A cognitive framework for understanding the role of students' expectations and motivations in interdisciplinary design collaboration

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***Abstract**: This paper presents an analysis of student expectations of and motivations for interdisciplinary collaboration using the concept of disciplinary egocentrism as a theoretical lens. Disciplinary egocentrism describes the inability to make productive connections between one's own discipline and the interdisciplinary topic and/or other disciplines. This paper builds on the theory by examining how expectations and motivations hinder or promote students' ability to cognitively engage in interdisciplinary collaboration. This approach provides an important link between the affective and cognitive domains, which in turn provides a critical framework for developing appropriate teaching practices.*

The findings are based on observations, interviews, and focus groups from a case study of an interdisciplinary green engineering capstone design course. The observation data shows significant gaps in students' ability to communicate of their expectations, motivations, and understandings of design. This gap in communication in turn correlates with struggles to form a cohesive team across disciplinary boundaries and establish productive design collaborations quickly. The focus group and interview data enhance the observations by revealing notable disciplinary differences between expectations and motivations of the students enrolled in the course. This finding reveals an additional area in which students may need guidance to overcome before being able to successfully collaborate on interdisciplinary teams.

Introduction

With the proliferation of multi- and interdisciplinary topics being used in engineering courses and projects, researchers (Bradbeer, 1999; Fruchter & Lewis, 2001; O'Brien, Soibelman, & Elvin, 2003) have begun to analyse the barriers of interdisciplinarity. Building on this work, Richter (Richter, 2008) and Richter and Paretti (Richter & Paretti, 2009) performed research in an interdisciplinary content course and identified a cognitive barrier to interdisciplinarity, termed disciplinary egocentrism, based on Piaget's construct of egocentrism from educational psychology. Disciplinary egocentrism refers to creating connections between an interdisciplinary topic and one's discipline, termed relatedness, as well as identifying the contributions of other disciplines to the topic and one's discipline, termed perspective. The construct provides a cognitive framework to analyse barriers to interdisciplinary learning and collaboration.

To further explore the nature and effects of disciplinary egocentrism, the authors designed another study to focus on interdisciplinary collaboration in the context of engineering design. To guide this research, the authors developed several research questions, including:

- How is disciplinary egocentrism manifest in interdisciplinary design collaboration?

- How does the phase of design affect the level of disciplinary egocentrism?
- How do students' expectations, motivations, and/or values affect disciplinary egocentrism?

This paper focuses on the last research question to explore the affects the educational psychology constructs of expectations and value on disciplinary egocentrism. In expectancy-value theory, the construct of expectation is defined as the perception of attaining success on a task while the construct of value is the perception of usefulness, importance, and interest of the topic (Brophy, 2008; Eccles, 2005; Wigfield & Eccles, 2000). In interdisciplinary collaboration, participants from different disciplinary backgrounds are likely to hold different expectations and values, which can impact their willingness to cognitively engage with other participants.

Methodology

Study Site and Participants

This research, approved by the Institutional Review Board (IRB #06-594), followed eleven self-selected student participants through their experiences in an interdisciplinary green engineering capstone design course; the capstone course was team-taught by three faculty members over the course of two semesters at a large mid-Atlantic university. These students represented seven majors within the fields of engineering and business; specifically, the engineering students came from the disciplines of biological systems (BSE), civil and environmental (CEE), industrial and systems (ISE), materials science (MSE), and engineering science and mechanics (ESM) while the business students majored in the areas of finance and management.

During the initial meeting of the course, the green engineering faculty member presented the students with three potential design projects. The student then formed teams by selecting a design project based on personal interest. This selection process resulted in two teams consisting of multiple engineering students and a business student; see Figure 1 for the composition of the teams. One of the projects, hereafter indicated as the water filtration project, challenged students to design a source of potable water for developing nations in Southeast Asia. Students on the other team, the industry partner project, were tasked with designing an environmentally friendly process or product to minimize amount of the company's waste disposal sent to a landfill. The business student on the industry partner team did not continue with the project into the second semester.

During the first semester, the faculty members held different class meetings for each team because of a lack of a common meeting time. This issue was resolved in the second semester by having all the students complete a survey before the class time was scheduled on the timetable of courses. In addition to the weekly class meetings, the green engineering professor held weekly technical meetings with each team to discuss concerns and address the teams' questions.

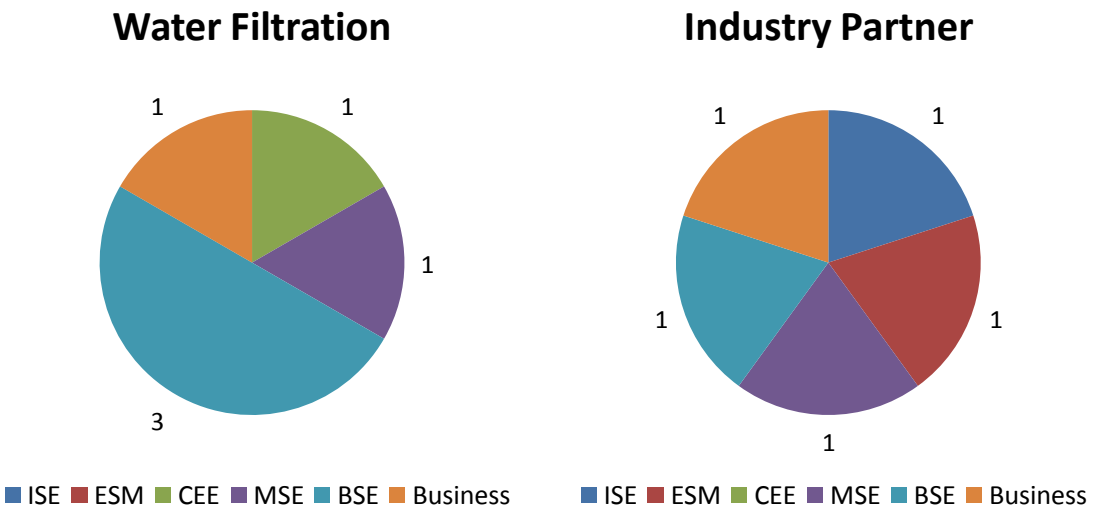

Figure 1: Team composition for the two design projects

Data Collection

In order to capture the students' interactions and perceptions, the research team collected multiple sources of data. Throughout the two semesters, two graduate research assistants collected field notes and audio recordings from both in-class and out-of-class meetings, resulting in 144+ hours of audio for transcription. At the end of the course, the primary graduate research assistant held focus groups and interviews with the students. Additionally, the primary graduate research assistant collected email communication from both teams as well as documents and artefacts the teams created throughout the course.

Data Analysis

For this study, the data analysis centred on sections of two transcriptions of class meetings and the transcriptions from the interviews and focus groups. These class meeting transcripts were chosen because the teams created "team contracts" as guiding principles for the duration of the project. The interview and focus group data were open-coded (Strauss & Corbin, 1998) to determine patterns within the students' answers of expectations and motivations. The transcripts from the class "team contract" exercise were analysed to examine the group expectations at the onset of the project.

Results

Motivation to Enroll

One of the important themes found in the interview and focus group data is the driving motivation for enrolling in the course. While all the students were receiving credit in their home discipline, students also had alternative motives for enrolling in the interdisciplinary green capstone course. For example, Grace explained her disinterest in design in her home discipline and contact with the green engineering program.

> Well, I know for [student's discipline] the design projects aren't really design projects. What they are is like a class on concrete where you design, but not even necessarily in a team probably your final project will be in a team kind of thing so it's not really the design you think about. So, I already knew that there weren't any of those that I had a strong interest in, and I was on the green engineering list, which is how I found out about it in the first place, and it looked fairly interesting to me because water treatment is the kind of thing I want to do and especially in developing nations.

Similarly, Victor "wanted to do something other than the same old what everyone does in" his major, and had met the green engineering professor "at some undergraduate research fair or something, and he told me about the project and I thought about it and thought it was neat and then throughout the summer kept in contact with him." While other students, such as Darren, only expressed that "the projects in [his discipline] weren't very interesting." Paige had a unique perspective of expecting that "we would actually really work with the manufacturing company."

Expectations of Team Members

The other recurring theme was the students' expectations of other team members. The level of dedication towards the project appeared in several of interview and focus group transcriptions. For example, Victor "couldn't get [his] team to meet that long ever so that's one expectation I had and didn't get." This level of commitment possibly stems from his experiences of teaming within his discipline. Victor's level of commitment contrasted greatly with Darren's, as shown by his response that, "Uhm, I guess like when I started work, like when I didn't care, I didn't care. They cared. ... But when I started being passionate it was upset when they didn't work really hard." Darren had disengaged from until he found a solution tied to his discipline approximately halfway through the second semester.

The other thread of expectations of team members centred on personal issues. Students responded with surface level details of working on teams. Stew, for example, expected other teammates to "do the assignments on time" and felt that was his team's expectation of him. Paige held a similar believe of expectations of her, as seen in her comment, "Uhm, I wouldn't know what they really expected of me

because I did everything that I was asked to do and they never had problems with what I brought to the table." Her perspective differs from Stew's when she expressed "my expectation of my team was... I knew that there were going to be some problems in the group because that's how it usually is."

These types of "typical" teaming expectations were also evident in the transcripts from the class meeting when the teams created the team contracts. The industry partner team focused primarily on rules regulating meetings and team roles; the actual team contract drafted follows:

1. If you plan to miss meeting inform other team members as soon as possible.
2. If you miss meeting, it is your responsibility to talk to other team members and find out what you missed.
3. Complete tasks on time.
4. Participate in all activities.
5. Be respectful to others.
6. When emailing your team, if related to the project and class, be sure to put in "[Industry Partner]" in caps in the subject line.
7. Meet after class or on Tuesdays (currently flexible).
8. Alternate turns with meeting minutes.

The water filtration team first focused on modes of communication before discussing the means of providing research for and gathering information about meetings in case of absences. The conversation shifted towards setting deadlines to submit work to the compiler, and finally, a brief conversation on voting procedure to make decisions.

Discussion

These two motivational themes, motivation to enroll in the interdisciplinary course and expectations of team members, can be linked to the theory of disciplinary egocentrism. Motivation to enroll in an interdisciplinary course can be attached to either the dimension of relatedness or perspective given the underlying motives. In this case study, the students primarily had negative reasons for not pursuing the capstone experience in their home discipline. Rather than focusing on the value of interdisciplinarity, which would be a positive link to the dimension of perspective, the students seemed to value green engineering. In the case of Grace, she views this opportunity as a precursor to a possible career path following interest in the area of water treatment, a positive instance of relatedness.

Several of these links appear in the theme of expectations of team members. With respect to relatedness, Darren disengaged from the project until he could find connections between the industry partner project and his home discipline. Darren's lack of relatedness seemed to directly influence his motivation from the project. In Victor's case, the expectation of long meetings for the team's success seems tied to his disciplinary background, but without the connections of perspective, he is unable to shift his disciplinary values to his teammates or understand their aversion to long meetings. Finally, the naive conceptions of interdisciplinary collaboration, resulting in an instrumentalist approach to collaboration rather than intellectual engagement, reveal a lack of students trying to gain insights into the disciplinary knowledge and skills of their collaborators at the beginning of the course. This lack in perspective continued throughout the course, with the interview and focus group data showing similar expectations of task completion.

Future Work

This study adds a new dimension to the theory of disciplinary egocentrism. By using constructs of expectancy and value from educational psychology, a link between motivational theory and disciplinary egocentrism has been established. Since this study focused on a small set of the available observation and transcript data and yielded favourable results, the researchers intend to analyse additional data sets to further develop the motivational component to the theory of disciplinary egocentrism.

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