AC 2011-772: THE EFFECT OF PREVIOUS TEAM EXPERIENCES ON STUDENTS' PERCEPTIONS OF INTERDISCIPLINARY ENGINEERING PROBLEMS

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The Effect of Previous Team Experiences on Students' Perceptions of Interdisciplinary Engineering Problems

Abstract

With a growing number of interdisciplinary engineering programs and courses, researchers are beginning to characterize interdisciplinary learning objectives, student development in these programs and courses, and the dynamics of interdisciplinary engineering teamwork. Focusing on students at the very beginning of the major coursework, this study examined second-year students' perceptions of interdisciplinary engineering project teams. In addition, the study attempted to define the conditions which give rise to those perceptions. Focus groups provided a setting for students to discuss the composition, the advantages, and the disadvantages of interdisciplinary engineering teams in the context of a real-world engineering problem. Follow-up interviews allowed the researcher to clarify comments made within the focus groups and address potential factors, which could have influenced students' responses during the focus groups. Qualitative analysis was used to identify emergent themes or categories within the discussions. Results from this analysis indicate that students acknowledge the importance of communication, trust, and mutual respect when working on an interdisciplinary engineering project. Overall, students focused on the components of team dynamics when discussing the major advantages and disadvantages of interdisciplinary team projects. In addition, students' previous experiences on team projects were shown to directly affect their responses to the questions throughout both stages of the study.

Introduction

To address changes in the field of engineering and the challenges that engineers will face in the coming decades, engineering education is currently experiencing a movement toward interdisciplinary courses and curricula at universities across the country[1-5]. Despite this increase in interdisciplinary engineering educational opportunities, researchers are only beginning to characterize the impacts these interdisciplinary experiences have on engineering students[5-8]. Within these courses and programs, faculty are introducing students to the concepts of an interdisciplinary approach to problem solving and the challenges of working on an interdisciplinary team as early as the second year of study[9-12]. Therefore, understanding students' perceptions of interdisciplinarity at the start of these programs and courses could provide faculty with useful information about the preconceived notions of students as well as the factors which led to those notions.

This paper discusses results from one dimension of a larger research project aimed at uncovering a model for second-year engineering students' perceptions of the interdisciplinary problem-solving approach[13-14]. The work presented here focuses on an important component of many of these interdisciplinary engineering courses and programs, teamwork[6,15]. For the faculty developing these curricula and courses, they must take into account the eleven program outcomes defined by the Accreditation Board for Engineering and Technology (ABET). One of these outcomes stresses the importance of engineering students having the ability to function on multidisciplinary teams[16]. In addition, engineering education research reiterates the need for engineering students to develop teamwork skills as part of the undergraduate curriculum[17-19].

Therefore, this paper will discuss the results of two research questions:

1) What are second-year engineering students' perceptions of interdisciplinary engineering project teams?
2) What conditions give rise to these second-year engineering students' perceptions of interdisciplinary engineering project teams?

Framework and Previous Research

In the context of engineering, interdisciplinarity is a term often misunderstood, especially in regards to what programs and research projects classify as interdisciplinary[7]. The Engineer of 2020 Project at Pennsylvania State University defines interdisciplinarity as,

> "a perspective, practice or problem-solving approach that utilizes modes of inquiry drawn from one or more disciplinary or nondisciplinary perspectives (i.e., the "real world"). It is marked by an appreciation of various perspectives and an ability to evaluate multiple disciplinary approaches to problem-solving. Interdisciplinarity also includes an ability to recognize the strengths or weaknesses of one's own disciplinary perspective, but also recognize the shared assumptions, skills or knowledge among disciplines."[20]

The research design and methods of this study were influenced by specific qualities of interdisciplinary understanding at the collegiate level[21-22]. Boix Mansilla and Duraisingh (2007; 2009) worked to determine a comprehensive definition of what constitutes a student's interdisciplinary understanding based upon faculty assessment of student interdisciplinary research. The study focused on four well-recognized interdisciplinary programs in the sciences and humanities[21]. Through interviews with faculty and students, classroom observations, and a document analysis of student work, Boix Mansilla and Duraisingh (2007; 2009) developed an assessment framework for the evaluation of interdisciplinary work and a grounded definition of interdisciplinary understanding. The four dimensions of interdisciplinary understanding presented in the framework are: (1) *purposefulness,* (2) *disciplinary grounding,* (3) *integration,* and (4) *critical awareness* (see Figure 1)[22].

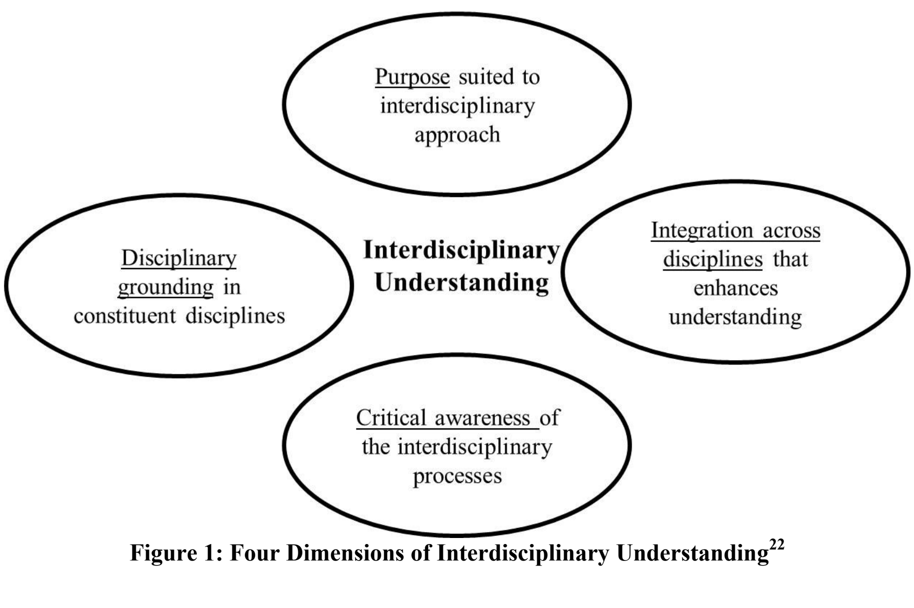

Figure 1: Four Dimensions of Interdisciplinary Understanding[22]

The focus of this paper is a single dimension of interdisciplinary understanding, *critical awareness.* According to Boix Mansilla et al. (2007; 2009), the dimension of *critical awareness* asks the question:

> "Does the work exhibit reflectiveness about the choices, opportunities, and limitations that characterize interdisciplinary work and about the limitations of the work as a whole, such as what an account failed to explain or what a solution could not address?"

In the context of interdisciplinary engineering teams, the study presented here refocuses this question to examine students' awareness of the interdisciplinary process as it relates to interdisciplinary engineering project teams and the opportunities and limitations associated with those teams.

Boix Mansilla et al. (2007; 2009) provided one of the most substantial studies of the evaluation and assessment of undergraduate student interdisciplinary work, which is utilized by researchers in the humanities, sciences, and engineering. One such study examined student development within interdisciplinary programs in the humanities and sciences[15]. Other researchers have used this definition of interdisciplinary understanding to study a graduate engineering program[6,8]. This framework has also influenced a study about an approach to biotechnology education, and the National Academies cited preliminary work by these authors in their report on *Facilitating Interdisciplinary Research* when discussing measures to evaluate interdisciplinary work[23-24]. Still, while this definition of interdisciplinary understanding, the framework, and the rubric are used across many fields, their origin was a study focused on students' projects only within humanities and sciences, fields where disciplinary borders and interdisciplinary programs have been studied for decades[22,25-26].

This gap in the literature for interdisciplinary engineering education carries over to research related to interdisciplinary engineering teams. Within the humanities and social sciences, for example, research has focused on the challenges within interdisciplinary research groups and characteristics which could affect the impact of those challenges on the team's success[27]. In the setting of health-care systems, studies observed the impact of interdisciplinary team dynamics and the major challenges associated with these teams[28-31]. In the context of interdisciplinary engineering projects and courses, on the other hand, research has defined a challenge to interdisciplinary collaborations as disciplinary egocentrism, or the "inability to think outside of one's disciplinary perspective", from an examination of a green engineering course offered to mostly upperclassmen engineering students[5]. Others have described the experiences of students on interdisciplinary engineering projects[32]. Yet, to continue to understand students' experiences and develop courses and programs which fulfill the learning objectives regarding interdisciplinary engineering teams[16], there is a need to examine students' perceptions of interdisciplinary engineering teams at an early stage in their major coursework.

Methods

Site and Sample Information

The research site for this study was Southeast Public University (SPU). Southeast Public University is a large public, research institution, enrolling close to 600 students each year in the School of Engineering. This university was selected due to the recent implementation of a

Leaders in Engineering Program (LEP), which is an interdisciplinary undergraduate engineering (IUE) program combining concepts and methodologies from Systems Engineering (SE) and Electrical and Computer Engineering (ECE). One of the main objectives of this program is to enable students to work on interdisciplinary engineering projects requiring an understanding of electrical and computer design and systems analysis. Over the course of three years in the program, students are required to complete coursework in both the SE and ECE departments, including two joint laboratory courses in the third year and a team-based, interdisciplinary capstone project in the fourth year.

Participants for this study were second-year engineering students within the SE and ECE departments. Data for this study was collected between October 2009 and March 2010, focusing on the first cohort of LEP students and their non-LEP counterparts. The first cohort to begin this program started in the fall of 2009 with 14 students. Of those fourteen students, five are women, while 7 are SE students, 4 are electrical engineering students, and 3 are computer engineering students**.** The maximum possible sample from these three majors (including students not in the LEP) was 155 students, with 68 electrical or computer engineering majors and 87 majors from systems engineering. The opportunity to study the first group to enter in the program, along with the particulars of the design of the program, made this site ideal to examine the perceptions of students in the very first year of the major coursework.

Data Collection

This study integrates two qualitative methods for the exploration of student perceptions and the conditions, which give rise to those perceptions. The data was collected sequentially using focus groups to gather the first round of qualitative data, followed by semi-structured interviews, which were designed using the results from the focus groups.
The focus groups were designed to have the students think critically about the design process for interdisciplinary engineering problems and engage in a discussion about this process, its advantages, and its limitations. The scenario was based on Midwest Flood Problem (MWF): "Over the summer the Midwest experienced massive flooding of the Mississippi River. What factors would you take into account in designing a retaining wall system for the Mississippi?"[33] This prompt has been previously used by researchers to examine how students approach design problems and how they frame engineering problems[34-35]. Each focus group was asked to discuss two provided solutions to the MWF problem. One solution included a substantial discussion of the context of the problem, while the other response included a limited discussion of context[33]. The text of each solution and the focus group protocol are included in Appendix A and Appendix B.

To facilitate the discussion of these two solutions, the students were asked to work together to respond to a second prompt about the composition of an interdisciplinary team, previously used by Richter and Paretti (2009): "If you were responsible for putting a team together to study and develop solutions for this issue what team members and or characteristics would you include on the team and why?" Focus group participants constructed teams for both sample solutions to the MWF problem; the moderator alternated the presentation of each sample solution for the different sessions.

The second half of the focus group was structured to guide the students through a comparison of the previously examined sample solutions and the teams the students constructed based on those solutions. Questions included, *"Of these two teams, which do you think would be better suited to solve the MWF problem and why?"*, "*If you were the project lead for team (fill in), how would you approach the problem differently than as the project lead for team (fill in)?",* and "*What types of challenges could you imagine you and your team would face working on this project?"*

Each focus group was limited to 4-5 students and lasted approximately 40 minutes. With 14 students in the LEP program, the maximum sample size for the focus groups was thus limited to 28 students (14 in the LEP, 14 not in the LEP). Students were recruited via an in-class announcement in the sophomore SE and ECE courses. The final sample of students was comprised of 18 students, with 9 students in the LEP program as well as 9 non-LEP students. The latter group was recruited in attempts to construct a sample which mimicked the composition of the LEP program. Overall, 7 of the 18 participants were women, while 6 students were ECE majors and 12 were students in the SE department. The complete demographic breakdown is included in Table 1.

Table 1: Demographic Breakdown for Focus Group Participants

SE	12	**Male**	8	**LEP**	3
				Not LEP	5
		Female	4	**LEP**	1
				Not LEP	3
ECE	6	**Male**	3	**LEP**	3
				Not LEP	0
		Female	3	**LEP**	2
				Not LEP	1

Following the preliminary interpretation of the results, semi-structured follow-up interviews were designed to explore the results from the focus group and gain a deeper understanding of the conditions which give rise to students' perceptions as well as other potential sources of differences in perception. The protocol for each semi-structured interview was prepared in advance and was unique to each participant. Sample topics included: previous experiences on team projects in their classes or extra-curriculars, previous experiences in their engineering coursework, and current desired career path.

To construct a sample for the semi-structured interviews that was representative of each combination of gender and disciplinary affiliation examined in this study, students' disciplinary affiliation and gender were taken into consideration. In addition, all the students invited to participate in the final interviews needed to have participated in all of the previous phases of the study (including others not presented in this paper). This provided the researcher with the opportunity to explore each phase of the study with each participant. Since none of the students who participated in the focus group were classifed as male, non-LEP, ECE students, only 7 of the 8 possible combinations of gender and disciplinary affiliation could be included in the sample. Within those remaining combinations, discriminate sampling was used to select participants who could provide clarity about the questions that remained after the initial interpretation of the focus group results. For instance, two of the students, whose names have been replaced by psuedonyms, engaged in a heated discussion of the role of an expert on interdisciplinary projects. To understand the reasoning behind Scott and Susan's strong opinions, both were invited to participate. Other students were noted for their unique or strong opinions regarding team formation, team dynamics, or disciplinary grounding. For example, Sarah centered many of her discussions of team formation around the need for trust and open lines of communication among the team members, while William indicated he thought, "getting a team that works well together is better than just having a group of smart people who are all going to do their own thing." By considering the students' perceptions as expressed in the focus groups, the final sample was representative of many of the common perceptions as well as those perceptions which remained unclear following the initial interpretation of the results.

Data Analysis

The coding scheme used to analyze the focus group data was based on the four dimensions of interdisciplinary understanding and open coding (see Table 2)[22]. Students' responses were first separated into segments, which are phrases or sentences that capture a comment made by the student. These segments were coded based on the four dimensions.

Table 2: Description of Dimensions of Interdisciplinary Understanding[22]

Dimension	Description
Purpose	• Clear reasons for utilizing an interdisciplinary approach • Need for multiple specializations and perspectives • Complexity • Large project scale
Disciplinary Grounding	• Selection of disciplines (if an explanation is stated) • How to develop disciplinary grounding • Challenges due to either a lack of knowledge or the amount of information to gather
Integration	• How to integrate knowledge and methods • Determining how tasks will be delegated
Critical Awareness	• Acknowledgment of limitations of process • Reflection on the process or the project's overall success or failure, such as project duration or amount of work

Within the *critical awareness* dimension, the segments were coded utilizing open coding to capture emerging themes about the interdisciplinary engineering approach to problem-solving and interdisciplinary team dynamics. Specifically, one researcher read and reread students' responses. During the first read through, the researcher separated the different segments into different categories. The different categories were then reorganized, modified, and combined upon each reread of the responses to develop a final coding scheme capable of capturing the overall themes and trends of the responses. A second researcher coded the transcripts based on the four dimensions as well as the open-coding scheme developed by the first researcher. Inter-rater reliability was calculated as defined in Miles and Huberman (1994). Since the reliability was greater than the inter-rater reliability goal of 80%, disagreements were discussed between the raters to achieve consensus.

Axial coding was utilized to examine the results of the interviews. The purpose of axial coding is to examine the conditions that give rise to a particular result and then develop relationships and categories to classify those conditions and results. Similar to open coding, this method required the researcher to read and reread student responses to expand upon the coding scheme developed for the focus group. During each read-through, the researcher considered the categories found in the focus groups and the relationships between those categories and students' responses in the interviews. As with open coding, the scheme was disassembled and reassembled to attempt to capture the connections among all the categories and the conditions that gave rise to those categories.

Limitations

In the subsequent discussions of the results of this study, it is important to keep in mind that limitations do exist within the research design. The sample of students is from a single university, which has a specific first-year engineering curriculum that may or may not be different than other universities. By not expanding the sample beyond one institution, it is possible responses from second year students at a smaller or large institution will not be consistent with the perceptions of this sample. Still, the intent of this research was to focus on developing a deeper understanding about the specific sample at one institution. Beyond sample size and selection, researcher bias must be taken into account, due to the nature of qualitative research. For the focus group data analysis, inter-rater reliability was established, but only one researcher examined the interviewer data, using peer de-briefing as the only method to decrease research bias. Finally, the data was collected over several months. Thus it is possible for a student's perceptions to have changed over that time. The choice of a semi-structured interview as the second data collection method was made in attempts to mitigate this limitation by capturing any changes in perceptions. By recognizing the existence of these limitations and attempting to mitigate them throughout the research design, the results of this study still provide an important contribution to the examination of students' perceptions of the interdisciplinary engineering approach to problem-solving and interdisciplinary engineering teams.

Results

Research Question #1

Throughout the focus group sessions, students reflected on the interdisciplinary process and the challenges of interdisciplinary teams. Within the *critical awareness* dimension, three major themes emerged from the focus groups, with general limitations and challenges specific to interdisciplinary teams being the most frequent. All three major themes are reflected in Table 3 as a Tier-1 category of *critical awareness.*

In the case where responses in a given category could be sub-divided to further describe students' perceptions, a Tier 2 sub-category was created. In the case of *Limitations and Challenges of Interdisciplinary Teams,* for instance*,* this category was further sub-divided to differentiate between challenges regarding the effect of different disciplines on team dynamics and general challenges. The sub-categories of *Limitations and Challenges of Interdisciplinary*

Teams include 1) *Team Members from Different Disciplines*, 2) *Members Want Things Their Way*, and 3) *General Challenges on a Team.*

Table 3: Phase II Coding Scheme - Critical Awareness (N = 18)

Tier 1	Tier 2	Description	% of Sample
Limitations and Challenges of Interdisciplinary Teams	*Team Members from Different Disciplines*	Team members could come from different disciplines	55.6%
	Members Want Things Their Way	Team members believe their work or discipline is the most important	27.8%
	General Challenges on a Team	General challenges involved in group work	38.9%
Importance of Communication		Importance of communication and how it can be a challenge	27.8%
Importance of Mutual Respect and Trust		Importance of mutual respect and trust and how both of these areas can pose a challenge	11.1%

When considering the challenges of an interdisciplinary team, Ron explained,

> "It's because the disciplines, these people, are like in totally different places, and they're trying to map what each person is thinking that they're obviously going to have different perspectives of how things should be done."

Scott echoed Ron's sentiments during a different focus group,

> "I still think in [the larger team] it will be tough, because in [that team] you are going to get all these people…different people's conflicting views who are going to be like yeah we need this and it is going to be a lot more difficult to be in that meeting and organize that meeting and get people to work together."

Anna, on the other hand, expressed her opinion that conflict would arise because team members may not consider the views outside of their own discipline as important for the project.

> "So this is not just specific to this project, but like different team members think their issues are the most important or most pressing. So like the contractor might be constrained by money or something. So try to keep the costs low whereas the civil engineer cares about I don't know the water or something."

While some students recognized the different perspectives and increased likelihood of conflict as limitations, other students described these characteristics of an interdisciplinary team as strengths. Frank, for instance, explained the difference in the potential success of the small, more focused team (B) in comparison to the larger, more diverse interdisciplinary team (A).

> "Whereas in A I have, you know, a lot of people who can help and like conflicting opinions are usually a good thing when you working on a project like this scale because there I mean usually if we work something out it is going to be the best solution. Where if

I only have 3 people who can tell me what to do in Team B then I feel like I am going to get a much worse solution."

Communication, trust, and mutual respect were also important components of the students' discussions of interdisciplinary engineering teams. Sarah, for example, described,

> "I think as long as there is mutual respect for everyone's expertise, it can be done really well." Thomas followed with "Yeah you need to make sure you have good team chemistry because with a bigger team, if they don't work well together like this is going to fall apart, so I mean as long as the team members don't butt heads and respect everybody like [Sarah] said, we're going to be fine."

Vlad and Maria determined that additional meetings would be necessary for interdisciplinary team members to exchange information often.

> *Vlad*: "Yeah true so it is probably better if you do that and then have them exchange every so often and update each other sort of."
>
> *Maria:* "Obviously communication is the most important thing."

The necessity for good communication among team members, nevertheless, affected Elizabeth's desire to lead an interdisciplinary engineering team.

> "I just think numberswise I can see with [a larger, more diverse team] the problems of like communication and stuff being like I don't know just being a big problem compared to B."

Still, overall, most of the students spoke positively about the type of results possible from an interdisciplinary team, regardless of the challenges involved. As Ron described it,

> "Well, in order to have the perfect solution, you need to have everybody working together, providing a different part, like all the perspectives are needed in order to make an unbiased solution."

Research Question #2

In the interviews, students were asked to consider the major challenges of the projects they had been involved in and to elaborate on comments made during the focus group. All of the interviewees, for example, participated in a team-based computer science project during one of their first semesters in the university. Each project team was composed of four students, and in many cases, the students were from different departments. From these projects, Veronica, a CS student reflected on the barriers which arose when she and her CS friends were asked to work with students outside of their department.

> "The project manager's really good in that we had a lot of kind of paperwork we had to do. And of course CS majors don't like paperwork, we just wanna code."

Other students noticed little about the difference in disciplines, beyond the advantage of having someone on the team with significant coding experience. As Frank described it,

> "Luckily we had one guy that was really really good at coding."

Still for the most part, students focused on the general team dynamics: issues with communication, students vying for the leadership positions, and students not completing their assigned tasks. Scott described some of the breakdowns in team management during his experience with the CS project.

> "It was just that everyone would be trying to work at the same time and it just, the program wasn't divided that way."

For most of the interview participants, the discussions of the class projects related to their responses in the focus group. For example, in the focus group, Anna discussed the effect of team members who don't contribute to the success of the overall project.

> "I just feel like…one person could be a horrible worker you know or they do horrible work. I don't know since the team is larger it would sorta help minimize the effects."

When describing her previous project experiences, she explained that the largest team she was on was for the SE project and her overall experience on this team was very positive. Her introduction to engineering project had only four members on the team and her experience was drastically different.

> "That [intro] project, like my group members did do some stuff, but for instance I asked them like, 'Oh we'll split up the portions of the report, you write this…' and I got it back it was just like horrible, so it was so bad, so I was like oh I'm not gonna fight it, I'll just write the whole thing."

For William, his experience on the SE project that previous semester was affected by conflict over team leadership.

> "We had a little bit of conflict. It wasn't like bad, it was just like um we kinda like had like two different people that were trying to take control, one of them being me…there were times when I was just like, 'No, what're we doing, we shouldn't do this.' and then this other girl was like, 'We should be looking at this, we should be doing this.'"

In the focus group, his remarks about the challenges of an interdisciplinary engineering team were rooted in this same idea of conflict over leadership.

> "The only problem I see with [the larger team] is the more people the more likelihood that there's going to be a disagreement and that would be tougher to handle. Um, especially in [the larger team] when you have a lot more alternatives and just if people you know want to be first and want their way and another person wants their way, then it's more difficult to lead them."

Outside of these projects, Susan's experience on a high school robotics team taught her that many individuals believe their own discipline is more important than others.

> "Nobody really understands the difficulties of the other subsections."

This lesson resonated in her responses about conflict on interdisciplinary teams. During the focus group, Susan was concerned with team members being "egotistical" and agreed that

> "People always ended up thinking [that they are more important than others]".

In addition, she expressed her opinion that an interdisciplinary engineering team should be comprised of "experts." Later, in the interview, she described her experience with the mentors on the robotics team who served as "experts."

> "They were like really smart people, I feel like they just knew everything about everything, so if you ever had a question, like oh, you know, 'How does this work?' Whatever, they just boom-boom-boom, they like knew it…it was a really awesome resource."

Sarah, on the other hand, stressed the importance of mutual respect and communication during the focus group discussion. When she talked about these issues in the interview, she utilized real world examples to explain her point.

> "I feel like it's been pointed at as the root of so many problems, even like 9/11. Like, you know, or um like the fall of our whole economy and stuff. Like, if people – if there hadn't been like one guy that everyone had just catered to, or something, you know. And, he's like 'I'm the boss,' then… I don't know, I feel like there's been so many situations in like history where people have a suggestion but are too scared to speak. And I think it's like always good when the ground's like open and like somebody in charge or Manager of whatever can be like, 'Tell me if you guys agree with this, or what do you think of this?'"

Across each of these examples, the importance of students' participation in projects and on teams, as well as students' knowledge of real life projects from family or friends, is evident in their perceptions of the challenges of interdisciplinary projects. These experiences and knowledge are the connections that explain some of the conditions which gave rise to students' perceptions during the focus group. Similarly, many of the students have not participated on an interdisciplinary project before, if any of them, therefore, it is reasonable to suggest that the students considered their previous project experiences when responding to the various focus group questions.

Discussion

When Boix Mansilla and her colleagues (2007; 2009) examined students' interdisciplinary work in undergraduate humanities and science programs, it was clear that the research focused on the examination of an individual student's interdisciplinary understanding. Specifically, their rubric and framework were designed to analyze a student's ability to internalize several disciplines, understand the strengths, limitations, and assumptions of those disciplines, and integrate those disciplines based on the overall purpose of the work[22]. For example, in their study, Boix Mansilla and her colleagues included the assessment of the disciplinary grounding of one student's work, explaining,

> "[Her] work is rooted primarily in philosophical argumentation. She prioritizes underlying assumptions…she could consider the evidentiary forms employed by sociobiologists, economists, and sociologists"[22].

As seen in this example, the form of assessment employed by these researchers focuses on one individual and his or her ability to execute interdisciplinary work by themselves. This is due in part to the characteristics of humanities and science disciplines, where it is common for students to work alone on projects at the undergraduate level.

For many second-year engineering students, on the other hand, team projects have been an essential part of the curriculum since starting college. By the time of graduation, it is expected that these students have developed as specialists who can contribute to a larger project in which multiple disciplines are required to achieve a solution. Thus, it is not surprising that the teamwork aspects of an undergraduate engineering curriculum affected students' perceptions of interdisciplinary engineering work.

During the focus groups, students identified critical components of a successful interdisciplinary engineering team as good communication, trust, and mutual respect. Students also acknowledged the existence of different dynamics due to the fact that team members were from different disciplines. These dynamics could exist due to the types of approaches and thought-processes used by the members as well as the possibility that some members believe their portion of the project is the most important. These perceptions illustrate that students, even as early as their second year, acknowledge the challenges of "disciplinary egocentrism"[5]. Additionally, students considered age, knowledge and experience as factors that could affect team dynamics. In the end, the results of this study indicated that most students perceive the outcome of an interdisciplinary engineering team project as worthwhile and are thus more willing to overcome the challenges of team dynamics.

As the results of the interviews demonstrated, students' previous experiences on team projects directly affected their responses to the questions throughout the study. In the discussion of challenges and the selection of disciplines, for example, it can be observed that students who had experiences with bad communication contributed responses about the importance of communication, while students who had positive experiences with mentors, or "experts," discussed the need for experts on an interdisciplinary project. Currently within these second-year courses, there is that feeling of what Scott described as "we are all in the same class" which works well to address challenges within the subject matter, project content, or general team dynamics. Yet, it is still unclear whether these students would be able to function on an interdisciplinary engineering team, even though these students have been exposed to engineering team dynamics and recognize challenges of interdisciplinary engineering team dynamics. As seen by Richter & Paretti (2009), "disciplinary egocentrism," for example, can limit students' interdisciplinary understanding in the later years of a curriculum. Thus, in developing interdisciplinary curricula, it will be necessary to keep in mind students' perceptions and design ways to confront the barriers to interdisciplinary understanding early within the curriculum.

Conclusion & Future Work

With a growing number of interdisciplinary engineering programs and courses, researchers are beginning to characterize interdisciplinary learning objectives, student development in these programs and courses, and the dynamics of interdisciplinary engineering teamwork. Focusing on students at the very beginning of the major coursework, this study examined second-year students' perceptions of interdisciplinary engineering project teams. In addition, the study attempted to define the conditions which give rise to those perceptions. Through the qualitative analysis of focus groups and interviews, second-year engineering students were shown to consider team dynamics as a critical component of an interdisciplinary engineering team project. In addition, students expressed that even with the challenges of an interdisciplinary engineering project, there are still significant benefits from working on an interdisciplinary team. These perceptions, as well as those previously discussed, were found to be directly influenced by students' previous team experiences, which in most cases were not interdisciplinary team experiences. This result emphasizes a need to continue to examine interdisciplinary engineering teamwork and to develop teaching strategies to provide students with these experiences early in the engineering curriculum.

The results presented here will contribute to the overall model for second-year engineering students' perceptions of the interdisciplinary problem-solving approach to be published at a later time. Other future work in this area includes a longitudinal examination of student development within an interdisciplinary engineering program, which can be compared with those studies already completed within the humanities. In addition, research could focus on following engineering teams within single discipline courses and compare the experiences and perceptions of those students with teams in interdisciplinary courses. Research in this area could determine whether students in engineering recognize the same or different team dynamic challenges regardless of whether a project team is single disciplinary or interdisciplinary.

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Appendix A

Instructions:

Hello, my name is []. Thank you for taking the time to participate.
The purpose of this study is to learn about your understanding and perceptions of engineering projects.

Before we begin, I would like to inform you that all information from this interview will be held confidential and there are no risks to this study. Additionally, your participation in the study is voluntary; therefore, you may withdraw from the study at any point. Here is the consent form. Please take a few moments to read through it. To participate in this study, you must sign a consent form. Please let me know if you have any questions. (HAND **PARTICIPANT** THE CONSENT FORM, OBTAIN SIGNATURES ON TWO COPIES) *This copy is for you to keep for your records.* (COLLECT ONE COPY AND RETURN ONE TO **PARTICIPANT)**

Thank you for agreeing to participate. I have planned this session to last no longer than 60 minutes.

As I stated previously, the purpose of this study is to learn about your understanding and perceptions of engineering projects. Due to the nature of focus groups, it is possible that others will know what was said. Therefore, please do not disclose what was discussed during the focus group outside of the focus group. Additionally, if I ask you anything that you do not feel comfortable answering, please feel free to tell me that you do not want to answer the question.

At this time, are there any questions?

This interview will be recorded. In addition, my classmate, (name), will be assisting me by taking additional notes about our conversation. All recordings are confidential and will be stored in a secure file until they are transcribed and destroyed. All notes will also be stored in a secure file until they are destroyed.

(BEGIN RECORDING)

For these first two problems, I will ask you all to work as a team to develop a solution. You will have 10 minutes to complete this problem. Please let me know if you are done before that. Do you have any questions?

FGQ1: For this first question, I am going to show you a response to the Midwest Floods Problem developed by a student at another university. (DISPLAY SOLUTION A) I would like you all to take a few minutes to answer the following question as a group. If you were responsible for putting together a team to study and develop solutions based only on these factors, what team members and/or characteristics would you include on the team?

TRANSITION:
(CHECK END TIME ON AUDIO RECORDER, AND IF NECESSARY): *Alright, it's been 10 minutes now. Please stop. Could one of you volunteer to describe the solution?*

(**PARTICIPANT** DESCRIBES SOLUTION) *Thank you!*

For the next question, again, I ask you to work as a team and again, you will have ten minutes to solve this problem.

FGQ2: Here is a second response to the Midwest Floods Problem developed by a second student at another university. (DISPLAY SOLUTION B). I would like you all to take a few minutes to answer the following question as a group. If you were responsible for putting together a team to study and develop solutions based only on these factors, what team members and/or characteristics would you include on the team?

TRANSITION:
(CHECK END TIME ON AUDIO RECORDER, AND IF NECESSARY): *It's been 10 minutes now. Please stop. Could one of you volunteer to describe the solution?*

(**PARTICIPANT** DESCRIBES SOLUTION) *Thank you!*

At this point, the focus group will become a semi-structured focus group, using the following questions as a guide. Some questions may not be used. Additionally, follow-up questions may be added to elicit detail and more in-depth information. Both solutions and the students' responses to the previous two questions will be displayed side-by-side for comparison purposes.

FGQ3: Thinking about the two solutions and the teams you created, which team member(s) or characteristics on these two teams would you say are the most important and why?

FGQ4: Of these two teams, which do you think would be better suited to solve this problem and why?

FGQ5: For team (fill in), if the CEO said that the company could only afford to have X members on the team, who would you keep and why?

FGQ6: If you were the project lead, for team (fill in), How would you approach the problem differently than a project lead for team (fill in)?

FGQ7: What types of challenges could you imagine you and your team would face when working on this project?

FGQ8: Do you have any questions for me?

TRANSITION:
That's all we have time for. Thank you everyone once again for your participation!

For each focus group, the moderator will rotate which solution is shown first. Also the moderator will include a copy of the original MWF prompt.

Prompt:
Over the summer the Midwest experienced massive flooding of the Mississippi River. What factors would you take into account in designing a retaining wall system for the Mississippi? Also, please explain your reasoning for selecting these factors.

Appendix B

These are the solutions extracted, with permission, from Atman, C. J., Yasuhara, K., Adams, R. S., Barker, T. J., Turns, J., & Rhone, E. (2008). Breadth in Problem Scoping: a Comparison of Freshman and Senior Engineering Students. *Journal of Engineering Education , 24* (2), 234-245.

SOLUTION A:

- Impact on the Environment, Urban areas, Farming/ Ranch
- Difficulties /Design relating to the Terrain - Higher elevation & less H2O/mile2 flow
- "Aesthetically Pleasing"
- Materials - transportation of materials, funding
- Accessibility to River, Commercial & Recreational
- Catering to EPA - less impact upon environment
- Government (funding) - smallest cost,
- How long it will take to finish
- How would affect other industries and businesses like fishing or the tourism

SOLUTION B:

- Price of materials
- Ease of using the materials
- When the best time of year would be to start the project
- How long it will take to finish
- How it would affect other industries and businesses like fishing or the tourism