AC 2009-1592: ASSESSING STUDENT PERSPECTIVES OF INTERDISCIPLINARY COLLABORATION

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Assessing Student Perspectives of Interdisciplinary Collaboration

Abstract

In order to prepare current engineering students to tackle the complex, global problems they will face in industry, engineering education researchers have begun to investigate interdisciplinary collaboration. As researchers continue to unravel the phenomenon of interdisciplinary collaboration, engineering educators are beginning to incorporate interdisciplinary design experiences into their courses. While these efforts aim to increase students' skills for future interdisciplinary collaboration, assessments focusing on interdisciplinarity are still lacking.

This paper presents the adaptation of a scenario-based instrument, used to assess design cognition; the instrument was redesigned to assess students' perceptions toward interdisciplinary collaboration. Specifically, the instrument was designed to measure students' ability to identify and value the contributions of a full range of disciplines, both inside and outside of engineering. In doing so, it seeks to measure the students' understanding of the need for broad-based interdisciplinary collaboration.

The instrument was piloted in an interdisciplinary green engineering capstone design course; this test data was triangulated with focus group and interview data, collected at the conclusion of the course. To reliably score the test data, a rubric was designed to quantify the students' understanding with respect to interdisciplinary design collaboration. This rubric takes into account the different levels of perspective students provided through their answers. In order to triangulate the test data, the scoring rubric was used to create a coding scheme that then was applied to the interview and focus group data. From the analysis of the pre- and post-course tests, the students show a progression towards an awareness of need for interdisciplinary collaboration, but the focus group and interview data reveals that the level of perspective may not be at the same level as indicated from the survey data.

Introduction

With the current complexity of the world, engineers are facing challenges that require knowledge, skills, methodologies, and perspectives from multiple disciplines while only having been educated in their specific engineering discipline. The new engineering workforce, specifically new graduates of engineering programs, need to develop skills of interdisciplinarity to collaborate in complex ways in order to integrate the knowledge, skills, methodologies, and perspectives from all the disciplines involved in developing solutions to these challenges. This call for interdisciplinarity at the undergraduate level comes from several government reports, including *Facilitating Interdisciplinary Research*[1], *Rising Above the Gathering Storm*[2], and *Educating the Engineer of 2020*[3]. Another driving force to introduce undergraduate to interdisciplinary collaboration and learning comes from ABET with criteria 3 (d) and (h): "an ability to function on multidisciplinary teams" and "the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context"[4].

To address this need, researchers have investigated the nature of interdisciplinarity[5, 6] and barriers to or challenges of interdisciplinary collaboration[7-11]. This literature, while greatly contributing to the knowledge of interdisciplinarity, lacks specific and developed instruments to assess interdisciplinarity. Mansilla[12, 13] addresses the lack of instruments and provides a framework to assess interdisciplinary learning within an individual through the criteria of "disciplinary grounding," "integrative leverage," and "critical stance." This framework was implemented on student writing and not used to create a specific instrument to assess interdisciplinarity.

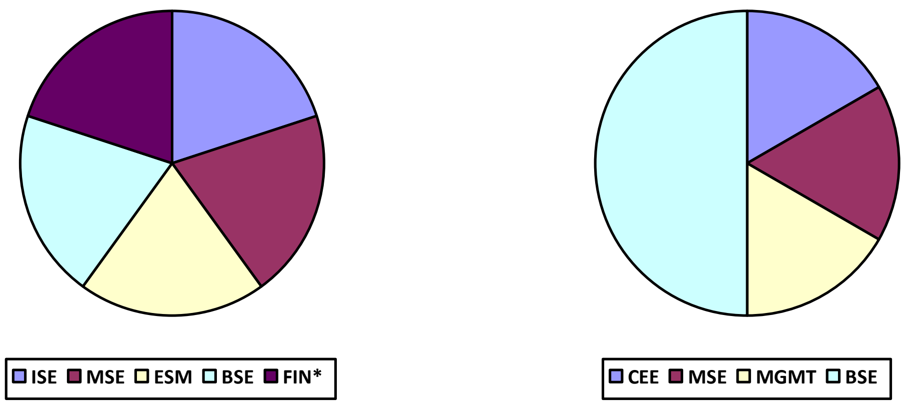
Methodology

Assessment Instrument: To address this need for specific instruments to assess interdisciplinarity, the research team developed a four item questionnaire adapted from the "Midwest Flood" problem, presented by Atman and Turns[14] and Cardella *et al*[15]. This scenario-based assessment placed the student in charge of hiring a team to design a retaining wall system to control flooding in the Midwest. Next, students were asked to choose the more important team member and explain their choice. The third question asked students to list, in order of importance, any potential difficulties that could arise while the team members are working together. Lastly, the students listed potential strategies to resolve those difficulties. The questionnaire is included in the Appendix.

Site and Participant Information: An interdisciplinary green engineering capstone design course was chosen as the research site to pilot this instrument. The green engineering capstone course is notably different from disciplinary capstone courses for three reasons: 1) greater emphasis was placed on design constraints involving environmental issues, 2) one of the primary instructors taught green engineering concepts, and 3) the other two instructors taught skills for working on interdisciplinary teams. Three faculty members, with backgrounds in materials science, chemical engineering, English, and linguistics, co-taught the course over a two-semester sequence. During the fall semester, each team attended their own individual 1.25-hour lecture as well as an hour-long "technical meeting" with the green engineering professor. For the spring semester, the two lecture courses were combined, though the teams were still required to hold individual technical meetings with the green engineering professor. Outside of the classroom and the technical meetings, the teams typically met at least once a week, with more frequent meetings occurring near project milestones.

Eleven students enrolled in the green capstone course for the fall semester, while only ten students continued through the spring semester. These student participants represented five disciplines within engineering, industrial and systems (ISE), materials science, (MSE), biological and systems (BSE) civil and environmental (CEE), and engineering science and mechanics (ESM), as well management (MGMT) and finance (FIN) in business. Depending upon the student's major, this course either fulfilled the student's requirement for the senior capstone course in their department or counted as credit towards technical electives. Six of the eleven, or 54.5 percent, of the students were female, well above the University's population of women in engineering.

The students self-selected their design project from a listed compiled by the faculty. One team chose to partner with a local industry to dispose of waste produced during the manufacturing process in a more environmentally friendly way; this team shall be called the Industry-Partner team. The second team selected to develop a sustainable water filtration method for a developing country; this team shall be referred to as the Water-Filter team. Figure 1 depicts the team composition by major for (a) the Industry-Partner team and (b) the Water-Filter team.



(a) (b)

Figure 1: Breakdown of students by major in (a) the Industry-Partner team and (b) the Water-Filter team
***Note: denotes the student that did not enroll in the class for the spring semester**

Data Collection: For this study, approved by the University's Institutional Review Board (IRB # 06-554), the research team distributed the questionnaire at the beginning of the fall semester and end of the spring semester and performed interviews and focus groups with the participants. The students received and completed a hardcopy of the pre-course questionnaire (see the Appendix for the exact verbiage) during the first week of class. During the beginning of exams in the spring semester, the lead graduate research assistant (GRA) conducted semi-structured, individual interviews with nine of the ten students as well as two focus groups comprising of five students each (two students from the Industry-Partner team and three students from the Water-Filter team); the audio recordings of the interviews and focus groups were later transcribed. Lastly, the lead GRA sent an email to all the students containing a link to an online version of the questionnaire; the third question on the online version left out the hypothetical team. Only four students from the Water-Filter team completed both the pre-and post-course questionnaire; the Industry-Partner team did not complete the pre-course questionnaire.

Data Analysis: The rubric for the survey data incorporates Biglan's[16] characteristics of academic disciplines, specifically the dimensions of hard-soft and pure-applied. On the first question, students that incorporated disciplines from multiple quadrants from the plot of hard-soft versus pure-applied disciplines graph received a higher score. The last three questions are rated on a holistic scale, awarding one point to answers common to any teaming experience, two points for potential difficulties that are exacerbated by working with other disciplines, and three points for answers unique to a team comprised of members from multiple disciplines; the rating of these questions may be influenced by the initial answer the student provided in the first question. Table 1 provides more details about the specific rating scales for each question.

Table 1: Rubric for coding the survey data

Score	Q1	Q2*	Q3*	Q4*
1	Only includes disciplines from one quadrant	The "expert" A team leader	Personality Level of expertise	Purely socializing
2	Includes disciplines from 2 quadrants	Partially shared importance	Scheduling Communication	Sharing knowledge Communication skills
3	Includes disciplines from three quadrants	Shared importance	Different perspectives (values, expectations, priorities, etc.)	Listing and negotiating priorities Developing understanding
4	Includes a discipline from each quadrant	---	---	---

***Note: scoring may depend on the student's answer to question 1**

The entries in the rubric provided key themes for coding the qualitative data collected in the interviews and focus groups. This coding structure presented points of comparison between the students' questionnaire responses and the interview and focus group transcripts for validating the questionnaire. Additionally, an interview question asking students to describe the disciplines of their teammates was compared against other students' responses as a measure of students gaining insight of the disciplines engaged in the interdisciplinary project.

Results

Questionnaire Data: The rubric from Table 1 was applied to all the pre- and post-course questionnaires to capture the level of interdisciplinary understanding of the participants. Overall, the students scored as low as four (only one point per question) to a high of eleven; the maximum possible score on the questionnaire is thirteen points. Scores on the post-course questionnaire ranged from five to eleven. Of the four students completing both the pre- and post-course questionnaire, two students increased their scores while the other two decreased. Table 2 displays the aggregate scores of the pre- and post-course questionnaire, showing a small trend towards interdisciplinary awareness.

Table 2: Summary of the responses on the pre- and post-course questionnaire

	Q1		Q2		Q3		Q4		Total	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1 point	2	0	5	5	1	1	2	2	10	8
2 points	2	5	0	1	3	2	1	3	6	11
3 points	2	2	1	1	2	4	3	2	8	9

Interview and Focus Group Data: Within the interviews and focus groups, the themes of personality as a difficulty to overcome, identifying contributions from the disciplines, lack of understanding of each other's disciplines, and valuing different disciplinary perspectives frequently appeared in the transcripts.

When asked what type of strategies or things to be aware of when entering an interdisciplinary collaborative project, most students identified their lack of familiarity with each other as a primary concern that would need to overcome. As one student stated, "the uncomfortableness of having to get to know each other and make it past that hump," was her primary concern when she entered the classroom. Another student reflected on the work (or lack thereof) over the first semester and commented that "I think like I think it took too long getting to know each other." Many students attributed the team's progress to forming social bonds and overcoming differences of personality.

When the participants were asked to name other disciplines that should have been on their project, the engineering students typically needed a prompt asking about non-technical disciplines. The students articulated how their own discipline, and sometimes a team member's discipline, contributed to the project, but when asked to describe the fields of their teammates, the student typically had a limited understanding of the other disciplines. One student's understanding of ISE graduates is that "you're just a business degree, business manager with an engineering degree I guess. That's just the way I see ISE."

Another pattern emerging from the transcript data involves the students' lack of knowledge about each other's discipline. In some instances, the discipline was equated with a specific type of career. For example, ISE majors become managers, and MSE graduates run testing equipment in laboratories. Other disciplines were equated to the type of knowledge in that field; specifically, ESM was linked to engineering-theory, mechanics of materials, upper-level dynamics, and similar courses students had previously completed through the ESM department.

Although the students may not have developed the necessary skills of interdisciplinarity to understand each other's discipline, the students did show awareness for and valuing different disciplinary perspectives. Example comments from the interviews follow.

- "I think if you get too many people together from the same field, you just have them argue in circles about the same thing" because "everyone has been taught the same thing."
- "It's cool having it from different perspectives because everyone from one certain department thinks one way"
- "[My team] just [brought] up stuff that [students in my major] don't think about."

Discussion

Using the current rubric, the maximum possible score on this questionnaire of interdisciplinarity is thirteen points; this number does not mean a student is completely interdisciplinary. While there appears to be a shift towards interdisciplinarity, when reviewing the questionnaire data, the transcripts from the interviews and focus groups reveal more of an awareness of the need for and appreciation of different disciplinary perspectives. These students seem to have an understanding of how their specific disciplines contributed to their unique design project as well as a having enough of a broad understanding of other disciplines to identify important disciplines for the Midwest flood problem. The knowledge these students still seem to lack is a deeper understanding of each of the disciplines involved with the projects.

This questionnaire may not directly measure a students interdisciplinary ability, instead is seems to measure the awareness for the need of interdisciplinary collaboration and the ability to value the contributions of multiple disciplines. This pilot study of the questionnaire encountered several difficulties. In the beginning of the semester, miscommunication between the faculty and graduate research assistants resulted in the Industry-Partner team only completing one of the pre-course assessments, not the questionnaire. Besides not having pre-course data from the Industry-Partner team, a potential complication arises from the implementation of the post-course questionnaire. The online version of the questionnaire instead of a hardcopy, the timing of the email requesting the students complete the online questionnaire, or combination of the two situations appears to have effected the students responses. Qualitatively, the answers on the post-course questionnaire were very brief and sometimes included extraneous comments.

Conclusions

In this study, the research team developed an instrument to assess interdisciplinary of students engaging in interdisciplinary collaboration. Through this pilot study, the questionnaire coupled with the interview and focus group data reveals the questionnaire measures the awareness for and openness to interdisciplinary collaboration; this type of instrument is valuable when students are entering an interdisciplinary environment. With these findings the instrument will be refined, and the questionnaire will continue to be validated.

Future work on this project includes analyses of observation data, collected over the entire two-semester period. The analyses of the observation data will likely yield specific behaviors, discourse patterns, and speech acts, which can also be utilized in future iterations of this interdisciplinary (awareness) questionnaire.

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Appendix

Green Engineering Design Course Assessment 2
Part A
Please answer the question below and hand it in to receive the second question.

Over the summer the Midwest experienced massive flooding of the Mississippi River. The firm you work for has just been asked to design a retaining wall system (e.g., a levee) for the Mississippi.

You are responsible for putting together a team to study and develop solutions for this issue. What team members and/or characteristics would you include on the team?

Which team member(s) or characteristic(s) would be the most important and why?
(Please annotate your response above or answer in the space below.)

When you are finished, please hand this sheet in to receive the second question.

Green Engineering Design Course Assessment 2
Part B
Please answer the questions below.

Given that the team selected to design the retaining wall consists of:
- You - White female city councilwoman representing the largest city hit by recent floods (environmental policy background)
- Mexican American female finance consultant
- Black male civil engineer with 25 years' experience designing retaining walls
- Indian male civil engineer who recently completed a master's degree on an experimental retaining wall design
- Chinese American female environmental science professor who consults regularly for the firm
- White male contractor specializing in retaining wall construction

What difficulties do you foresee the team members having in working with each other?
(Please list the most important first.)

What strategies would you use to resolve these difficulties?