121st ASEE Annual Conference & Exposition
Indianapolis, IN
June 15-18, 2014
Paper ID #10127

Industry-sponsored Vs. Internal design projects at the Iron Range Engineering Program

Dr. Mohammad Habibi, Minnesota State University, Mankato
Jeffrey Lange, Iron Range Engineering

Jeffrey Lange graduated from Iron Range Engineering (IRE) in 2012 with his Bachelors of Science in Engineering with an emphasis in electrical engineering. He is currently working as a Project Mentor at IRE and passing on the knowledge and the love of the program that he developed as a student. Jeffrey completed his first two years of schooling at Anoka Ramsey Community College and then transferred to the University of Minnesota, Twin Cities. He struggled in school until he found IRE and then excelled in his education. He is a big supporter of Project Based Learning in the Engineering field and wants to constantly improve the style and engineering education in general.

Industry-sponsored Vs. Internal design projects at the Iron Range Engineering Program

Abstract

At the Iron Range Engineering program, students must enroll and complete four design courses in their junior and senior years. In this program, the majority of design projects are defined and sponsored by local industry. However, the faculty or occasionally students propose design projects called internal projects. Both internal and industry-defined projects have their pros and cons. For example, industry projects are problems which help students know and build relationships with industry. On the other hand, internal projects can be good research projects which help students gain extensive technical learning. This paper provides a general comparison between these two types of projects. Additionally, the different perspectives of the students, graduates, and faculty of Iron Range Engineering on these two types of design projects are discussed. Data were collected by conducting surveys, and the responses from our students, graduates, and faculty are presented. This paper also provides direction to the faculty for which types of projects should be pursued for optimal educational benefit and to pinpoint areas that might need improvement in project design and implementation.

1. Introduction

Engineering design courses provide valuable design experience for engineering students. The capstone design courses has gained considerable attention ever since it was found that the student outcomes set forth by the Accreditation Board for Engineering and Technology (ABET) are achievable in this course[1] . Although capstone design courses are commonly taught at most engineering schools, how they are taught and what they include varies widely[2]. Many suggestions have been made to improve the quality of these courses including expanding the contents and expectations[3], integrating professionalism into the course, and using more effective assessment methods[4,5].

Several national surveys have been conducted to understand the practices and trends in capstone design courses. In 1994, Todd et al. surveyed capstone design courses to understand educational and logistical practices in these courses[6,7]. A follow up survey was conducted by Howe and Wilbarger in 2005 to collect current practices and examine trends between 1994 and 2005[8,9]. In addition to the questions from the survey conducted by Todd et al., Howe and Wilbarger included further questions on student deliverables and evaluation, program funding, and course management. They also performed direct comparisons between the results of the 1994 and 2005 survey.

One of the areas surveyed by Howe and Wilbarger in 2005 was project sourcing. Generally, there are two sources of capstone projects, external (industry and community service) and internal (student-proposed, faculty research, and external competition). The 2005 survey indicated a shift toward industry projects. In 2005, 71% of capstone design projects were from industry while there were only 59% in 1994. This means that external projects are currently the largest source of capstone design projects.

A comprehensive investigation on the effectiveness of industry projects was conducted by Okudan et al.[10]. They found that although industry projects give students a deeper sense of how they will use their technical knowledge and skills in industries, there are a few concerns. For instance, faculty complained that they were not able to improve the quality of instruction because industry projects are only offered once. Moreover, industry projects require faculty to spend more time on course preparation. Finally, due to the multidisciplinary nature (electrical, mechanical, etc.) of industry projects, students' motivations were occasionally decreased when the project did not match with students' interests.

In this paper, we compare aspects of industry and internal projects with respect to professional and technical learning, measures of success, client availably, developmental path for students, project constraints, and emotional responses. The claims put forth by this paper are supported by data collected from three groups of stakeholders: current students, graduates currently working in industries, and faculty.

2. Iron Range Engineering

Iron Range Engineering (IRE) started in 2010 and received full ABET accreditation in 2013. The program is administered collaboratively by Minnesota State University, Mankato and Itasca Community College. IRE is located in Virginia, Minnesota at the Mesabi Range Community College campus. Prior to joining IRE, students complete engineering prerequisites and general education courses as freshmen and sophomores at other institutions, commonly local community colleges. Students then join IRE as upper level engineering students (juniors and seniors).

IRE is based around an innovative idea: learning engineering by practicing engineering. IRE is a 100% Project-based Learning (PjBL) and design-oriented engineering education program; the students gain their technical and professional learning while completing design projects. IRE students must take four, three credit, design courses called Design I, Design II, Capstone Design I and Capstone Design II[11,12]. Figure 1 shows the IRE curriculum. The majority of the projects at IRE are industry projects; however, internal projects are also defined. The industry partners of the program provide engineering design projects and technical mentorship for the students who are completing these projects. These projects are completed by the teams of IRE students comprised of both juniors and seniors.

IRE has received projects from many industry leaders such as Medtronic, Cliff's Natural Resources, Polymet, Cirrus Aircraft, US Steel, MN Power, and many others. Internal sources include ideas from the students themselves. Two such projects include a portable, low cost electrical generator and a transformable camera mount. Faculty also propose internal projects for students; examples include design and development of a skin cancer detection device and an efficient sun-tracking solar panel. The design projects are meant to give students experience in the entire design process from scoping to the final product.

In a typical industry project, IRE students solve complex and open-ended industry problems from the mining, milling, and manufacturing industries. A majority of their learning and assessment activities are organized and indexed by the aforementioned team-based, semester-long projects. For instance, in a recent semester, an IRE team designed a condenser performance test to be applied to a power plant's condenser. To solve the problem, students learned cycle analysis, conduction heat transfer, convection heat transfer, heat exchanger design, engineering economics, and studied the environmental implications of their condenser. All of this learning was done in the context of a deliverable product for a major client. Learning occurs individually or in student-organized small groups. Students have a wide variety of resources available to them; these resources span the spectrum from experienced faculty, peers a few steps ahead, printed materials, electronic libraries, to external experts practicing in the field.

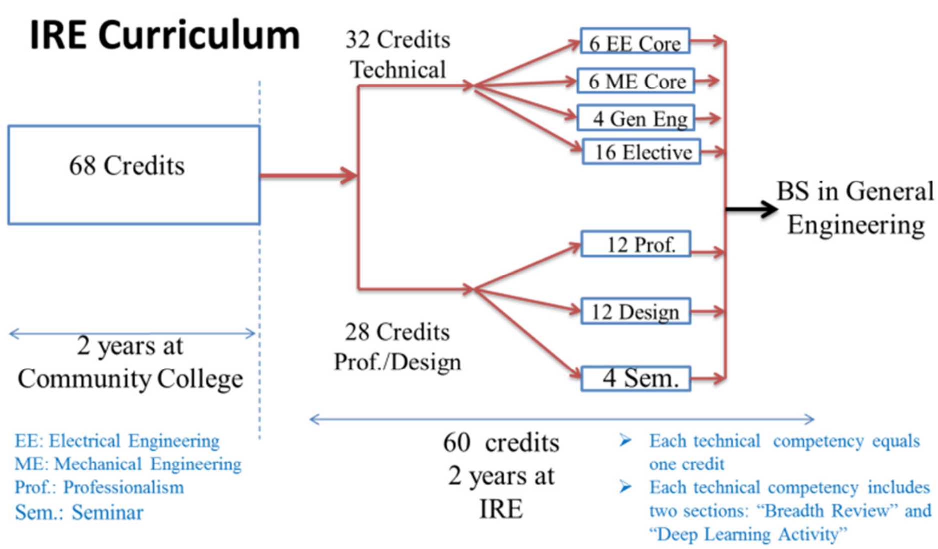

Figure 1. IRE Curriculum showing the breakdown of credits to complete a BS in General Engineering.

3. Industry vs. internal projects

The evaluation of industry and internal projects shows what improvements can be made in project design and whether faculty resources should be allocated toward initiating internal projects or looking for industry projects. Three groups were surveyed for input to compare the learning parameters listed below. Each group has their own specific areas of expertise that give beneficial information while looking at the different project types.

Group I is the current faculty mentors of the project teams. The faculty not only propose internal projects, but they also monitor students' performance while they are working on both types of projects. Group II is the current students in the program. These students have first-hand experience in dealing with these projects and the benefits and problems that can be found in each project type. Group III includes the graduates of IRE. The alumni not only have the first-hand experience that the students have, but also are getting feedback from their current occupations as to how well each of these project types helped them. Since IRE graduates had opportunities to work on several industry projects while they were still students, we wanted to know how they perform their duties in compare with graduates from other institutions. Therefore, we surveyed the IRE industry partners asking them to compare the performance of IRE graduates to that of graduates of other schools with different learning styles. We compared industry and internal projects based on the following parameters:

- Technical learning – Was there an adequate assimilation of technical information gleaned from the project? This includes information related to the engineering core principles as well as specific technical information that was developed to complete the project.
- Professional learning – Was there an adequate amount of professionalism developed through completion of the project? This includes written and oral communication, leadership, ethical decision-making, professional responsibility, and teamwork skills.
- Measure of success– What was being used as the measure of success for the project; was the primary focus the final product, documentation, or technical learning?
- Students' design experience– How was the overall design experience; was it worth their time and effort or was it just busy work?
- Client availability – What was the availability of the client to answer questions or change the requirements of the project?
- Development path – Which project types prepare students to work in the field and which ones prepare them for further education?
- Constraints – Which project type had more tightly focused constraints?
- Emotional response – Which project types were the students and faculties favorites, and which did they feel looked better on a resume?

These parameters were placed into electronic surveys (see Appendix) that were sent out to the faculty, students, and graduates using Survey Monkey. Information was attained from all parties anonymously.

4. Results and discussion

Sixteen program graduates, thirteen current students, and five faculty, out of eighty one people who received the survey, responded to the survey. The graduates are currently working in various positions as electrical and mechanical engineers. All the graduates indicated that they worked on both industry and internal projects while at IRE. Some of the current students have had the opportunity to work on both types of projects while others have experience with only one type. IRE students often work on internal projects at their first semester. The results from the surveys are organized by the parameters mentioned above.

Technical and Professional Learning

Figure 2 shows the professional and technical learning that was accomplished while participants were working on industry or internal projects. The rating scale ranges from 1 (poor learning) to 10 (excellent learning). The results from all participants show that technical learning is almost the same in both project types, but professional learning in internal projects is significantly lower. The likely reason is due to the extensive professional interaction between the students and external engineers.

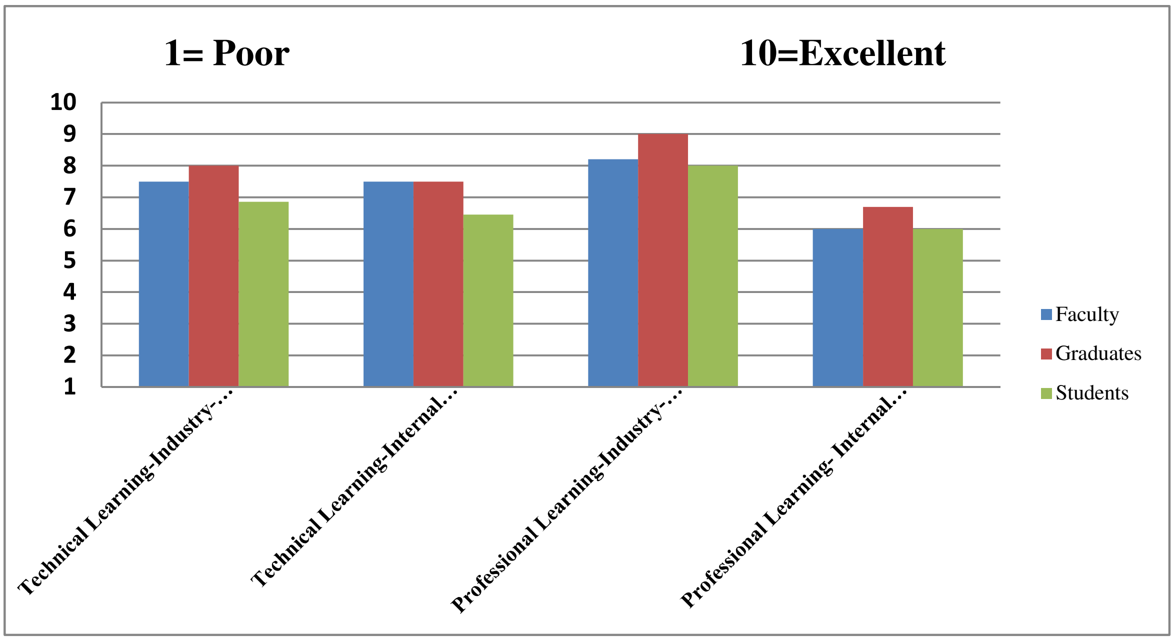

Figure 2. Survey results on the Technical and Professional Learning in both internal and industry projects showing similarities in technical learning across the board but significantly lower ratings for professional learning in internal projects.

Measure of success

The participants were given three options to choose from: a final product, extensive technical learning and documentation; the participants were able to select more than one option. The results show (Table 1) that all three groups agree that the final product is the main objective in industry projects. The students and graduates thought extensive technical learning was the main objectives of internal projects; the graduates also considered documentation to be the second most important objective in internal projects.

Table 1 summarizes the participants' perceptions as a measure of success for both internal and industry projects. Due to the ability to select more than one option, some total percentages add to over 100%.

Measure of Success	Graduates		Students		Faculty	
	Internal	Industry	Internal	Industry	Internal	Industry
Final Product	13.3%	66.7%	40%	66.7%	66.7%	100%
Extensive Technical Learning	73.3%	33.3%	60%	16.7%	33.3%	0%
Documentation	53.3%	46.7%	0%	25%	33.3%	0%

Students' design experience, Client availability, Development path, Constraints, and Emotional response

The results (Table 2) on the students' and graduates 'design experience showed that their best design experience was in their industry projects; interestingly, their worst design experience was also mostly in their industry projects. Almost all participants indicated that internal clients were more available for guiding and answering students' questions than their industry counterparts. Most of those polled believed that the industry projects helped them prepare for industry while internal projects helped them if they wanted to continue on to graduate school.

Table 2 summarizes the survey results for the design experience, development path, constraints, and pressure to succeed. (Participants were allowed to select more than one option.)

	Graduates		Students	
	Internal	Industry	Internal	Industry
Best Design Experience	6.7%	73.3%	40%	60%
Worst Design Experience	26.7%	46.7%	60%	55.6%
Prepared you for graduate school	23.3%	23%	36.4	18%
Flexible requirement	60%	20%	30%	10%
Pressure for achievements	0	80%	10%	80%

The students and graduates agreed that the initial constraints were higher for industry projects, where internal clients were more willing to change them once they were set. In response to one of the survey questions that asked which type of project(s) (industry or internal) created the most pressure to achieve the outcomes, more than 80% of the students and graduates agreed that there was far more pressure to succeed in industry projects than in internal projects (Table 2).

We also surveyed the employers of our graduates and interns to see if the IRE students actually achieve the desired outcomes after going through four cycles of working on internal and industry projects. In order to assess the outcomes, a survey was sent to the direct supervisors who had supervised IRE interns or graduates. They were also asked to compare the IRE interns or graduates to those they supervised from other institutions. Figures 3 and 4 display the employer ratings on the technical and professional skills of our graduates and interns compared to graduates and interns from other engineering schools. Scoring guide was provided to the employers as follows: scoring from one to five as one being significantly below and five being significantly above average in which average (three in figures 3,4) was defined as being the performance of graduates from other institutions.

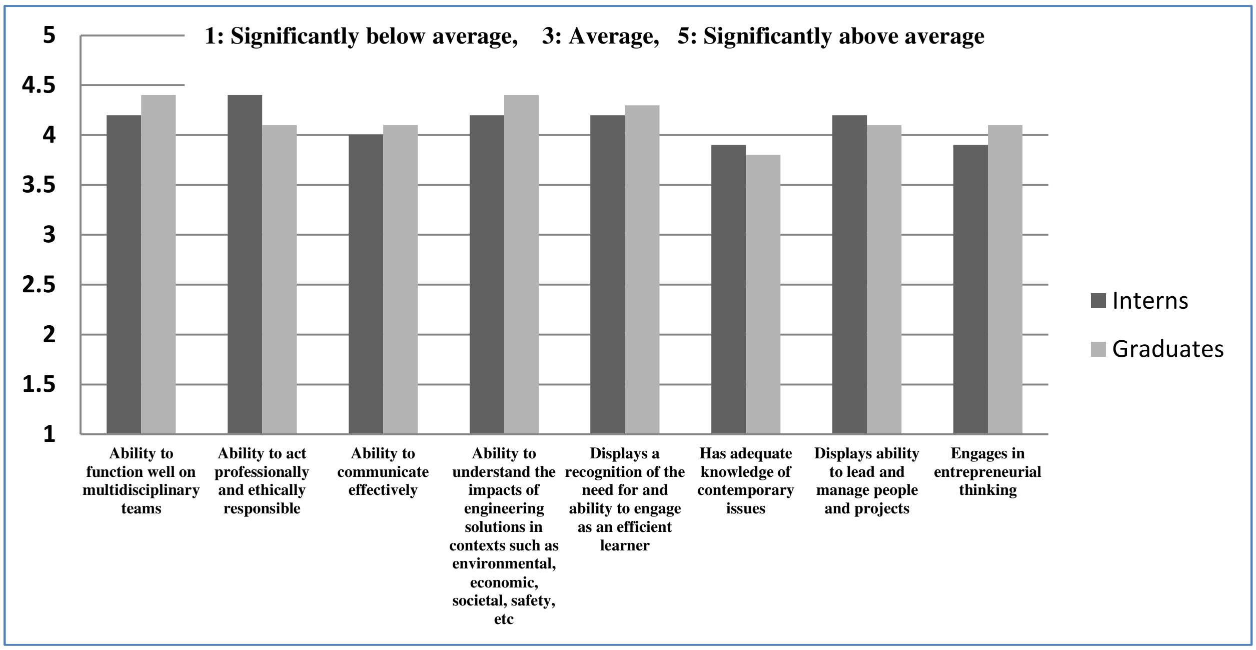

Figure 3. shows the results of the Employer Satisfaction Survey based on the - Professionalism of the IRE interns and graduates. This chart shows the rating on a scale of 1 (Significantly below average) to 5(Significantly above average)

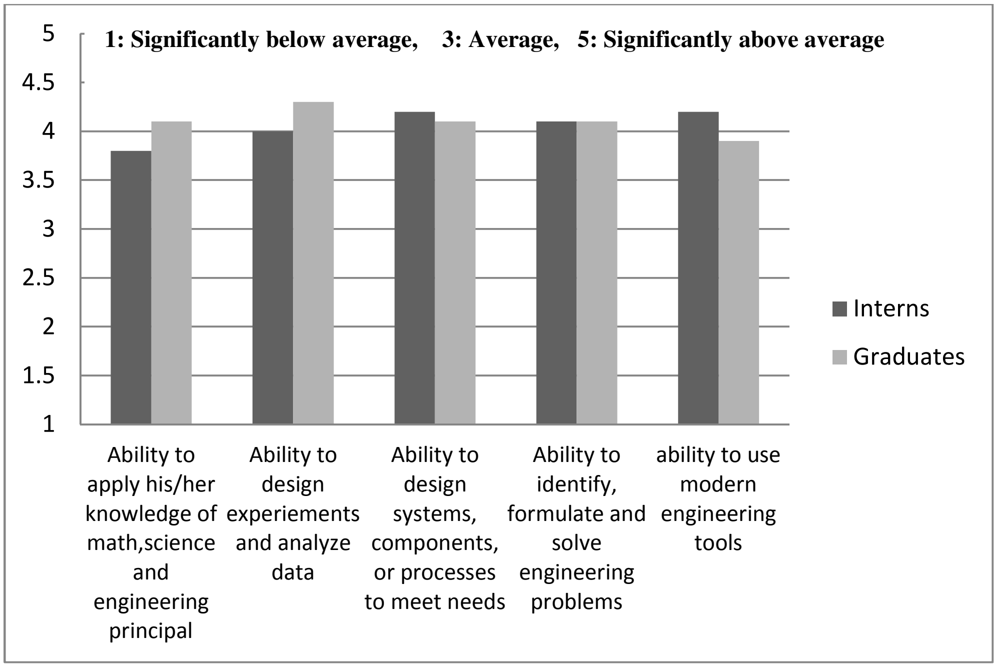

Figure 4 shows the results of the Employer Satisfaction Survey based on the Technical knowledge and Design capabilities of the IRE interns and graduates. This chart shows the rating on a scale of 1 (significantly below average) to 5 (significantly above average)

The benefits of this comparison will be evident not only to the groups who were surveyed, but also to other educators in the field. This paper provided direction to the faculty for what types of projects should be pursued for optimal education benefits and to pinpoint areas that might need improvement. This paper is also beneficial to students in determining which projects would be most valuable for them to pursue based on their educational goals. Finally, other educators in the field can look at which project types they may want to include for their students, and what areas they may need to focus on to improve the educational benefits to the students. For instance, it was found that professional learning must be improved while students are working on internal projects.

5. References

1. Prados, John W., George D. Peterson, and Lisa R. Lattuca. "Quality assurance of engineering education through accreditation: The impact of Engineering Criteria 2000 and its global influence." *Journal of Engineering Education* 94.1 (2005): 165-184.

2. Davis, Denny, Steven Beyerlein, Phillip Thompson, Kenneth Gentili, and Larry McKenzie. (2003). "How Universal are Capstone Design Course Outcomes?" Proceedings of the American Society for Engineering Education, Session 2425, June

3. Habibi M., Ulseth R., Carlson M. (2013), " Developing design courses in a project-based curriculum," Proceedings 2013 ASEE Annual Conference

4. Capstone Design Courses and Assessment: A National Study Larry J. McKenzie, Michael S. Trevisan, Denny C. Davis, Steven W. Beyerlein Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exposition

5. Coleman, Robert J., and J. William Shelnutt. "Fostering university/industry partnerships through sponsored undergraduate design." *Frontiers in Education Conference, 1995. Proceedings., 1995*. Vol. 1. IEEE, 1995.

6. Todd, Robert, Spencer Magleby, Carl Sorenson, Bret Swan, and David Anthony. "A Survey of Senior Projects or Capstone-Type engineering Courses in north America." Proceedings of the Advances in Capstone Education Conference, Brigham Young university (1994): 3–12.

7. Todd, Robert, Spencer Magleby, Carl Sorenson, Bret Swan, and David Anthony. "A Survey of Capstone engineering Courses in north America." Journal of Engineering Education (April 1995): 165–174,

8. Howe, Susannah and Jessica Wilbarger. "2005 National Survey of Engineering Capstone Design Courses." Proceedings of the 2006 ASEE Annual Conference and Exposition (2006),

9. Howe, Susannah. "Where are we now? Statistics on capstone courses nationwide." *Advances in Engineering Education* 2.1 (2010): 1-27.

10. A Comprehensive Investigation on Industry-Sponsored Design Projects' Effectiveness at the First-Year Level: Phase I , Gül E. Okudan, 2 Susan Mohammed, Madara Ogot and Xinli Wu, Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition

11. Habibi M., Ulseth R. (2012), "Time allocation Scaffolding in Project-Based Learning" Proceedings 2012 ASEE Annual Conference, AC 2012-4180

12. Ewart D., et al, (2011) "Entrepreneurship in the Iron Range Engineering (IRE) Model," Proceedings 2012 ASEE Annual Conference, AC 2011-974

Appendix

Survey questions with the possible answers in parenthesis:

1. Are you an IRE students or graduate? (Student, Graduate)
2. Which type(s) of project have you worked on at IRE? (Industry, Internal, Both, Neither)
3. Please rate your technical learning while you were working on an industry-based project(s). (1-10: 1 (poor learning) to 10 (excellent learning))
4. Please rate your technical learning while you were working on an internal project(s). (1-10: 1 (poor learning) to 10 (excellent learning))
5. Please rate your professional learning while you were working on industry-based project(s) (1-10: 1 (poor learning) to 10 (excellent learning))
6. Please rate your professional learning while you were working on an internal project(s) (1-10: 1 (poor learning) to 10 (excellent learning))

7. Which type of project was your best design experience? (Industry, Internal, Both, Neither)
8. Which type of project was your worst design experience? (Industry, Internal, Both, Neither)
9. Which type of project prepared you more for graduate school? (Industry, Internal, Both, Neither)
10. Which project was more constrained? (Industry, Internal, Both, Neither)
11. Which project do you believe shows up best on your resume? (Industry, Internal, Both, Neither)
12. In an industry-based project, which one of the following is the main measure of success? (Final product, Documentation, Technical learning, None of the above)
13. In an internal project, which one of the following is the main measure of success? (Final product, Documentation, Technical learning, None of the above)
14. Which client was more available to answer your questions? (Industry, Internal, Both, Neither)
15. Which client was more willing to change the project requirements? (Industry, Internal, Both, Neither)
16. In which project did you feel the most pressure to achieve everything that was required? (Industry, Internal, Both, Neither)
17. Any additional comment or suggestion that could help us understand the differences between industry-based and internal IRE projects.