be involved in either the presentation itself or the answering of questions. They should also be present at all monthly meetings.
Conclusion	Summarize the outcome of the project, what you learned, and what you would do next (future work)
Questions	How well the team handles and answers questions

Implementation – Prior to the college orientation, student organizations were solicited to mentor freshman teams participating in the challenge. The challenge was introduced to the freshmen at the college orientation just before the start of school. Mandatory follow-up/progress meetings were then lead by mentors on a monthly basis for the rest of the fall semester.

The number of freshman students originally participating was 89. Students were randomly assigned to one of seven teams, led by the one of the seven participating student organizations.

Teams were purposely not separated by majors to create an opportunity for all disciplines to contribute different perspectives in developing their designs. The average size of each group was 12 students. As the semester progressed, the number of students in groups decreased as some students chose to drop out, with the smallest group dropping to 4 students.

Freshmen were informed of the challenge and that they were to be assigned to teams the day of Blueprints, the College of Engineering orientation event. In the morning session of Blueprints, each student was designated a team by a number on their nametags and were told that they could not switch teams. This was purposefully done to force students to get to know new people (not group together with friends from high school) and also to keep the amount of members even on each team. During lunch, the student organization mentors met with their assigned teams facilitated by an announcement to sit with their student number groups. In the last session of the Blueprints, mentors led their first meeting with their teams to hold introductions and explain the challenge in separate assigned rooms.

The mandatory monthly meeting dates were decided with the student organization mentors and freshmen input to ensure that all students could commit to times that would work best for them. Student organization mentors were asked to take an active role in the decision making process and develop a consensus among groups on meeting times for the semester. Logistically, having all teams meet at the same day and time made it easier for facilitators who would be providing food, bringing supplies, and announcing updates. Beyond the mandatory meetings, mentors and freshmen were encouraged to meet more often on their own as needed.

Mentors were also in charge of helping teams with purchase requests for supplies and materials. Instructions were given to mentors on how to submit request for purchases. Mentors were also given several deadline reminders for submitting purchase requests. In addition, mentors were asked to encourage their teams to use recycled material, to be cost efficient with their budgets. Facilitators ended up doing only one supply run, while a few teams purchased items on their own, with prior facilitator approval, and submitted receipts for reimbursement. Four of the seven groups purchased items through requests and three of the four groups submitted receipts for reimbursement.

An engineering student leader who worked with the facilitators and was not involved in mentoring a team was selected to be the point person to stay in closer contact with the mentors. This point person organized and ran most of the mandatory monthly meetings. During mandatory meetings, this point person and at least one facilitator made announcements to all participants and mentors and also checked in with each group to make sure any questions were answered.

Mentorship – The mentors were a combination of current undergraduate and graduate students involved in various engineering student organizations and represented all engineering majors offered by the college. An email was sent to all of our student organizations that were interested in expanding their role at the college orientation. Normally student organizations are invited to orientation to mingle with freshmen and recruit them to join their organization. They were notified of this new opportunity to serve as mentors in leading the freshmen in a design challenge competition. Not only would they be able to build more solid connections with the freshmen,

who are notoriously difficult to recruit, but they would also have the chance to practice and improve their leadership skills.

Facilitators held three meetings just before the start of the program to introduce both the challenge and the mentorship expectations to each student organization. All mentors were given the same information that included the details of the challenge as well as a written mentorship guide. The mentorship guide provided a breakdown of the engineering design process and outlined milestones in engineering design process that they should aim for throughout the semester. The meetings and the written guide also included information on facilitating their team’s progress and not just doing the work for their freshmen. The mentors were expected to work with each of their freshman groups, by serving as resources and points of support. Representatives from each student organization (not necessarily the same people each meeting) were required to be present to mentor their teams at each mandatory monthly meeting.

The mentors were also charged with the responsibility to communicate with their teams outside of the mandatory meetings, whether it be checking in with them, reminding them of upcoming meetings or answering any questions in regards to completing their project. Additionally, the mentors were expected to share with their teams any information disseminated by the student point person and facilitators.

Program Assessment Tools

To assess how well the program achieved its goals and to gain an understanding of the student experiences, surveys were created for the freshmen participants and the mentors as shown in tables 3 and 4, respectively. The surveys were distributed to the students during the final mandatory meeting of the semester, which was the presentation/demonstration event. Each question had a possible rating between 4 (positive result) and 1 (non-positive result). The survey also allowed for students to comment on what they liked or disliked about the program and to provide recommendations to the facilitators.

Table 3. Freshmen Participant End of Program Survey Questions

1. Did you enjoy being a part of this program?
2. Do you feel like the program details and purpose were well communicated to you?
3. Were you able to connect/get along with your student organization mentors?
4. a. Do you feel more connected to the engineering college by making meaningful relationships with Freshmen Peers
4. b. Do you feel more connected to the engineering college by making meaningful relationships with Student Mentors
4. c. Do you feel more connected to the engineering college by making meaningful relationships with Faculty/Staff
5. Would you have liked to meet with your mentor more often?
6. Did participating in this program and working with your mentors help you with your studies and/or school life?
7. Do you feel like you have gained knowledge and experience about

the engineering design process?
8. Do you feel like you learned more about the different engineering disciplines?
9. Do you feel like you have improved your teamwork skills?
10. Do you feel like you have improved your communication skills (interpersonal and presentation)?
11. Would you recommend this program to future freshmen?

Table 4. Mentor End of Program Survey Questions

1. How would you describe the quality of your experience as a mentor in the program?
2. Would you have liked additional training for mentors?
3. How clearly defined were your mentor responsibilities?
4. The program coordinators were accessible and easy to talk to and seek advice from when necessary.
5. How would you describe your relationship with your mentees?
6. Do you think that the time you spent with your mentees was sufficient?
7. Do you think that the time you spent together was helpful for your mentee?
8. Did you think your student organization has gained from participating in this program?
9. Do you feel like you gained valuable experience from mentoring in this program?
10. Would you volunteer to serve as a mentor again next year or in the future?

Results

Since the program is in its pilot year, results on first to second year retention are not yet available. Instead, the preliminary impact of the program on first to second semester persistence will be presented as compared to previous years. Previous first to second semester persistence rates were calculated on incoming first time engineering freshmen cohorts as shown in table 5. Two more first to second semester persistence rates for the Fall 2014 incoming freshmen were calculated separately for challenge participants and non-participants. For Fall 2014, overall persistence for to the second semester was similar to the past few years. When broken down to into the rates for challenge participants and non-participants, 87.1% of non-participants persisted to the second semester. Of the non-participants that did not persist, 70% changed to a non-engineering major and 30% dropped out of the university. On the other hand, 96.2% of challenge participants persisted to the second semester. All challenge participants that did not persist to the second semester dropped out of the university. None of the challenge participants changed to a non-engineering major. These results show promise that participation in the challenge may have a positive effect on keeping students interested in an engineering major.

Table 5. Persistence rates from first to second semester for fall incoming freshmen cohorts

Incoming semester cohort	Fall 2011 Overall	Fall 2012 Overall	Fall 2013 Overall	Fall 2014 Overall	Fall 2014 Challenge participants	Fall 2014 Challenge non-participants
Persistence rate	92%	85.7%	83.7%	90.1%	96.2%	87.1%
Total number of students in cohort	212	238	228	233	78	155

The end of the program surveys as listed in the previous section in tables 3 and 4 also provided insight into the freshmen and mentor experiences. From the survey results, there were both areas of success and areas of improvement identified. Many of the successful areas involved the relationship between students as follows:

- Freshmen highly rated their connection to both their freshmen peers and upper-classmen mentors
- Freshmen also highly rated their improved ability to work in teams
- Many freshmen cited that their favorite parts of the program was meeting other students and provided food
- Many freshmen also cited that they learned the importance of communication
- Mentors highly rated that both they personally and their mentees benefited from the experience
- Mentors also highly rated that their student organizations gained from participating
- Mentors also highly rated that project facilitators were easy to contact

Survey results from both freshmen and mentors show that the participating in the challenge did build a stronger sense of community among engineering students.

Many of the identified areas of improvement centered about a lack of preparation and communication.

- Freshmen did not appreciate being put into a mandatory semester long project with no warning
- Freshmen did not like the mandatory attendance at all monthly meetings (although they chose the meeting times themselves)
- Some freshmen felt that the challenge was not difficult enough (this was due to the previously mentioned rule change that inadvertently made the challenge too easy)
- Freshmen did not feel that they connected with faculty
- Mentors wanted more time to prepare (they were only notified less than a month before the start of the program)
- Mentors also wanted more mentorship training
- Mentors also wanted a clearer explanation of the challenge

It was recognized that students, both freshmen and mentors, needed to be informed much earlier to prepare for commitment to this program. The feedback received was that while most freshmen appreciated the benefit of meeting other students and experiencing a design project early in their college careers, they did not like the feeling of being forced to participate in a mandatory extra-curricular program.

In order to improve the program, the following steps will be taken during the spring semester in preparation for the following fall's challenge.

- Provide mentorship training to the student organizations in the spring semester
- Sending notifications to incoming freshman beginning in May that include information about participation in the challenge in the fall semester
- Soliciting more faculty to get involved in developing new challenges
- Soliciting more faculty to get involved with mentorship of teams

Conclusion

Overall the program worked in connecting incoming freshman with each other and their mentors to create relationships that may continue beyond the challenge. As the results show, the freshmen were appreciative of the opportunity to work closely with other engineering students that they otherwise would not have without this program. In addition, persistence from the first to second semester data shows that the challenge may have a role in keeping students interested in majoring in engineering. The College of Engineering has decided to continue this program as part of the package of programs that engineering freshmen can participate in during their first year. Many areas of improvement were identified and plans have been made to address these issues for the next run of the program. So far the program has shown some initial promise, as more data is collected and as more cohorts move through the program, the impact of the program will become clearer. Until then, future work will include following up with participants as they progress through their college careers, by collecting data on their retention, graduation, and involvement in engineering student organizations.

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