Program Assessment of a Living and Learning Community for Women in Engineering at Oklahoma State University

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Abstract - Women students in engineering at Oklahoma State University can choose to make their home in Allen Hall, affectionately known as Maude's Quad. Maude Spear was the first woman to graduate in engineering from Oklahoma A&M University in 1915. She studied architecture and was determined to rise to the top in her profession. She also was the only female member of the Senior Engineering Club. Maude's Quad has been in existence since fall 2005. Allen Hall consists of suites of 4 one-bedroom, two-bathroom units with a common living room. The program components include a learning community, career exploration and course clustering. The staff includes a chemical engineering faculty member, an academic advisor, and a residential life coordinator.

The course clustering consisted of placing students in common math and science courses. The science courses were chemistry, biology and physics and the math courses ranged from college algebra to third semester calculus. The students were put into the courses based on their academic ability. For the career exploration, the students were placed in a common "Introduction to Engineering" course. The class met for 15 hours during the semester, with extra time for meetings with success coaches/peer mentors. The six main areas covered in the class were academic success, professional success, engineering information, engineering design and problem solving, societal issues of engineers, and personal development.

Background

Living and learning environments have started to gain popularity for a variety of students in college. These programs incorporate a living environment and a common academic experience[1]. Typically these students earn a higher GPA than similar students, have higher persistence rates in majors, and involve themselves in their institutions more. Student also report more enjoyment in their academics and show higher gains in critical thinking. For females, in the STEM areas, recent studies have not been generalizable or conclusive as of yet[1].

Several universities offer living and learning communities for their female engineering students. These include Ohio State University and the University of Memphis. The Memphis program includes a focus on mentoring[2]. The Ohio State program includes a design competition[3]. There are a number of Women in Science and Engineering (WISE) Living and Learning Communities nationwide.

The Women in Engineering Program has been in existence since 1991 with the addition of Dr. Karen High (author) as a Chemical Engineering faculty member and coordinator of the Women in Engineering programs. Dr. High assumed full time status on the Chemical Engineering Faculty in 1996. Since then there have two additional coordinators of the program, Pam Waterman and Jennifer Hamby. Jennifer Hamby renamed the program Women in Engineering,

Architecture and Technology (WEAT) to reflect the full spectrum of students in the College of Engineering, Architecture and Technology. The program has been involved with many initiatives including the Society of Women Engineers (SWE), summer residential programs for High School students, mentoring programs, high school girl fall programs, and advisement of female students. Jennifer Hamby left OSU in the summer of 2006 and the college is currently looking for a replacement.

Jennifer Hamby initiated Maude's Quad in the fall of 2005 with Sharon Stead (co-author) of Residential Life. Jennifer served as advisor for the students as well as Introduction to Engineering instructor in 2005. In 2006, Susan Phillips (co-author) served as academic advisor and Dr. Karen High served as Introduction to Engineering instructor in 2006. The 20 students for Maude's Quad are selected in the spring and early summer. The selection is based on ACT scores as well as high school grades. The students attend summer enrollment and are placed in their courses at that time. Allen Hall is a desirable location for students as it is very close to campus. The units are fully furnished and have internet capability. The students were randomly assigned roommates, unless they had a particular roommate request.

Course Clustering

In June, the students were placed in math and science courses based on their abilities as determined by their High School transcript and ACT scores. Oklahoma State University uses ACT scores for admission. Clustering of courses did not happen in either the spring of 2006 or spring 2007.

Table 1 – Number of Maude's Quad Students in Science and Math Courses

Science Course	2005	2006	Math Course	2005	2006
Intro Chemistry*	5	3	College Algebra*		1
General Engineering Chemistry	11	12	Trigonometry*	1	2
Intro Biology		3	College Alg. And Trigonometry*	5	6
Intro Physics	3	2	Calculus I	8	7
Geology	1		Calculus II	5	3
			Calculus III	1	1

* Does not count towards degree. Intro Chemistry is taken by students not prepared to take the Chemistry that is required for Chemical Engineering. Calculus I is the first math course that counts towards the student's degree and has a prerequisite of College Algebra and Trigonometry.

The Introduction to Engineering Course

As part of the Maude's quad experience, the students take a common "Engineering 1111" course. The class is a freshman level, one hour course, "Introduction to Engineering." In the fall of 2005, the Maude's quad section was taught by Jennifer Hamby and consisted of many topics relevant to women in engineering. The course has been taught by Dr. Karen High for eight years in sections predominantly for chemical engineers. Dr. Karen High taught three of these sections with a total of 66 students during the fall 2006 term. Two of these sections were populated with "engineering entrepreneurship" students. The third section was for Maude's Quad. Susan Phillips also taught a section specific to chemical engineering in the fall of 2006.

The major goal of this course is to increase the retention of freshman students in the college by introducing the students to engineering concepts and experiences. The class meets for 15 hours during the semester. Essentially, this course addresses "professional skills" as defined by ABET criteria. There are 25 sections of the class that are taught in the college with each section typically having 21 students.

These sections of the course are made up of college freshmen who have chosen any engineering major. Class meets for 15 hours during the semester, plus extra time for meetings with success coaches/peer mentors and additional speakers. The six main areas covered in the class are detailed below:

- Academic Success- study skills, time management, finding help for classroom material, test-taking skills, and college survival skills.
- Professional Success – career planning and effective presentations.
- Engineering Information – career and advisement information and research presentations/laboratory tours.
- Engineering Design and Problem Solving – creativity, effective teams, brainstorming, process design, and product design.
- Societal Issues of Engineers – ethics, diversity/international issues, environmental issues/sustainability, medicine and bioengineering.
- Personal Development – stress management and other wellness issues.

As part of the sections that are taught by Dr. High, cooperative hands on activities are provided. This course is a particularly good class to do problem-based, cooperative activities because it addresses the goal of giving students engineering experiences and if the activities truly engage the students, can be excellent retention tools. One of the main such activities is the Airplane Design Challenge. The 2006 Maude's quad women very much enjoyed this activity. Additionally, the students performed a "slime" process and product design project that they also found very enjoyable.

The Airplane Design Challenge

The cooperative, in-class activity, "The Airplane Design Challenge" asks students to jointly find solutions to the problem of designing an airplane with limited materials and production challenges in order to learn the essential notions of engineering process and product design. The written assignment tasks students to complete a reflective assignment in which they consider their impressions from the activity, how well their group functioned together, describe their group's product and process design, provide definitions of product and process design and draw conclusions about what this exercise tells them about what engineering is and what an engineer does.

The Airplane Design Challenge was developed for this course because it is problem-based, gives students a chance at cooperative learning, involves dialogic opportunities for thinking, makes students consider other perspectives, builds team learning, promotes student engagement, and simulates how the design process/product works and helps them make connections to what engineering is all about.

The airplane challenge is done in the 5th week of the semester because the students have had a chance to get to know each other which make the teamwork easier. Also, it gets them engaged early enough so they can use these experiences to help in later semester activities. The airplane challenge is an activity that is done in a fifty minute class period. The students first are placed in a multidisciplinary group of 3-4 and are then tasked with determining a group name. Once they have the group name determined they are given a handout with the challenge (see High and Damron's[4] work for details).

The teams are to take toothpicks, rubber bands, paper clips, tootsie rolls, post it notes, lifesavers and gum and design a prototype airplane (doesn't have to fly). The team then designs a process/method to manufacture the airplanes considering that process calamities and upsets might occur during this phase (for example – a student might be made to simulate a work related accident by not allowing them to use an arm or supply chain issues are simulated by removing some of their tootsie rolls or power outages simulated by shutting off the lights and not allowing anyone to work). The teams then build as many airplanes as they can in 10 minutes and deliver them in a shipping container (lunch bag). All students then rank individually the group designs for those that meet specifications (looks like an airplane). The team that receives the most points wins the product design contest. The process design contest is won by the teams that produce the most airplanes. The students kept track of details in a lab notebook.

The Writing Assignment

This assignment was designed based on the author's experience with the University Critical Thinking Assessment Committee. The work of the committee has revealed that there are not many freshman-level courses in the university that require or assess critical thinking. The components of the assignment were developed to specifically address the University level rubrics so that the artifacts from the assignment could be used by the committee. The author felt that this would be a unique opportunity for the Engineering students to experience a different kind of writing assignment than they had faced in their English composition class. They were writing and assessing an in-class engineering experience. The students were also given a copy of the writing assignment (see High and Damron's[4] work for details) at the beginning of the hour so that they knew what was expected of them. This provided for meaningful entries in their lab books.

The writing assignment was due in the seventh week of the semester which was two weeks after the in-class challenge. Design resources[5,6,7,8] were given to help the students understand engineering product and process design concepts. The students were tasked with finding a reference that they can use as evidence to support their claims about the airplane design challenge and its ability to help them understand the difference between product and process design.

The students were asked to consider how their groups functioned together because group work is a very important part of engineering and it is important for the students to start considering what makes a good team and how they can be good team members as addressed by ABET. The students were asked to use an additional resource outside of the ones provided by the instructor to force the students to learn to research literature. The assignment was also written to get the

students to realize that the exercise itself required critical thinking. The exercise made them question their own assumptions about design and engineering. It required them to consider alternatives in both the product and process design phase.

Demographics of Students

The Airplane Design Challenge and critical writing assignment were given to Dr. High's three sections of Engineering 1111. They are highlighted here to show some comparisons between general sections and the Maude's quad section. The three section demographics are given as follows:

Section A:

- 23 Students (3 males did not complete the assignment) 16 male and 7 female
- Male and Female students in an Entrepreneurship Engineering section
- All engineering majors
- One of the first sections of Engineering 1111 to fill up (cap usually is 21 students)

Section B (the focus of this paper):

- 19 Students (one of the 20 students dropped out of Maude's Quad early in the semester and transferred to another section)(all completed assignment)
- All Female students in Women in Engineering Section
- All engineering majors

Section C:

- 24 Students (2 males did not complete the assignment) 19 male and 5 female
- Male and Female students in an Entrepreneurship Engineering section
- All engineering majors
- Section opened up during the middle of summer enrollment after Section A filled

Dr. High hypothesized that the all female group would perform the best on the written assignment and would show higher critical thinking ability. This is based on Dr. High's knowledge of the students for the 5 weeks as well as prior experiences with highly motivated female engineering students. It was also expected that Section A would perform very well because of their desire to enroll early, be in an engineering entrepreneurship section, and the experiences from the first 5 weeks. Students who are interested in Entrepreneurship tend to be go getters and self starters. Section C was expected to perform the lowest on the assignment. These students hadn't been very engaging in the first weeks of the semester and had a very lackadaisical attitude. They had already established a pattern of complaining about any amount of work. These three sections provided an opportunity to compare an all female section with other typical sections.

The Slime Project

To continue to reinforce process and product design to the students, the Maude's quad section in 2006 completed the slime project. For the multi-week slime project, the students were given a recipe and procedure to follow to make slime from poly(vinyl alcohol) bags (see High and Yauch[9] for details). They were also given relevant cost information.

There were two components of the design project: to come up with a robust process to manufacture the slime and to develop a new product that used the slime as a basis. The students were motivated by an ending evaluation that selected the best new product and the best product presentation.

Safety and environmental issues were addressed, as well as background information on polymerization. The students were then tasked with developing a process to make their slime, and they produced their first batch. Next, the students prepared a second batch but were confronted with process upsets and/or environmental changes. These included supply issues, loss of group members, sitting versus standing, and changing the assigned tasks. Performance and quality control issues were discussed. The next session involved brainstorming about products that could be developed from slime. The students were to think about the name of their product, how it would be packaged and how the process would be impacted. They were also tasked with determining product cost and marketing plans. The students then purchased and were reimbursed for supplies to make their product.

For their final PowerPoint presentation, the students were asked to incorporate the following (in 6-7 slides): title slide (with group name and members listed); assignment; name and function of product; changes in product and process from original; new process flowchart; packaging; marketing plan; costing and pricing; and what concepts of engineering have you learned from the Slime Project? The judges selected the best presentation, the best new product and the best overall (equally weighting the presentation and product). For this class, the best product that was developed was a pair of jeans that had "bun enhancers" made from the slime.

Non Academic Activities

In addition to academic activities completed in the Introduction to Engineering Section, a number of non academic, fun things were done. One of the first get-togethers was a welcome at Karen High's house. This was a low stress, fun dinner where the girls got to meet Sharon Stead, Susan Phillips, Dr. High and her family. The students really enjoyed getting bussed to the dinner in a University bus. An additional get together for Christmas happened at Susan Phillips' house. The students completed a service project where shoeboxes were filled with small items (toys, toiletries, stationery, etc.) to be sent to international children. Another service project that the students helped with was a Girl Scout science night at the end of the semester.

Assessment

The fall 2005 Maude's Quad first semester average GPA was 3.227 and for the fall of 2006 it was 3.179. One of the 2006 students left the quad in the middle of the first semester and had quite a lot of academic challenges (0.833 GPA for the semester). The other 19 fall 2006 students had an average GPA of 3.202. The fall 2005 Maude's Quad students who are still in Engineering have a cumulative GPA of 3.145. For fall 2006, all freshmen in the College had a GPA of 2.667. The GPA for women in the college was 2.959 for fall 2006. Statistics from fall 2005 are comparable. Three of the seven women in engineering who received a 4.0 GPA for fall 2006 were in Maude's Quad. Twenty five total students received a 4.0 GPA for fall 2006. Of the 400 fall 2006 freshman students, 71 were females (17.8%).

Retention numbers are also positive. Of the fall 2005 group, 14 of the 20 students are still in engineering. Two of the students have left OSU, the other four transferred to psychology, business, chemistry and microbiology at OSU. For the fall 2006 group, all students are still enrolled in engineering; however one is on academic probation, so it is not clear that she will remain in the college. This student moved out of Maude's quad in the middle of the fall semester. The 70% retention of the 2005 group compares very favorably with the general retention in the college of 48.9% freshman in 2005 remaining in engineering.

At the end of the fall 2006 semester, an assessment was administered. The open ended questions follow with typical representative student responses.

1. What went into your decision to be a part of Maude's Quad?
   "The fact that I could easily meet other ladies in the engineering field"
   "I really wanted to meet a strong support of other women in engineering to help me get used to college life and engineering classes"
   "Being able to room with other women in engineering"
   "To help with my education and decision in engineering fields of study"
   "I already knew one of the other girls and thought it would be helpful to live with other girls of the same type of major"
   "I knew no one on campus and felt the program might give me a head start in forming friendships and succeeding in engineering."

2. Comment on the living community in Allen Residence Hall. Were your expectations met? Why or why not?
   16 of the 19 students said that their expectations were met.
   "I really enjoyed living in Allen, the rooms are nice and I got along with everyone."
   "It is a great place but I have had a taxing roommate and constant problems regarding noise above me (in 401). Also, several things in the room routinely break down, but things break."
   "I wanted to be some what isolated and in an area with few people and that happened."
   "I got to meet new people with similar interests. I like it better than the typical noisy crazy dorm life. Allen hall is a great environment that promotes studying and learning"
   "There weren't very many planned activities in the dorm."

3. Comment on the course clustering. Were your expectations met? Why or why not?
   13 of the 19 students said that their expectations were met.
   "The clustering provided built-in study groups. However it got me a little off track in my major courses"
   "I really like the course clustering it was great I wish we could have done it 2nd semester"
   "At first I wasn't aware of who anyone was involved in my classes other than my suitemates, but eventually I met people and we've been helping each other."
   "Class clustering was very helpful especially when needing to find a study buddy."
   "Too many people had different classes."

"The math I took no one else was taking and only one other person was taking physics but it seemed to work for everyone else."
"I thought everyone in Maude's Quad would be in the same classes."

4. Comment on the Introduction to Engineering course. Were your expectations met? Why or why not?

12 of the 19 students said that their expectations were met.
"I would have liked to learn more about what chemical engineers do, but that is difficult when there are many different engineers."
"I liked the overall course but I am not a fan of the success coaches because I knew where everything was."
"The last project is the most engineer- like."
"Didn't exactly know what to expect but did get a nice feel for whether or not this is something I am capable of making a career out of and actually liking."
"I really liked it because it was educational and fun."
"I thought we would do more engineering and less welcome to OSU."
"Some of the assignments were a little time consuming for the credit but the projects were fun."
"I would have enjoyed more strictly engineering related activities, such as tours of labs and explorations of majors."

5. Do you plan to stay in Engineering? If so, what major? If not, what major are you switching to?

18 of 19 plan to stay in engineering and 1 is undecided
Electrical – 2; Chemical – 3; Industrial – 3; Mechanical – 6; Architectural – 1
Electrical and Computer – 1; Aero and Mechanical – 1; Civil – 1; Undecided - 1

6. How did Maude's Quad (the living community, the course clustering, or ENGR 1111) affect your decision to stay in or leave engineering?

"I am more confident now that I can handle the studies and the team projects."
"I have women friends in engineering to encourage me."
"Knowing that other people struggle in a similar manner made me not feel as outcast."
"It helped me feel more welcome in the college by getting a steady friend base and helped me get to know some faculty."
"I would say it helped a lot. I think the Engr. 1111 class was especially relevant."
"It had a big difference in making me stay."
"I was pretty decided before I came here."
"With Maude's Quad, I feel like I have made many friends in the Eng. department which will be beneficial in the real world."

7. How could Dr. High, Susan Phillips and/or Sharon Stead have improved your experiences in Maude's Quad?

"The course clustering could take into account our major course plans, and the class time could be more structured."
"We could have clustered for the second semester also."
"More help with schedules."

"I think they did great"

The students were given a 5-point Likert Scale to evaluate their agreement with the following statements. Strongly disagree was 1 and strongly agree was 5. Neutral is 3. The average result is given with the statement.

1. **3.58** I am comfortable using a Lab Book.
2. **4.00** I know the concepts of product and process innovation.
3. **3.89** I understand engineering design approaches.
4. **4.00** I understand problem solving and problem definition.
5. **4.37** I am comfortable working in groups/on teams.
6. **3.68** I know the types of things that are done in my discipline of engineering.
7. **4.21** I am confident in my brainstorming and creativity abilities to solve problems.
8. **3.79** I am confident giving presentations using Power Point.
9. **3.37** I am confident in my MS Word and EXCEL abilities.
10. **3.37** I know what polymerization is.
11. **3.95** I know how to determine production costs, price a product and market the product.
12. **3.47** The ENGR 1111 course helped me decide to stay in engineering.
13. **4.26** The course clustering was very useful to me.
14. **4.21** The living community was beneficial to me.

The most positive agreement was for the statements about working in groups/on teams and for the course clustering. The lowest scores were for confidence in MS Word and EXCEL and for polymerization. All statements received positive agreement (scores over neutral of 3.00).

The next part of the survey was to evaluate the effectiveness of the speakers in the course. Not effective was 1 and extremely effective was 5. The average result is given after the statement.

1. **3.72** Safe Dating/Healthy Relationships
2. **3.47** Resume/Career Services
3. **3.87** Teamwork
4. **3.14** Student Panel
5. **3.67** Study Abroad
6. **3.37** Technical Writing/Presentation Skills
7. **3.05** Library

The two most effective speakers were on safe dating/healthy relationships and teamwork. The least effective speakers were the student panel and the library.

In another study[4], the writing skills and critical thinking/writing skills were assessed with the airplane contest assignment. The Maude's Quad section and the two mixed sections completed the writing assignment. A very interesting result was that when the authors ran a correlation between the overall writing scores and the overall critical thinking scores, there was a better correlation for the all female section. The R^2 for the correlation with all students was 0.6817 and the R^2 correlation for the female only section was 0.8533. The hypothesis is that while the critical thinking scores are fairly consistent (no statistically significant differences) among the

sections the writing scores were enough higher to give a better correlation between writing and critical thinking for Maude's Quad.

Concluding Comments and Future Directions

The authors felt that the Maude's Quad experience was a positive one for the students involved in both 2005 and 2006. The cohorts for both semesters felt particularly positive about the course clustering opportunities. There was definite perceived benefit of living with other female in engineering students. Plans are underway for recruiting for a fall 2007 cohort. The future direction of Maude's quad depends on the objectives of the new Women in Engineering Coordinator.

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