

# Faculty Strategies for Facilitating Interdisciplinary Collaboration

David M. Richter<sup>1</sup>, Marie C. Paretti<sup>2</sup>

**Abstract** – Building on prior work, this study uses the framework of disciplinary egocentrism to examine faculty roles in facilitating interdisciplinarity. Observation notes and a transcription of an audio recording from a team meeting with a technical advisor were selected for this analysis. This particular meeting was selected from a series of meetings in which the students were developing a testing plan. Developing the testing plan became a complex task because the students drew upon their disciplinary and practical viewpoints to explain concepts and argue strategies. In this meeting, the advisor provided additional insights and mediated some of these differences. Further analysis of the interactions between students as well as the technical advisor reveals opportunities to develop strategies and/or interventions to guide students through conflict to reach a shared understanding of content knowledge. This paper will discuss the observations and present strategies faculty can use when guiding students through such conflicts.

*Keywords:* interdisciplinary, disciplinary egocentrism, teaching strategies, teacher roles

## Interdisciplinarity in Engineering Education

The demands of the current global economy and the complexity of design challenges have begun to shift the nature of collaboration from traditional disciplinary units to multi- and interdisciplinary teams because these problems cannot be successfully negotiated by using the knowledge and skills of any single discipline. These demands and challenges span levels of government, industry, and academia, and require input from multiple fields to provide the variety of knowledge and skills to develop feasible solutions and create new knowledge. Several interdisciplinary areas with direct links to engineering include, but are not limited to: micro-electro-mechanical systems (MEMS), nanotechnology, biotechnology, security and terrorism, energy, and sustainability.

Members on these multi- and interdisciplinary teams bring unique knowledge and skills, which then require strategies to connect all these disciplinary knowledge and skill sets. At minimum, disciplinary experts contribute their part, and disjointed segments are pieced together, similar to a jigsaw puzzle, a mode of multidisciplinary collaboration. In contrast, interdisciplinary collaboration is a complex blending or integration of the knowledge and skills from different domains [1, 2]; envision weaving a tapestry.

Several government reports have specifically promoted interdisciplinary learning and research. Specifically, *Facilitating Interdisciplinary Research* [3] and *Rising Above the Gathering Storm* [4] have shown the need for interdisciplinary collaboration in national laboratory settings focusing on global, national, and social needs. In *Educating the Engineer of 2020*, the National Academy of Engineering calls for the inclusion of interdisciplinary learning in undergraduate curriculum to better prepare students to face the real-world challenges that transcend traditional disciplinary boundaries [5].

This demand is echoed in accreditation criteria for undergraduates. When developing accreditation criteria of the technical and professional knowledge and skills graduating students must be able demonstrate, ABET incorporates

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<sup>1</sup> Department of Engineering Education, Virginia Tech, 660 McBryde Hall (0218)  
Blacksburg, VA 24061, richterd@vt.edu

<sup>2</sup> Department of Engineering Education, Virginia Tech, 660 McBryde Hall (0218)  
Blacksburg, VA 24061, mparetti@vt.edu

viewpoints from stakeholders in government, industry, and academia. The professional skills were included in the development of ABET’s EC2000 [6], and one specific criterion requires students to demonstrate collaboration skills. Although the criteria call for “multidisciplinary” collaboration, the need for a more interdisciplinary approach can be inferred from combining criterion (d) (“an ability to function on multidisciplinary teams”) and with criterion (h) “the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context” [7]. Criterion h, in fact, suggests the need for a broader, more integrated approach than the siloed mindset implied by a stricter use of the term “multidisciplinary.”

One particular barrier to this mode of collaboration both in the classroom and in the workplace is disciplinary egocentrism, or the inability to perceive 1) relatedness, connections between an interdisciplinary topic and a specific discipline, and 2) perspective, seeing beyond a specific discipline to begin to incorporate knowledge, beliefs, methods, and values from other disciplines [8, 9]. This barrier, particularly for students, provides a basis for faculty to both operationalize ABET criteria (d) and (h) in the form of more measurable learning outcomes and develop specific teaching strategies to support those outcomes. These issues are particularly salient for multidisciplinary design courses. When examining the learning outcomes for multi- and interdisciplinarity in papers submitted to the 2007 ASEE conference, Richter and Paretti [9] found that few authors provided measurable learning outcomes in the descriptions of interdisciplinary educational contexts, let alone specific strategies for helping students develop transferable skills to engage in other interdisciplinary contexts. Elsewhere, we then identified possible learning outcomes [10] and classroom interventions [8]. This study begins to identify specific teaching strategies that may be used to facilitate interdisciplinary collaboration by trying to answer the following research question:

What strategies can faculty use to mentor students in developing skills to overcome disciplinary egocentrism?

## Methodology

### Study Participants and Research Site

Eleven students self-selected to participate in this research study, approved by the Institutional Review Board (IRB #06-594), by enrolling in an interdisciplinary green engineering capstone course at a large mid-Atlantic university; three faculty members team-taught this course for the duration of two semesters. The student participants represented seven different majors, including five engineering disciplines (biological systems, civil and environmental, industrial and systems, materials science, and engineering science and mechanics) as well as finance and management from business. The faculty members presented several design projects to the students at the beginning of the semester, and the students formed two teams by selecting design projects. Figure 1 shows the team composition for both teams.

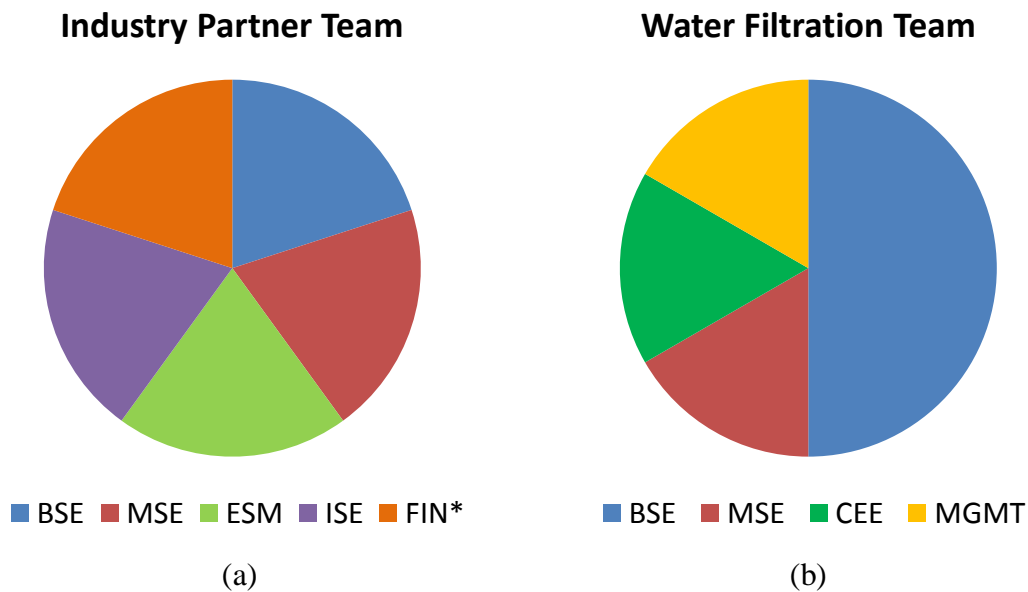


Figure 1: Team composition for the a) Industry Partner and b) Water Filtration teams

The two design projects selected included 1) teaming with an industry partner to minimize landfill disposal of waste and 2) developing a means of providing potable water to locations without clean drinking water. For the first project, the industry partner constrained the team to waste management, rather than focusing on strategies to minimize waste production. Conversely, the students that chose the water filtration project initially planned on creating a solution that could be used worldwide, but later realized they needed to concentrate their scope to one particular region of Southeast Asia.

### **Data Collection**

Over the course of the two semesters, researchers collected field notes (of 97 meetings) and audio recordings (144+ hours) of team meetings, classes, and technical meetings with an advisor. Additional data collected included 717 email communications between the team members and faculty, interviews with nine participants, focus groups with the final ten participants, artifacts – primarily documents, and pre-/post- assessments including a concept map of “green engineering” and an instrument to assess interdisciplinarity.

### **Data Analysis**

For this particular study, data analysis focused on one transcript from an hour-long technical meeting between the Industry Partner team and the technical advisor. This particular meeting was chosen for the manifestations of disciplinary egocentrism in the students and the level of student-teacher interactions. The primary purpose of this meeting was to discuss and develop a testing plan to statistically illustrate the feasibility of one of the team’s proposed solutions. With respect to manifestations of disciplinary egocentrism, Victor and Paige discussed statistics, but did not understand each other; Karen provided insights from her disciplinary knowledge of materials; and Darren was absent from the meeting because he had disengaged from the project. The technical advisor addressed these manifestations at various points during the meeting. These interactions were analyzed in the transcript through open-coding for specific “strategies” the technical advisor incorporated into the meeting.

### **Teaching Strategies**

From the open-coding of this transcript, the technical advisor used eight different strategies throughout the meeting that may have influenced the level of disciplinary egocentrism in the students, as evident by the team negotiating and making progress on developing the testing plan.

### **Gaining Knowledge**

The technical advisor displayed the strategy of “gaining knowledge” when he needed factual information from the students. In one particular instance, Paige and Karen had been discussing the creation and number of test samples. In order to more completely understand their limitations, the technical advisor asked, “so how many molds?” Both Paige and Karen were unsure of how many molds were available at the testing facility.

In the continuing conversation of the test samples, the technical advisor asked both Paige and Karen, “Does that take into account the statistics thing that Victor is doing?” He knew that Victor was working on a statistical plan, a design of experiments, with some of the faculty from his home department, so this question seemed to focus on gaining insight into the level of sharing knowledge within the group.

### **Clarification**

During this meeting when the technical advisor displayed instances of “clarification,” he moved beyond “gaining knowledge” by trying to get the students to explain what they meant. For example, when discussing statistics and the design of experiments, Victor kept referring to “replicates” without defining what he meant by a replicate. In the excerpt below, the technical advisor is attempting to understand what Victor means by a “replicate”:

Victor: But we won’t- we’ll only do one replicate. I think

Prof: One replicate of everything or one,

Victor: Yeah. Well actually two.

Prof: one replicate of everything. Two replicates of each point.

Victor: We’d- well no it’s one replicate, two samples because there’s two damaging tests. So you have to have two samples.

Prof: Ok.

By repeating his understanding of a “replicate,” the technical advisor also helped Victor articulate his understanding of the term.

### **Questioning**

In other instances, the technical advisor probed the students for the considerations involved in their decisions and assumptions. In discussing the different tests the team wanted to perform on the samples, the technical advisor asked, “why both the compression test and the split tension test. What’s the-, wh- wh-, just like we were saying with doing XPS and SEM, do y-, do we need to do both?” Both Paige and Karen revealed that the team trusted the judgment of a graduate student from the testing facility and were developing the testing plan solely on his recommendations. In this particular instance, the technical advisor also reminded the students they encountered a similar experience earlier in the project. The technical advisor revealed to the students they had not thoroughly considered factors when making this decision.

The technical advisor also questioned the assumptions the students were making about the testing process, specifically in creating the test samples. Since this meeting took place with only six weeks before the final presentation and report due dates and the testing plan possibly included a waiting period of twenty-eight days, the technical advisor used information he gained earlier, the limited number of molds, and identified a potential problem. He then questioned the students, “Let me ask this question, once you’ve got it in the mold, and it’s curing for seven days it has to cure in the mold for seven days? Or it cures out of the mold?” Paige, Karen, and Victor could not answer this question, thus showing they were missing vital information of testing procedures before developing the testing plan.

### **Explaining**

In addition to “questioning” the students about decisions and assumptions, sometimes the technical advisor also “explained” his thought process and rationalization for asking the question. Since Paige, Karen, and Victor were unable to answer the question about the test samples curing inside or outside of the molds, the technical advisor explained why he wanted to know more about the curing process of the test samples.

if it doesn’t have to cure in the mold, you know after the second day you can get the molds back and make more and then you don’t have twenty eight days to wait you really have, fourteen plus two or if it takes three days in the mold and then you can take the mold off, so that’s a key question to ask which is does it have to cure all fourteen days in the mold.

From this interaction, the team identified an important assumption that needed to be clarified before finalizing the testing plan.

### **Telling**

The primary strategy the technical advisor used was “telling.” The technical advisor used this strategy to present the students with information to consider in decision making or when they encountered difficulties on finding information on their own. In the case of the different testing methods, the technical advisor presented the team with additional information on concrete.

there are these general classes of concrete ... And they have different strengths. High strength concrete, regular strength concrete, lightweight concrete and they’re used for different things and, you just need to pick a class that you think this is most likely to be, or maybe you don’t know and the test will tell you that.

Once presented with this information, the team realized the importance of further specifying limitations on the application of their solution.

### **Presenting Hypothetical Situations**

Another strategy the technical advisor used to promote considering alternatives before making decisions was “presenting hypothetical solutions.” During this meeting, Paige presented the first hypothetical situation before the technical advisor began using this strategy later in the meeting. When Paige and Victor were discussing potential levels for the control variable, the technical advisor presented the team with possible data trends to have the team systematically explore the response during an initial pilot test.

So if this is what you're gonna do. A good thing to do would be the edges first, right? Cause if you do the second one and it's right here, you probably aren't gonna spend the time to do the two in between. If you do the edges and it's here, now you've got to decide do I want to do two more to see what it looks like in here. But if you just do these, two. You can't tell it might start to go up then. But if you do the edges first, it might eliminate a sample in the middle.

This strategy incorporates different levels of "questioning," "telling," and "explaining," but focuses on systematically approaching the problem in addition to evaluating multiple considerations.

### **Reminding of Practical Concerns**

While this strategy is similar to "telling," it differs when using the lens of disciplinary egocentrism. Instead of relying on disciplinary knowledge, this strategy draws from experience, which may or may not be from a specific discipline. With respect to scheduling times for creating samples and testing them, the instructor reminded the students to ask the graduate student about the lab's availability: "You need to- you know he'll know when the lab is open he'll know if other people are using the equipment all those things."

In another instance, the technical advisor pointed out the potential difficulty of measuring the ingredients for creating the samples if the team used one particular method instead of another. In this case, the team was evaluating the benefits and drawbacks of measuring the ingredients by volume or by weight. After considering the specific proportions of ingredients, the technical advisor pointed out one specific challenge with measuring: "The measuring, now you gotta measure out thirty eight point six and forty two point seven and."

These practical considerations may come from disciplinary experiences, but could also be linked to non-disciplinary experiences.

### **Filling In**

One last strategy the technical advisor used was "filling in" a team member about the previous discussions from the meeting. Victor had arrived late to the meeting and appeared confused by the discussion. Instead of continuing the conversation with Paige and Karen, the technical advisor addressed Victor, "we talked before you came here, about, whether you have a really good reason to do a second, strength test and you may, but one of the questions I asked these guys was..." By quickly summarizing the points Victor had missed, the technical advisor was able to draw Victor into the discussion.

### **Complexity of Interactions**

While the strategies used by the technical advisor in this particular meeting seem simple, the categories described do not capture the complexity of these interactions. Even though the technical advisor relied on "telling" as a primary strategy in this meeting, he shifted between strategies frequently. In a limited number of interactions, he shifted between strategies during the same speaking turn. For example, while discussing the different tests and possible applications of their solution, the technical advisor began "telling" the team information about concrete testing and switched to "explaining" his concerns about doing too many tests.

Um and the tension test may be ok but you might find out that, ninety-nine percent of applications go just by the compression test, and they use the tensile test just as a double check or, ten percent of applications, have some tensile component so it's important . . . , so either way you can do both tests. I mean, having two different sets of data is always nice but if it, if you get two partial sets of data that don't help you make a decision, that's worse than getting one set of data that helps you make some decision, and saying somebody should still follow up and do a tensile test.

The complexity of these interactions may be necessary due to the complexity of interdisciplinarity.

### **Conclusion**

From this study, eight teaching strategies for facilitating interdisciplinary collaboration have been identified. While these strategies seem simplistic, the technical advisor switched between multiple strategies in complex ways. Since interdisciplinarity is a complex phenomenon, facilitating students in interdisciplinary settings may require the use of multiple strategies in complex interactions.

## Future Work

Since this technical meeting was one of a series in which the Industry Partner team held in order to develop the testing plan, additional meetings are being identified and analyzed for additional strategies. Email communication and supporting artifacts may also be analyzed.

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### David M. Richter

David Richter is a doctoral student in the Engineering Education department at Virginia Tech. He earned a B.S. in mechanical engineering from Saint Louis University and a M.S. in mechanical engineering from Virginia Tech. For his dissertation, Mr. Richter is investigating the role of disciplinary egocentrism in interdisciplinary design collaboration. His other interests are in the areas of engineering design education, design cognition, and outreach programs for youth.

### Marie C. Paretti

Marie C. Paretti is an assistant professor of Engineering Education at Virginia Tech, where she co-directs the Virginia Tech Engineering Communications Center. Her research focuses on communication in engineering design, interdisciplinary communication and collaboration, and design education. She was awarded a CAREER grant from NSF to study expert teaching practices in capstone design courses nationwide, and is co-PI on several NSF grants to explore interdisciplinary collaboration in engineering design.