Student Perceptions of Interpersonal Skills Intertwined in an Engineering Classroom

Miss Carmen Angelica Carrion, Georgia Institute of Technology

Doctoral studies in Science Education. Specifically in informal settings and through the application of problem based and project based learning.

Prof. Joseph M. LeDoux, Georgia Institute of Technology

Joe Le Doux is the Associate Chair for Undergraduate Learning and Experience in the Department of Biomedical Engineering at Georgia Tech and Emory University. Dr. Le Doux's research interests in engineering education focus on problem-solving, diagrammatic reasoning, and on the socio-cognitive aspects of the flipped and blended learning environments.

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By: Carmen Carrion MS & Joe LeDoux PhD

Introduction: This research paper describes the study about teaching interpersonal skills in an analytical engineering course and how students from this course actually experienced the interpersonal skills curriculum. In the field of engineering, model-based reasoning and the employment of engineering judgment are two of the most important practices that are critical for the success of practicing engineers [1]. Additionally, through industry and public institutions we know that engineers do not work in isolation, but in teams [2]. There is a need for a more authentic course experiences where engineering students can build content knowledge but also knowledge in how to collaborate with peers.

Background: Educational researchers Chi and Wylie began to investigate groups of twos and threes in different learning contexts to better understand what occurs in these group dynamics and how do these dynamics affect learning [3]. They created the ICAP framework which allows one to categorize students' levels of cognitive engagement into one of four modes based on their overt observable behaviors: Interactive, Constructive, Active, Passive (aka ICAP). In general, students learn more as their level of engagement increases from passive to active to constructive to interactive, which suggests that the most effective learning environments will be those that are structured to maximize the extent to which students interact with each other and the instructor [4][5]. The Problem Solving Studio (PSS), which we created in 2008, is one example of such a learning environment [6]. PSS is a cognitive apprenticeship learning environment that is composed of a set of participant structures that help ensure students work together [7]. In PSS, students are required to work with another student, on a public and shared problem-solving space, to solve challenging analytical engineering problems. Each team of two is seated at a table with another team of two with whom they can confer as needed. PSS is one approach for how to make use of the in-class time that is freed up when instructors choose to flip their lecture course. Flipping a course means that instructors record their lectures and require their students to view the lectures prior to class, so that the in-class time can be used for more interactive learning activities [8]. In PSS the instructor has the option of occasionally leading "just-in-time" discussions or mini-lectures, but students spend most of their time in PSS interacting with their partner and their tablemates. These tablemates can also be viewed as teammates. Just as on a sports team in PSS students are working as teams. The full potential of this team-centered interactive learning environment requires students to skillfully negotiate with one another: their roles, ideas, and problem-solving approaches [9]. The ability to negotiate ideas with a team or group are known as interpersonal skills also sometimes known as professional skills [10][11]. This skill set allows individuals to be better prepared in understanding how to work with others who may have different ideas and learn how to empathize and view situations from different perspectives [12]. Therefore, researchers decided to integrate within PSS learning activities that would develop students' interpersonal skills, in addition to the more traditional technical engineering skills. This constitutes a significant change from traditional engineering instructional

practices. Researchers wondered how students would perceive these activities and to what extent students would value the need to develop their interpersonal skills in the context of a highly technical engineering course. Researchers therefore asked the following research questions: Do students' value learning interpersonal skills in an analytical engineering course? How do students transfer learning interpersonal skills learned within an analytical engineering course?

Methodology: A mixed methods approach was used to collect and analyze data. Data sources for this study are from a 2000 level biomedical engineering course taught in the spring of 2018. They were the course syllabus and schedule, end of semester course evaluations, and end of course open-ended questions. This is a mixed methods study, quantitative data consists of a self-report Likert scale survey and the qualitative data consists of three open-ended questions found on the survey after the Likert scale items. Triangulation between the three data sources was used to investigate the extent to which students' valued, or do not value, interpersonal skills as being important to learn in a technical course and to the practice of engineering. Throughout the course the instructor taught foundational engineering principals along with activities that highlighted the use of interpersonal skills. The total number participants was N = 146. Demographics were not asked on the survey therefore there is no data on gender or ethnicity.
Materials - The given survey was paper and pencil format. The end of course survey consisted of two parts: Likert scale items and three open-ended questions. The Likert scale items asked students "to what extent do you agree that each of the following topics improved your ability to effectively interact with your partner(s) in the problem-solving studio?" Eleven topics on interpersonal skills were given including i.e. constructive feedback, selective attention, effective listening. Each topic was given with a 6 point Likert scale ranging from 0 – I don't recall this topic, 1 – disagree strongly, to 6 – agree strongly. Student mean scores ranged from 0 – 6. Each topic was scored for overall mean therefore, if a student answered zero on the Likert scale the zero was calculated in the overall score for that topic. Following the Likert scale items, students were asked to fill out three open ended questions: *1) Describe an experience when you've used one or more of the interpersonal skills that we discussed this semester outside of this course, 2) Overall, what was the most valuable thing you took away from this course?*, and *3) What can we do to improve this course?*. After collecting, the end of course surveys from students the surveys were transcribed from paper and pencil to a digital format. Once transcribed the open ended questions were analyzed using thematic analysis for themes centered on interpersonal skills. Interrater reliability was facilitated until both researchers agreed upon the same themes. Themes were constructed for all three open-ended questions. A frequency count was taken of each theme.

Results: The results section is organized by type of analysis conducted: quantitative and qualitative.
Quantitative results:

For the Likert scale portion of the survey descriptive statistics were conducted for each topic. Topic descriptives: Kolb learning cycle (M = 2.248, SD = 2.10), selective attention (M = 2.80, SD = 2.016), ICAP framework (Chi & Wylie, 2014) (M = 4.22, SD = 1.597), models of communication (M = 3.5, SD = 1.966), cognitive bias (M = 4.441, SD = 1.594), false consensus bias (M = 4.359, SD = 1.508), attribution bias (M = 4.175, SD = 1.562), effective listening (M =

4.296, *SD* = 1.610), three types of talk (*M* = 3.385, *SD* = 1.665), Johari Window (*M* = 2.945, *SD* = 1.763) , and constructive feedback (*M* = 4.338, *SD* = 1.741). Out of the eleven topics eight received mean scores 3.5 or higher demonstrating that the majority of the topics were positively valued in this learning experience.

Qualitative results:

Course syllabus: The course syllabus was analyzed to better understand if explanations were given about the addition of interpersonal skills to the current technical curriculum and how interpersonal skills support what is naturally occurring in the engineering workplace. In the course syllabus, interpersonal skills were discussed once in the entire five-page syllabus. This skill set, interpersonal skills, is not italicized or in its own section on the syllabus as with the other skill sets: basic engineering calculations or analysis of physiological systems. However, team building and team problem solving were expressed throughout the syllabus; both are areas in which interpersonal skills are implicitly discussed. Moreover, the course schedule does not explicitly indicate when interpersonal skills are intertwined with the other course topics such as estimation or energy balances.

Following the Likert scale items students were asked to answer three open ended questions. Recall the open-ended questions asked:*1) Describe an experience when you've used one or more of the interpersonal skills that we discussed this semester outside of this course, 2) Overall, what was the most valuable thing you took away from this course?,* and *3) What can we do to improve this course?*. All themes are focused around interpersonal skills to investigate if students were grasping the larger more holistic reason why interpersonal skills are necessary in the field of engineering.

Table 1. *Themes for each open-ended question*

	Themes	
Question 1	Positive – student answered yes and gave an example of using interpersonal skills outside of the course. Other courses – the use of these skills in other courses Personal life – the use of these skills in personal daily life	Negative – left blank or wrote interpersonal skills were not used outside of the course.
Question 2	Value of engineering content – describing the usefulness of engineering principles.	Value of interpersonal skills – describing the usefulness of interpersonal skills
Question 3	Removal of interpersonal skill curriculum from course.	More interpersonal skills in engineering curriculum

A frequency count was conducted for each opened-ended question. Table 2 below displays the frequency count for each theme by question. In question two, students received a count if either theme was mentioned. For example if a student describes learning the value of estimation and listening to others, they would receive a count of one under each theme because of them explaining the use of both curriculum. Additionally for question three, students earned a count if

their response was specifically about the removal of interpersonal skills or better implementation of interpersonal skills in this technical course.

Table 2. *Frequency count for each theme by question*

	Theme and frequency count of each theme	
Question 1	Positive – 75 Other courses – 40 Personal life – 30	Negative - 71
Question 2	Value of engineering content - 87	Value of interpersonal skills - 40
Question 3	Removal of interpersonal skill curriculum - 15	More interpersonal skills in engineering curriculum - 5

Below Table 3 displays examples of students written answers to the specified question on the survey. Many of the answers were concise but the students were explicit with their explanations for which content was more valued.

Table 3. *Examples of transcribed written responses from students*

Question #	Student Responses	
1.	"Group dynamic skills facilitated group interactions for me and allowed me to be more comfortable with asking questions." "Cognitive biases have helped me to better understand how I and others think." "Recently I attended a conference in New York where I met w/ several executives. I really used my effective listening skills in that situation. "	"I thought they were a little pointless (true in theory, but not super translated to real life)." "Almost all of this information is common sense." "NEVER"
2.	"The most valuable thing I gained were problem-solving skills. " "How to problem solve on the fly and rapidly apply known knowledge to now and novel problems to formulate solutions." "Diagramming and setting up problems before solving."	"I think the most valuable thing from this course is the skills required to work effectively in groups." "Working in a group is an effective way to explore the best approach to solving problems. " "How to have a conversation with a person who has opposing views than you."
3.	"I feel like much of the ICAP framework is very counterintuitive & sort of assumes we have no idea how to be an actual person & interact w/ other people." "Don't make this interpersonal skills material part of the course." "Cut most of/all of the interpersonal skill topics since they are more or less useless for anyone who has ever interacted regularly with anyone ever."	"I actually think that listening and communicating are such essential parts of any career and I like reading books about effective communication & how it is an asset. However, some of what we go over in class regarding this topic feels a bit basic or redundant. Considering we are all 18 & 19 y/o, I think we know how to act like we're listening. I would love to learn more about how to take that to the next level and be amazing communicators"

		"Continue to emphasize the importance of team learnings in P.S.S, as it is something that will help us not only in our school career, but beyond and into our professional one. Additionally, ensure that learning objectives are clearly communicated and that the problems presented to us are within our toolset. We have trouble solving exam problems we have never seen before." "When teaching us about the interpersonal skills I think it would be best to spend a little bit of PSS talking about it, rather than having us just read about them at home."

Overall, many of the students appreciated learning about interpersonal skills after analyzing both the Likert scale item ratings and the answers to the first open-ended question. Positive themes were found for question one. However, when delving deeper into open-ended questions two and three a large shift begins. Students are explicitly discussing a need to learn more about technical engineering content rather than describing a need for more interpersonal skills content. Consequently, by open-ended question three the majority of students do not even mention the use of interpersonal skills.

Discussion: PSS is a learning environment that is structured to maximize the amount of time that students are in the interactive mode of cognitive engagement because this leads to the most learning. However, this assumes that students are skilled at listening to each other, being open to each other's ideas, and are able to successfully negotiate and resolve the interpersonal conflicts that are almost certain to occur when two or more people are working together to solve a challenging problem. The data shows that many students see the value in learning about and practicing interpersonal skills in an analytical engineering course but some did not. From the student responses, many students did not explicitly connect interpersonal skills with being an effective practicing engineer. Demonstrating that students still do not see the connection, that working in groups in class is similar to working in teams in the engineering workforce. Moreover, by open-ended questions two and three the majority of students did not mention interpersonal skills in the course curriculum. Therefore, for interpersonal skills to be valued and understood by students the instructor of the course must be extremely explicit in making the connections for students in why these skills are a necessity in the field of engineering. As well as making the connections that, these skills are used daily by professional engineers who typically work in teams.

These findings raise a number of questions: why do some students see the value in learning these skills and others do not? To what extent are students in PSS in the interactive mode of cognitive engagement and to what extent is that influenced by students' proficiency at working with other people? Do students see interpersonal skills as something that can be taught, learned and developed? And lastly, to what extent do students believe these skills are critical to being an effective engineer?

Future work: More studies are needed to investigate how to facilitate the development of students' interpersonal skills within the context of interactive learning environments such as PSS. Additionally, we are interested in examining instructors' perspectives about the value of teaching interpersonal skills within the context of technical engineering courses. Another study could investigate how a more explicit syllabus and course instructions might affect how much students value learning interpersonal skills in engineering courses.

Broader impact: Interpersonal skills are critical to the success of professional engineers. This is because they are often tasked with working on interdisciplinary teams of engineers and other professionals to solve complex ill-structured problems. A range of interpersonal skills are needed for these kinds of diverse teams to reach their full potential. This study shares some preliminary results of a novel set of interventions that were infused within a highly interactive technical engineering course to help engineering students develop the interpersonal skills needed to work with others to collectively solve complex analytical engineering problems.

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