

Retention of Freshman Agricultural Engineering Students Through an Experiential Lab Course

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Abstract

Retention of freshman agricultural engineering (AE) students has been a struggle at Iowa State University (ISU) in past years. This has been attributed to the lack of interaction of the freshmen students with faculty, upperclassmen in AE, and meaningful exposure to the field of AE during their first two semesters. A laboratory-based, team orientated, and hands-on course was developed to help address this problem. Students took this course during their second semester at ISU. Using a pre- and post- semester questionnaire assessment tool, the success of the course was evaluated. Results showed that the students attitude toward the department improved significantly during the semester, that meaningful relationships with faculty and upperclassman in the department increased, and that they were still confident in the major they had chosen. Mentoring by upperclassmen was also found to be a very positive experience for the freshmen. The mentors also found the experience very valuable. An additional benefit was that students became more comfortable in writing technical lab reports. Faculty support was found to be excellent.

I. Introduction

Like most agricultural and/or biosystems engineering departments around the country, the Department of Agricultural and Biosystems Engineering (ABE) at Iowa State University has been looking for better ways to increase the retention of the students that we work so hard to recruit. Although our number of incoming freshmen over the past several years has ranged 30 to 40, our retention of these students has sometimes as low as 50% within the first two years. Part of the problem has been the lack of interaction between the faculty and upperclassmen with our freshmen agricultural engineering (AE) students within the first year. Pascarella (1980) has found that the quantity and quality of contact with faculty is strongly associated with student retention¹. Interaction with peers provides support, opportunities, and models for pro-social behavior². Students are also more likely to stay in college if they are satisfied with their learning experiences³. The main contact with the freshmen with faculty was through two R-credit courses that were offered the first and second semester of their freshman year. Each of these courses met for one hour a week and were mainly lecture format with little or no interaction with our AE students. To help combat this problem, the curriculum committee decided to develop a 1-credit interactive, hands-on agricultural engineering laboratory course to replace the R credit seminar course offered in the second semester of the freshman year. The course title changed from AE 110-Seminar to AE 110-Experiencing Agricultural and Biosystems Engineering. The original AE 110 course exposed the freshman to the various options within the AE curriculum through

lectures by various AE faculty and helped to get the students registered for the next semester. The new experiential course would expose students to several faculty and upperclassmen within the AE department in a meaningful setting. Upperclassmen were also obtained to help mentor the freshmen students during the labs and outside of class. The catalog description for the new AE 110 course is given as:

Laboratory-based, team-orientated experiences in a spectrum of topics common to the practice of agricultural and biosystems engineering. Report writing, coops, internships, and careers.

II. Background

A. AE 110 Course Objectives

The main goal of the new AE 110 course was to get the freshman students excited about the field of engineering they had chosen to increase retention within the department. The hypothesis being higher retention of freshmen student with higher interaction with the department in general. Specific course objectives are shown in table 1.

Table 1. Course Objectives.

- Build community for freshman within Agricultural Engineering
- Develop team skills
- Introduce students to various agricultural engineering experiences
- Learn of the various options within agricultural engineering
- Experience hands-on laboratories related to the AE options
- Increase student involvement within the Department of ABE
- Increase involvement in professional society and student branch
- Increase student interaction with upperclassmen
- Increase student retention in the AE program
- Build excitement for engineering
- Career development/job preparation
- Faculty mentoring in helping make option decisions
- Develop report writing skills
- Receive academic guidance on registering for classes

B. Course Design/Development

Since AE 110 was to be laboratory-based, it was necessary for the faculty to develop interesting hands-on, experiential laboratories that related to the options available with the AE curriculum. These options included Biosystems Engineering, Food and Process Engineering, Power and Machinery Engineering, Environmental and Natural Resources Engineering, and Structures and Environmental Systems Engineering. In all, nine different faculty developed ten labs. Intertwined with the hands-on laboratories was plant trips to local engineering companies, career guidance, community building, peer mentoring, faculty mentoring, report writing, portfolio development, and registration guidance. Two sections of the new AE 110 were offered in the spring of 1999 and one section was offered in the fall of 1999. Each section allowed for up to 16

students. One faculty member was the overall coordinator for the course. Table 2 shows the course syllabus for the spring 1999 sections of AE 110.

Table 2. AE 110 Course Syllabus

| Agricultural & Biosystems Engineering Department | | | AE 110 – Experiencing ABE | | |
|--|---------------------|----------------------|--|-----------------------------|--------------|
| Dr. Steven K. Mickelson | | | Spring 1999 | | |
| Lab Period | Section A Monday | Section B Tuesday | Topic/Activity | Professor in Charge | Meeting Room |
| 1 | JAN 11 | JAN 12 | Introduction/Team Building/ Student Portfolio's/ Pre- assessment | Dr. Mickelson | 142 |
| 2 | JAN 18-22 | | <i>Mentor Meetings – Community Building</i> | Dr. Mickelson | |
| 3 | JAN 25 | JAN 26 | Reverse Engineering – Watt-hour Meter | Dr. Bern | 143 |
| 4 | FEB 1 | FEB 2 | Electric Motor Testing Lab/ Graphing Data | Dr. Bern | 143 |
| 5 | FEB 8 | FEB 9 | Career Development/Job Opportunities/Faculty Mentors | Dr. Mickelson AE Faculty | 142 |
| 6 | FEB 15 | FEB 16 | Tractor Engines Evaluation/Analysis | Dr. Birrell | 147 |
| 7 | FEB 22 | FEB 23 | Introduction to Tractors and Machinery | Dr. Quick | 149 |
| 8 | MAR 1 | MAR 2 | Industry Visit – Sauer- Sunstrand Company, Ames | Dr. Mickelson | |
| 9 | MAR 8 | MAR 9 | Seed Quality – Seed Laboratory | Dr. Misra | Seed Lab |
| 10 | MAR 15-19 | | SPRING BREAK | | |
| 11 | MAR 23, 6 PM | | Registration Meeting/ Pizza Social | Advisors | 110 |
| 12 | MAR 29 | MAR 30 | Environmental Systems - Rainfall/Runoff | Dr. Baker | 142 |
| 13 | APR 5 | APR 6 | Environmental Control/ Instrumentation for Livestock | Dr. Hoff | 142 |
| 14 | APR 12 | APR 13 | Industry Visit | Dr. Mickelson | 125B |
| 15 | APR 19 | APR 20 | Biofeedback / Controls | Dr. Richard | 142 |
| 16 | APR 26 | APR 27 | Environmental Systems – Ventilation Fan Controllers | Dr. Harmon | 142 |
| 17 | MAY 3-7 | | <i>FINALS WEEK (Post- Assessment)</i> | Dr. Mickelson | 142 |

C. Grading/Report Assessment

Grades were determined by using attendance (20%), team participation (20%), and an individual laboratory portfolio (60%). Attendance was taken at each class; team participation was verified by the course coordinator during class and by the peer mentors outside of class; and the course coordinator evaluated the portfolios. The portfolios included all in-class assignments and the laboratory reports. Portfolios have been shown to be an effective way of assessing a student's work⁴. One of the objectives of AE 110 was to have the student learn correct laboratory report procedures and layout. To do this, each team member was given a technical report rubric that was to be used for self-evaluation of the laboratories. The portfolios were collected and graded at the end of the semester. The peer mentors were asked to meet with the team outside of class to help given guidance in relationship to the lab write up, in addition to helping facilitate team building efforts.

D. Peer Mentoring

To increase the exposure to upperclassmen and to help in the facilitation of the class periods, peer mentors were recruited. Peer mentors consisted of volunteer upperclassman who were willing to come to the weekly 2-hour labs and meet outside of class for one hour a week. During the labs the mentors were asked to help facilitate the group without doing the lab for them. They were only to give guidance when the team was not progressing or when clarification was needed. It was important that the peer mentors help keep each team member engaged in the lab activity. Peer mentors were paid a nominal hourly wage, although some declined this offer. Overall the peer mentor objectives were to:

- Give guidance during class laboratories
- Develop a connection between the freshmen and the upperclassmen
- Help to develop team roles
- Develop individual accountability within assigned team
- Encourage involvement within the departmental student organizations
- Give guidance on technical report writing

E. Cooperative Learning Teams

It was important for the success of the course to have effective cooperative learning groups. According to Johnson et al., 1991, the basic elements of a successful cooperative learning group is positive interdependence, face-to-face promotive interaction, individual accountability, social skills, and group processing⁵. Johnson and Johnson also stated that "Cooperative learning experiences, compared with competitive and individualistic ones, promote more positive attitudes toward the subject area, more positive attitudes toward the instructional experience, and more continuing motivation to learn more about the subject area being studied⁶." Typically the biggest concern amongst faculty with cooperative groups is the area of individual accountability. The students in our course were asked to commit to the following:

- Come to class
- Participate with team in class
- Meet with team and mentor outside of class

- Develop individual course portfolio to be handed in at midterm and final weeks for assessment

III. Course Assessment

In order to assess the success of the new AE 110 course, pre- and post- semester questionnaires were developed to evaluate a student's attitude toward the university, college, department, and their chosen major. Students were asked about how they learn best, concerns they had for the semester, and what academic support they would like. We also wanted to see if student would change options after experiencing the various laboratories. Also evaluated was student participation within the department, familiarity with other grade levels of AE students, familiarity with faculty, and comfort with writing a technical lab report.

Figure 1 shows the pre-evaluation questionnaire that was used during the first class period of the semester. Figure 2 shows the post-evaluation used during the last class period. A peer mentor evaluation was also given at the end of the semester to the peer mentors to obtain their assessment on the effectiveness of the peer mentoring process and the course design. Results from these questionnaires are given in the following section.

IV. Results

A. How the students learn best

When asked how they learned the best, the students responded in a variety of ways. The majority said they learned the best through hands-on, visual, and interactive modes. Grouping or collaborative learning was also mentioned several times. Here are some of their responses:

- Hard work
- By watching someone else do it.
- Study hard in the library.
- Hands on (3 students)
- When I study a lot.
- I learn best by doing problems and reviewing them.
- Watching others do something first.
- By writing things down and taking time to think about the underlying concepts.
- Listen & participate
- By applying myself
- Visually
- On my own or with a group of friends (2 students).
- Give me examples so I can see what's going on & then I can catch on by seeing what is happening.
- By concentrating on the work, usually by myself.
- I enjoy group work but then I only understand the part I did. I work best alone. Visual aids really help.
- Listening & watching someone talk about something or do something.
- I learn best by seeing examples and having it explained at the same time.

On a scale of 1 (bad) to 5 (excellent), how would you rank your experience at ISU so far?

On a scale of 1 (insufficient) to 5 (superior), how would you rank the help that you have received from the College of Engineering so far?

On a scale of 1 (insufficient) to 5 (superior), how would you rank the help that you have received from the ABE Department so far?

On a scale of 1 (unsure) to 5 (very confident), how strongly do you believe ABE is the correct major for you? Explain:

The Agricultural Engineering curriculum is comprised of five distinct option areas. Check the area or areas you are considering selecting as your area of concentration and explain why.

| | |
|--|-------|
| Biosystems Engineering | _____ |
| Environmental and Natural Resources Engineering | _____ |
| Food and Process Engineering | _____ |
| Power and Machinery Engineering | _____ |
| Structures and Environmental Systems Engineering | _____ |
| I'm not sure at this time what option is for me! | _____ |

Why?

Are you currently a member of?

| | | | |
|---------------------------|-----|----|-------------------|
| 1. The AE Student Branch | yes | no | thinking about it |
| 2. The AST Student Branch | yes | no | thinking about it |
| 3. Other student club(s) | yes | no | thinking about it |

If yes, please list the club(s) _____

About how many students in ABE do you know well enough to engage in a conversation?

| | |
|-------------|-------|
| Freshmen: | _____ |
| Sophomores: | _____ |
| Juniors: | _____ |
| Seniors: | _____ |

About how many faculty in ABE do you know well enough to engage in a conversation? _____

Describe any academic concerns you had about last semester.

Describe any academic concerns you are anticipating this semester.

What kind of assistance could we offer to help you address these concerns?

How do you learn best?

What things should happen in a classroom for you get the most out of class? (i.e., what can the instructor do in the classroom to help you learn?)

How competent are you in the following aspects of problem/lab presentation (1 =low, 5 = high):

| | |
|---|-------|
| 1. Recognizing and understanding the problem | _____ |
| 2. Accumulating facts and data | _____ |
| 3. Creating a problem diagram | _____ |
| 4. Selecting appropriate theory or principles | _____ |
| 5. Making necessary assumptions | _____ |
| 6. Showing necessary solution steps | _____ |
| 7. Graphing data | _____ |
| 8. Drawing conclusions | _____ |
| 9. Making generalizations to other situations | _____ |
| 10. Report formatting and layout | _____ |

Figure 1. Pre-evaluation questionnaire

On a scale of 1 (bad) to 5 (excellent), how would you rank your experience at ISU so far?

On a scale of 1 (insufficient) to 5 (superior), how would you rank the help that you have received from the College of Engineering so far?

On a scale of 1 (insufficient) to 5 (superior), how would you rank the help that you have received from the ABE Department so far?

On a scale of 1 (unsure) to 5 (very confident), how strongly do you believe ABE is the correct major for you? Explain:

The Agricultural Engineering curriculum is comprised of five distinct option areas. Check the area or areas you are considering selecting as your area of concentration and explain why.

| | |
|--|-------|
| Biosystems Engineering | _____ |
| Environmental and Natural Resources Engineering | _____ |
| Food and Process Engineering | _____ |
| Power and Machinery Engineering | _____ |
| Structures and Environmental Systems Engineering | _____ |
| I'm not sure at this time what option is for me! | _____ |

Are you currently a member of?

| | | | |
|------------------------|-----|----|-------------------|
| The AE Student Branch | yes | no | thinking about it |
| The AST Student Branch | yes | no | thinking about it |
| Other student club(s) | yes | no | thinking about it |

If yes, please list the club(s) _____

About how many students in ABE do you know well enough to engage in a conversation?

| | |
|-------------|-------|
| Freshman: | _____ |
| Sophomores: | _____ |
| Juniors: | _____ |
| Seniors: | _____ |

About how many faculty members in ABE do you know well enough to engage in a conversation? _____

Describe any academic concerns you had about this semester.

Describe any academic concerns you are anticipating next semester.

What kind of assistance could we offer to help you address these concerns?

How competent are you in the following aspects of problem/lab presentation (1 =low, 5 = high):

| | |
|--|-------|
| 1. Recognizing and understanding the problem | _____ |
| 11. Accumulating facts and data | _____ |
| 12. Creating a problem diagram | _____ |
| 13. Selecting appropriate theory or principles | _____ |
| 14. Making necessary assumptions | _____ |
| 15. Showing necessary solution steps | _____ |
| 16. Graphing data | _____ |
| 17. Drawing conclusions | _____ |
| 18. Making generalizations to other situations | _____ |
| 19. Report formatting and layout | _____ |

List four of the labs or events that made the greatest impression on you, starting with the greatest and working your way down.

Figure 2. Post-evaluation questionnaire for AE 110

- Working with other people and then on my own.
- In a group atmosphere.
- Group work and examples
- By having a good mixture of classroom instruction and hands on labs/experiments.
- With a group of people.
- By listening and observing and by hands on.
- By doing things.
- By having someone show me how to do a problem properly then I will do it over and over until I feel confident.
- I learn best during independent study/with tutor.

B. Student's attitude toward the university, college, department, and their chosen major

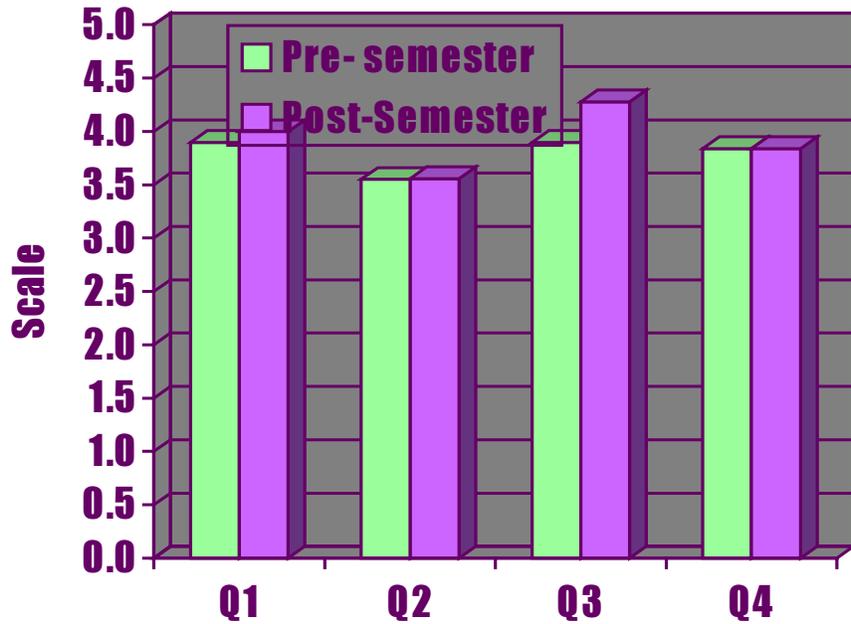
Student's attitudes toward the university, college, department, and his/her chosen major at the start and end of the semester are shown in Figure 3. The only significant change was in response to the help that the students received from the ABE department. Even though there was not any or much increase in the other categories, this was still considered positive in the sense that the student attitudes had not worsened. It was also encouraging to see that students were still as confident at the end of the semester that AE was still the major for them.

C. Club Activity

One interesting surprise from the questionnaires was the change in participation or membership in the American Society of Agricultural Engineers (ASAE) Student branch. The percent that were members of the club increased from 26 percent at the beginning of the semester to 55 percent by the end of the semester. This can probably be attributed to the peer mentors encouraging the freshmen to become more involved in the ASAE club, and to the comfort level of the freshmen with the upperclassmen who were currently members.

D. Peer Interaction

To determine the level of interaction and comfort for the freshmen with the upperclassmen, the following question was asked: How many students do you know well enough to engage in a conversation? Figure 4 show the pre-semester percentages for all grade levels. Figure 5 shows the post-semester results. At the beginning of the semester the freshmen knew very few of the upperclassmen well enough to engage in a conversation. The percent that knew at least one freshman, sophomore, junior, or senior at level comfortable enough to engage in a conversation was 71, 47, 26, and 48 percent, respectively. The highest percentage for number of students was found to be other freshmen, probably due to attending the R-credit orientation class the first semester. After the semester was over, the percent that knew at least one freshman, sophomore, junior, or senior was 92, 70, 48, and 70 percent, respectively. There was a significant increase at each grade level.



On a scale from 1 (bad) to 5 (excellent):

Q1: How would you rank your experience at ISU so far?

Q2: How would you rank the help that you have received from the College of Engineering?

Q3: How would you rank the help that you have received from the ABE Department so far?

Q4: How strongly do you believe AE is the correct major for you?

Figure 3. Pre – and post- evaluation of student’s attitude toward the university, college, department, and his/her chosen major

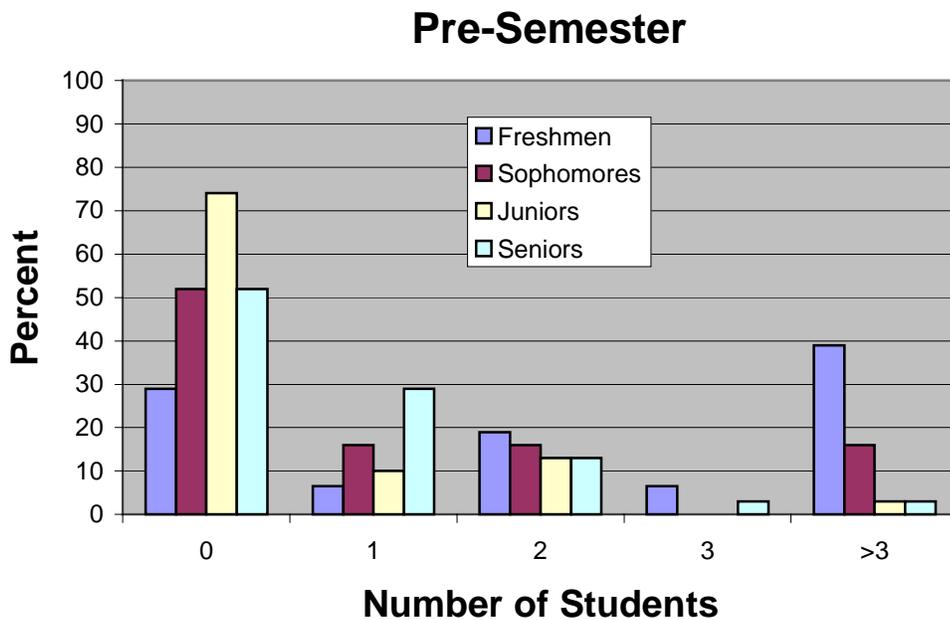


Figure 4. Pre-semester percent of AE students a freshman knew well enough to engage in a conversation with.

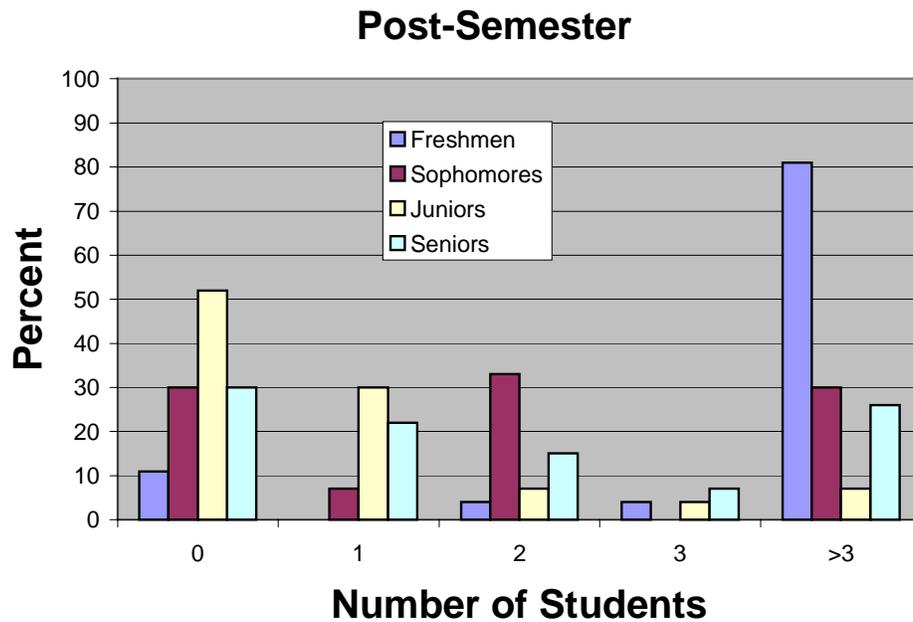


Figure 5. Post-semester percent of AE students a freshman knew well enough to engage in a conversation with

E. Faculty-Student Interaction

Faculty-student interaction also increased dramatically by the end of the semester. The percent of the freshmen students that felt comfortable enough to engage in a conversation with at least 2 faculty members in the AE department changed from 26 percent to 63 percent. The percent that didn't feel comfortable engaging in a conversation with any faculty dropped from 16 to 7 percent.

F. Retention

The key to this whole effort was to do a better job of retaining the freshman AE students past the first year. By the end of the next semester following these students taking AE 110, 84.4 percent of those enrolled in the class were still in the AE curriculum. This is compared to only 41.9 for those who took the AE 110 seminar course the spring of 1998 percent (22% switched to the agricultural systems technology major which is also administered by our department). Carlson also found similar results for an one-credit course at the freshmen level that showed "that carefully structured hands-on experience is an effective way of motivating freshmen", and that "that the course...increased creativity and confidence."⁷

G. Peer Mentor Assessment

The thirty-two freshman students and the eight peer mentors were asked to assess their experience in and outside the classroom. The results of the student rankings for their mentors are shown in Figure 5. Ninety-four percent of them ranked their experience with their mentor at a 3 or higher. The average ranking was a 3.77 out of 5. The mentors ranked their experience at a mentor at a 4.6 out of 5. Here are a few of the comments the students had about their experience with their peer mentor. Most of the comments were very positive. Those that weren't were related to their peer mentor not attending the team meetings.

- Really helped out
- Great peer mentor fun to work with.
- He was always willing to meet whenever the group was able to meet he always helped out when typing up the labs.
- Did a good job of answering our questions.
- We had a great time. He introduced me to more people and got me more involved.
- We get along great and he is a great source for information.
- He was a nice guy to talk to and he was helpful when we didn't know how to solve some equations or didn't understand the questions.
- Great mentor, and a great group.
- He told us what we needed to get done and helped us with every lab. He was also very nice and helpful, and I became a friend with him.
- She was easy to get along with. She didn't know much about the tractor and machinery. She knew a lot about the structures though.
- She helped us out very much and encouraged us to be there for the workshop hour that we had once a week.
- She was helpful when we asked her. It seemed like we had to pull things out of her. It would have been better if she was more willing to give out help without asking.
- He was always at meetings and very helpful. He always answered our questions or found somebody that could answer them. He worked around our schedules to make things easier for us.
- He was always there at our group meetings and he was a really good guy to talk to.
- He was a good guy to work with. He often offered encouragement, and was always interested in how we were doing in classes, etc.
- I enjoyed having him as our mentor; he helped us when we needed it, and was fun to work with.

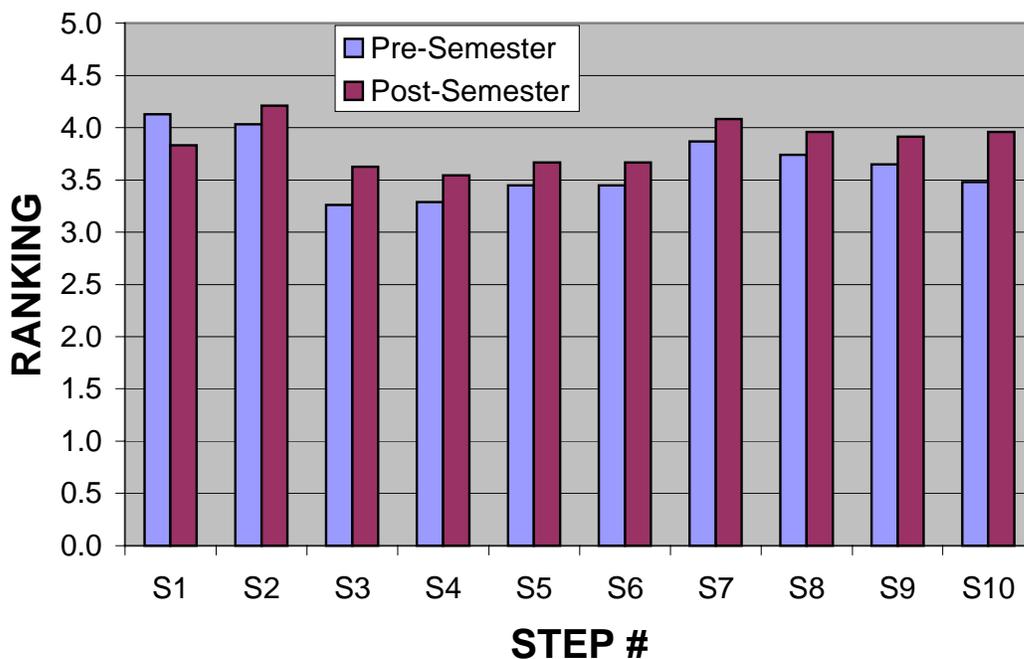
The mentor's comments were very positive and insightful. Here are just a few of their comments about this experience:

- I thought it was a great chance to meet younger students. It also got them involved with club activities. It is about the only way I can get to know them!
- I got to meet 4 great new Ag Engineers. Through talking with them about their plans – I got to share my experiences and hear different perspectives.
- I hope I provided a few younger students with some insight to the future (i.e., classes, professors, industry experience) and I learned a lot (some review, some new). I wish I had had a program like this, if only to make friends with an upperclassman.

- It gave me the opportunity to communicate my experiences here at ISU. It helps the underclassmen relate since we've been there and to meet AE's in their own classes for study partners.

H. Engineering Problem/Lab Presentation Competency

Students were asked to rank their level of competency in several steps of engineering problem/lab presentation. The steps assessed were those defined by Eide et al, 1994.⁸ Figure 6 shows these steps and how the students evaluated their competency before and after the semester. It is interesting to note that the students felt more competent at the end of the semester in all the steps of engineering problem presentation except step 1. Students seemed to show less confidence in recognizing and understanding the problem given to them. This could be due to the level of difficulty of the laboratory problem presented to them or to poor definition of the problem by the faculty. Both are probably true to some extent.



- S1: Recognizing and understanding the problem
- S2: Accumulating facts and data
- S3: Creating a problem diagram
- S4: Selecting appropriate theory or principles
- S5: Making necessary assumptions
- S6: Showing necessary solution steps
- S7: Graphing data
- S8: Drawing conclusions
- S9: Making generalizations to other situations
- S10: Report formatting and layout

Figure 6. Problem/Lab Presentation Competency

V. Conclusions

The following conclusion can be made from the evaluation of the data obtained from this study:

- The experiential, team-based freshman laboratory course was successful in improving the student perceptions about the ABE department.
- The new course increased the number of relationships between these freshmen and the AE upperclassmen.
- Faculty/Student comfort levels increased significantly by the end of the semester.
- Students felt more comfortable in every step of the problem/lab presentation except “recognizing and understanding the problem” by the end of the semester.
- Experiences with the peer mentors were very positive for the majority of the students.
- Peer mentors found the mentoring process enjoyable and rewarding.
- Retention of student in the AE curriculum one semester following the semester the students took AE 110, 84.3 percent of the students were still in the AE program compared to only 41.9 percent from the previous year.
- The new course was successful in increasing student club participation.

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