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# Investigating Student Behavior in an Interdisciplinary Computing Capstone Course

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## Abstract

Interdisciplinary project teams are increasingly vital in organizations that are focused on providing successful technical solutions that include a positive user experience. In response to the need for experience in this area, some higher education institutions have created interdisciplinary project-based experiential learning opportunities. In this research, we examine an interdisciplinary computing capstone course and present results from a qualitative study of student participants. We investigate how teams in an interdisciplinary capstone course self-organize, what convictions drive these decisions, and how they assess and value the expected contributions from disciplines other than their own. We analyze students' attitudes, beliefs, and motivations as gleaned from interviews and offer suggested improvement strategies for future interdisciplinary capstone courses.

**Keywords:** interdisciplinary, experiential learning, capstone course, computing

## 1. INTRODUCTION

In higher education technology degree programs, it is common to provide a team-based capstone experience that serves to give upper class students the opportunity to synthesize solutions to novel problems from a knowledge base acquired across their entire curricular experience. The benefits of this approach, and of team-based experiential learning in general, are well-understood and well-documented (Brooks, 2017; Carrasco et al., 2016). In such courses, students earn important perspectives on the interconnected nature of seemingly disparate technology knowledge areas and are better prepared for navigating the workplace and/or future graduate studies.

A common concern with capstone course experiences in computing fields is how to provide an effective real-world experience given the inherent lack of discipline diversity. Most technology degrees become increasingly discipline specific as students progress. Thus, the pool of students in senior-level courses from which team members are drawn is often limited largely or entirely to a single degree program. Any possible team roster will necessarily lack discipline diversity.

In response, some higher education institutions require interdisciplinary study as a significant component of their core curriculums. One such approach piloted at a University in the southeastern United States involves creating an interdisciplinary capstone course to increase interactions between multiple disciplines and represent an experience similar to the workplace where teams are composed of people with diverse backgrounds and skill sets. The capstone course serves as the culminating experience for an interdisciplinary program. In this case, the program is a joint effort by multiple departments: mass communication, marketing, design, and computer science. Students in the capstone course are a mix of students from these disciplines.

This paper reports on data gathered from semi-structured interviews conducted with students from the capstone course immediately after completing the course. It focuses on understanding team dynamics in an interdisciplinary capstone.

We are motivated by the following research question: how do teams in an interdisciplinary capstone course self-organize, and what convictions (especially what unsupported convictions) drive these decisions? Specifically, we seek to understand how students choose leadership roles, how they negotiate task assignments, and how they assess and value the expected contributions from disciplines other than their own?

This paper presents results from a qualitative analysis of student behaviors and motives. This type of analysis allows us the flexibility of openly exploring formative research questions and allows for future research to build on our results.

We identify some trends in student motivation and behavior that we believe are useful for informing academic stakeholders currently teaching or planning to teach an interdisciplinary capstone course. Section 2 presents a review of relevant literature, section 3 describes the course structure, section 4 describes the research methodology, section 5 describes our research findings, and section 6 provides lessons learned and presents suggestions for improving the interdisciplinary capstone experience. Section 7 suggests additional avenues for further research.

## 2. LITERATURE REVIEW

Teamwork is an important skill needed in the workplace (Abraham, et al., 2006; Drake, Goldsmith, and Strachan, 2006), and researchers have examined various aspects including satisfaction and productivity (Napier and Johnson, 2007), personality styles (Gorla and Lam, 2004), self-selected teams (Brabston and Street, 2005), and virtual teams (Chen et al., 2008; Goodbody, 2005; Nandhakumar and Baskerville, 2006). Additional research found that success in teams can be related to factors such as work ethic, equal contribution, and meaningful projects (Napier and Johnson, 2007; Ngai, Lok, Ng, Lo, and Wong, 2005).

From an educational perspective, research has shown that working in a team environment positively impacts student learning (Jensen, Moore, and Hatch, 2002). To help develop these skills, higher education institutions have introduced team projects and even entire courses that focus on developing teamwork skills. These efforts include components to ensure graduates possess effective communication and teamwork skills to adequately prepare them to be successful in diverse business environments.

James Shaw (2004) conducted a longitudinal study of 390 students examining the effects of diversity in project teams. The results of the study suggested student performance was significantly impacted by both the structure of the group as well as the position or role a student assumes within the group. Other research has focused on cohesion of interdisciplinary teams by improving communication and emphasizing the need for participation from all members within an interdisciplinary group (Becher and Trowler, 2001; Byram, 1997; Woods, 2007).

There are a number of recent education case studies on the benefits of interdisciplinary capstone courses and many of these cases indicate participants are better prepared for future workplaces and/or graduate school (Brooks, 2017; Carrasco et al., 2016; Flannery and Malita, 2014; Maloni, Dembla, and Swaim, 2012; White and Miller, 2015).

Kruck and Teer (2009) found that the student experience in an interdisciplinary technical capstone course was improved by including group activities about team success and establishing consistent group meeting times. Other case studies find that students generally have a positive view of interdisciplinary capstone courses (Heikkinen and Isomöttönen, 2015; Nettles et al., 2016; Smith et al., 2014) and interdisciplinary teams enable students to identify their own expertise and increase their occupational identity (Heikkinen and Isomöttönen, 2015). Spradling and Strauch (2010) presented a case study of an interdisciplinary course and found that less antagonistic attitudes were exhibited when a shared governance philosophy of managing the course was used.

Finally, our research also touches on how students perceive other students from different discipline areas. Research by Seipel and Brooks (2019) reviews the literature on academic entitlement and its effect on academic outcomes and also reports on a comparative study between business and non-business majors. In particular, they note that entitlement is related to inflated views of the self-concept.

Our research builds on these studies by directly investigating the motives and preconceived notions held by students in technology-focused interdisciplinary capstone course. We report on some noteworthy trends that inform course curriculum and philosophy.

## 3. INTERDISCIPLINARY COURSE STRUCTURE

In order to maximize the positive outcomes identified by the research into interdisciplinary capstone courses for students, it’s imperative that the course be carefully designed. It’s important that this experience be obviously different from a normal lecture course, focusing instead on modeled real-world experience, positive team experiences, and collaborative work on appropriately designed projects.

The following discussion about the structure of this course is provided, not because we intend to study the efficacy of this particular course design, but rather to demonstrate that students completing this course had ample opportunity in both preparation and course design to experience positive outcomes.

Students in the study course met regularly at an off-campus location for the entire day (9:30 a.m. to 4:30 p.m.) each Friday during the semester. Meeting off-site provided a clear indication of a different experience. Students spent significant time focusing on the semester group project, met comfortably with clients in conference settings, and worked to foment as a team (team lunches, etc.). The course content mimicked real-world experience by including daily scrum meetings and having all daily activities dictated directly by the needs of the project and client.

The course instructor(s) selected projects from the community and ensured they were a good fit for the interdisciplinary capstone setting. Projects were selected to offer opportunities for contributions from all four disciplines to provide a meaningful semester experience for all students. The instructor(s) ensured that each group had at least one student from each discipline and additionally worked to form the best possible teams given the nature of the project.

In most semesters, two instructors were made available during class time; one from design and one from computer science, as projects typically needed ample guidance in those areas. Additional instructors from the other disciplines attended on the first day to provide coaching and establish an avenue for communication throughout the semester.

Finally, each student who reached the capstone course was primed with an academic background that prepared them for maximizing outcomes from an interdisciplinary experience. Students who majored in the program began by taking a common core of classes across the component disciplines to build foundational knowledge in each area. Critically, each student was required to learn basic programming. Students then increasingly focused on their chosen concentrations and gained a depth of specialized knowledge and training. Students emerged from their specialized training and combined their diverse skills to form their capstone course project teams.

## 4. CASE ANALYSIS

To facilitate analysis of student motivations, decision-making structures, beliefs, and expectations we designed a semi-structured interview protocol (IRB approved) that was administered to students who were just completing their capstone experience.

Each interview began by asking students to review an informed consent agreement. The consent document described the scope of the study, indicated that there was no compensation of any kind, and informed that participation in the study was completely voluntary. Since the collection of data occurred after the conclusion of the semester, it was clear to students that their participation had no impact on grading or graduation. Once the student accepted the informed consent agreement, we started recording audio for later transcription and analysis.

To gather insight into student decision-making in choosing an interdisciplinary program we first asked students how they learned about the interdisciplinary program. We also asked their reason for choosing their major, their concentration, and for any general thoughts about the program. In addition to providing a valuable resource these questions served to establish a relaxed atmosphere where there were no "right" or "wrong" answers.

To evaluate group decision making we asked students to discuss the role they played in the project as they saw it, followed by a question about how they decided on the first task to complete. To better identify what role each student played we asked each to disclose all the tasks they personally performed throughout the semester to accomplish the group project.

Each student was also questioned about the major project tasks they did not participate in and asked to identify which students worked on that task and why. In cases where students from one or more academic concentrations were not involved in a task we asked why.

This gave us insight into not only why students worked on certain tasks but also why they did not. We also compared the provided answers and attempted to find correlation between chosen tasks and students' academic discipline.

Next, we asked students to predict what specific additional tasks they would have needed to accomplish in each of three hypothetical situations where their team would have been missing students from one of the three other disciplines. In each case, we asked them to rate their confidence in their ability to compensate for the missing expertise on a ten-point scale; ten being the most confident. In each case we also asked them to explain their rating.

To better gauge group-level decision making and to assess the assignment of leadership roles in the groups we asked students to consider how their group decided which tasks to work on and how they prioritized tasks. We also directly asked who the team leader was in their estimation, and asked what leadership qualities were valued most highly.

For this analysis, a single investigator conducted interviews with 10 students forming 3 teams. The class had a total of 13 students; however, 3 students were not available during the data collection. Of the 10 students in the study, five students were from computer science, two were from design, two were from mass communication, and one was from marketing. To ensure all teams had representation from all disciplines, some students served as the discipline expert on multiple teams. The investigator was given freedom to follow-up on any partial or unclear answer and could pursue interesting lines of reasoning with ad-hoc questioning. Each interview typically lasted 20-30 minutes. Each student was assigned an arbitrary participant identifier and each interview was audio recorded and transcribed using a professional transcription service.

To process these transcriptions, investigators independently employed open coding techniques to code a single interview transcript as provided by the interviewing investigator and developed a set of themes and codes. Next, three investigators independently coded the other 9 interviews. After the initial round of coding, the investigators worked together to unify codes and resolve discrepancies.

## 5. FINDINGS

The results show that students in the study group were both excited by and prepared to participate in an interdisciplinary group setting. In regard to the interdisciplinary program itself, we observed many general compliments and complaints typical of any program with no single deficiency standing out. Students listed job availability (n=4) and providing valuable information (n=3) as the most common strength of the program. Some students enjoyed the creativity afforded by the program (n=2). One student typified these feelings when he said, "Sort of just that merger between two different domains is what I really thought was the best, was perfect. It's so hard to find something like that out there. It's usually very technical, like just straight CS, straight CS engineering… a lot of depth but not very broad, and that's what I really liked about [the program]."

The results also show that students have been very intentional about the specific concentration they have chosen. In discussing the reason for choosing their concentration, students overwhelmingly cited a personal interest in the specific concentration (n=7).

The marketing concentration student primarily saw their contribution to the project as marketing, market research, and developing social media strategy. Design students saw their contributions as front-end design and HTML/CSS development. Mass communication students saw their role as content creation, client management, interaction design and sales. Students in computer science saw their role primarily as back-end development. The self-reported prioritized "first tasks" cited by students aligned typically with degree concentrations as well.

Tellingly, students in computer science also mentioned HTML/CSS, front-end development in Java-script, and client management among their primary contributions. The computer science students were unique in so far as they listed areas of expertise that crossed into the expected domain areas of the other disciplines.

This trend around self-reported contributions was born out when examining the role that students took in each group. Students tended to choose specific roles in the group in alignment with the curriculum of their concentrations and with their reported key areas of contribution. Again, the one exception was computer science students who also tended to take front-end development and client management roles; roles the investigators would have presumed belonged to mass communication and design. These discrepancies are interesting in and of themselves, but the potential impact to the success of the interdisciplinary experience comes into focus with further investigation of student motives and beliefs.

When we asked students who led their teams, every student indicated that their team was led by a member of the computer science concentration. More than half of the students cited effective communication(n=6), a skill set not stereotypically attributed to computer science students in general, as that person's key leadership quality. Half the students indicated their group leader was most knowledgeable and best able to mentor and answer questions.

On the surface, this is a glowing report reflecting well for the group of computer science students. However, when considering that the projects were chosen by the instructor(s) to provide ample experiential opportunity for all students, and weighing the intentionally diverse structure of the teams, this is not necessarily the best outcome for project success.

Survey results indicate an inequity between concentration specific self-efficacy as reported by students from outside concentrations. Appendix 1 illustrates that on a 10 point Likert scale (10 registering the highest confidence) students in the other concentrations felt confident in their ability to carry out the work of the marketing (m=7.7, SD=3.3), mass media (m=6.6, SD=3.5), and design (m=6.6, SD=3.5) students. Students outside computer science were far less confident about their ability to perform the task of the computer science students (m=3.4, SD=2.2). Moreover, the smaller standard deviation shows even less variance in students' low assessment of their ability to perform those tasks. These ratings were consistent for mean, median, and mode and showed only marginal differences between the three measurements. Despite the balanced nature of the selected projects we saw a clear differentiation of perceived importance of academic background between concentration areas.

Further highlighting these discrepancies were the results when students were asked to discuss the major tasks contributed by their teammates. We found that students overwhelmingly identified tasks that were performed by design and computer science students as major tasks and those by marketing and mass communications students as lesser tasks. This indicates that students from certain disciplines either were actually, or were at least perceived to be, more active in accomplishing tasks than others. This is not the anticipated outcome especially given that group projects were carefully chosen to engage all participants.

Analysis of interview data draws an interesting picture. The concentrations where students reported higher self-efficacy ratings were marketing, mass communication, and design, respectively. In each of these, data suggests that students are under valuing the expertise of others and overvaluing their own abilities.

For example, one student reported concerning the importance of marketing expertise said, "I could have just brought in a plugin or looked up how to do that (marketing). Analytics and AdWords, I understand how that works. Data analysis, we've done stats classes and stuff like that, maybe not specifically with this, but certainly I've had enough experience in doing it to where I could figure it out."

Another student acknowledged that they did not understand the marketing discipline, but then proceeded to show an undervaluing of that discipline specific knowledge. "I feel awful. Which is I don't exactly know all they do or all they've learned beyond search engine and optimization, but even the people that are in the capstone kind of felt confused about that, even the [computer science] kids sort of seem to know a little more about that than they did... "

Students also tended to assert a belief that domain knowledge in marketing was quickly attainable on their own with minimal effort. "If I do the research, I think I would be able to pick up all the necessary skills to accomplish that task." From another student: "... at the time, I was taking [a professor's] usability test class, so I had very fresh knowledge on how to do that. … It was all very fresh in my mind, on how to do everything for it.

This undervaluing of domain-specific expertise is not limited to marketing. In the case of mass media, we are able to observe similar attitudes. One participant noted, "Not trying to knock it, but it's not… I feel like I have natural skills to be able to do that stuff as well."

When discussing their confidence ratings for design, one typical student reported, "Yeah, I could do it, but I don't want to because I don't like the individual experience in what colors mean and positioning looks best." While design students do consider colors and positioning, their work is obviously far broader involving information flow, conceptual design, user experience, responsive design, programming frameworks, and typography. None of these were identified by students from the other disciplines. At least in the case of design, many students seemed able to admit a creative shortfall in completing design tasks, but even in so doing undervalued those tasks. One student wrote, "I think that, well personally like I want to do front-end development, so I have a lot of outside knowledge on coding the stuff, just not designing it. So the designs would take me longer than would probably take them, but in terms of usability, the way that it's coded, it would probably be a higher quality and take less time."

For the areas of marketing, mass communication, and design, students from other disciplines all showed a confidence in understanding what those disciplines entail, while simultaneously and obliviously exhibiting an outsider's limited viewpoint and expertise. That confidence in being able to encapsulate those academic areas in a few limited notions seems to boost their self-confidence that they themselves could fairly easily learn enough content knowledge to replace team members from those disciplines. Given the limited scope of what the students can report about what these academic areas even are concerned with, this seems less than likely.

The opposite is true, however, for computer science. Students outside the discipline don't think they understand what the discipline is about; at least not to the level that they feel confident they could learn to perform tasks specific to that discipline. We do not see the same undervaluing as with the other three disciplines, if anything, we observe the opposite.

When asked to qualify their low confidence in completing computer science related tasks students primarily cited a lack of knowledge or understanding (n=3) or lack of programming skills (n=2). One participant typified responses from almost all the others, "I mean I know that they do things, I want to make that very clear. I don't think they don't do anything. I just don't understand exactly what they do. I know that it's a lot of stuff that I would probably not even understand if they tried to explain it."

Obviously, these trends have negative impacts on the outcomes expected from interdisciplinary capstones. To track this, we asked study participants how their group interacted with each other over the course of the semester. Initially, some group members felt their groups started out with poor group cohesion (n=4), but most group members felt that their groups worked well together. A significant minority of group members (n=3) felt that the groups never achieved good group cohesion. "So [mass communication], and one of the, what's it called, [marketing] people seemed to not really know what they should be doing or had the appearance of working, but then if I ask them what they're working on, they'd ask like, 'What do you want me to do?' I was just curious; I didn't really have anything to give them." All three of these students came from computer science and had previously exhibited an undervaluing of the contributions from other disciplines. These three were not from the same group. Based on conversations from other team members, the negative feeling of poor cohesion was not shared by their teammates.

## 6. DISCUSSION AND PEDAGOGICAL IMPLICATIONS

In this section, we highlight the major findings from our analysis and offer suggestions as to how instructors can mitigate potential issues in the design and implementation of an interdisciplinary capstone course.

### Overvaluing and undervaluing disciplines

We consistently found that team members from different disciplines either undervalued or overvalued the other disciplines. In our analysis, this phenomenon appeared to be the overarching concept that led to other issues within the team.

When we examined students' confidence in completing tasks related to concentration areas other than their own, we found unsupported confidence displayed in every concentration. Students tended to under-value the expertise provided by disciplines other than computer science, and often trivialized the value of the discipline specific domain knowledge.

To address this, we suggest great care be taken in the design of an interdisciplinary capstone course to emphasize the importance of each discipline in the success of the team. It is important that steps be taken early in the course to help mitigate these student perceptions.

Suggested improvement strategies:

1. Highlight real-world examples of projects that failed due to lack of involvement from all disciplines. For example, there are numerous examples of projects that met the basic requirements, but failed due to poor user experience, resulting in millions of dollars in losses.
2. Design discipline specific activities that showcase the knowledge and talents of each discipline. For example, create a task that highlights aspects of design, usability, or digital marketing.

### Unbalanced leadership

We observed that each interdisciplinary team independently built an ad hoc hierarchy with the more `technical' disciplines at the top. This occurred despite the fact that all students were required in the shared curricular core to learn programming and despite the inclusion of additional web development courses in some of the less-technical concentrations.

Every student in every group in the study self-identified a student from the computer science discipline as their group's leader. Prior to this study, our expectation was that group leadership would naturally be uniformly distributed over all concentrations. We found this interesting as computer science students are not typically known as "charismatic" or " natural born leaders". Survey data suggests a two-fold reason for this. First, this likely results from the computer science student's overconfidence in their ability to complete tasks typically associated with the other disciplines. The effect is exacerbated by the other students' self-doubt in their ability to learn to complete more technical tasks.

Suggested improvement strategies:

1. Include activities that highlight important leadership qualities and strategies for selecting team leadership. Make sure that students understand that technical ability and/or overconfidence is not necessarily a good leadership quality.
2. Introduce real-world examples of how poorly chosen leadership doomed projects, and how technical projects are often led by people without deep technical backgrounds.

### Team Cohesion

To maximize positive outcomes, teams need to exhibit a unity of purpose as soon as possible. Students need to begin building team cohesion on the first day and continue strengthening that cohesion throughout the semester. Our results showed that some team members felt their team never reached a satisfactory level of group cohesion.

We posit that better group cohesion is more likely when group members respect one another and believe that different disciplines are equally important to achieving the goals of the group. Our research indicates that more emphasis and improved teaching methods are needed to help students internalize that all disciplines are essential to the project and that there are important outcomes above and beyond merely completing the project.

Suggested improvement strategies:

1. More emphasis on the importance and value of interdisciplinary teamwork needs to start early in the program(s) of study and be maintained throughout the higher education experience.
2. Include activities focused on the respect of the ideas and abilities of others. Highlight real-world examples where these principles were not followed leading to failed projects or disastrous consequences.

## 7. CONCLUDING REMARKS

Interdisciplinary capstone courses provide learning opportunities and experiences that augment what is available in a siloed degree program. We examined one such capstone class and found that students sought out the program because of their desire to broaden their knowledge and take advantage of the unique learning environment. We also found that despite efforts to foster appreciation for the equal value of different disciplines, students created an ad hoc discipline hierarchy. Unfortunately, this led to undesirable effects such as limiting learning opportunities, lack of diversity in group leadership, greater reliance on faculty for guidance, and a perceived lack of group cohesiveness, each of which hampered the development of expected positive outcomes and undermined critical teamwork experiences.

We find that additional work is needed to convey the idea that the breadth of interdisciplinary knowledge is critical to project teams and that each discipline is of equal value. The perception that a student–and the concentration they represent on the team–could be replaced by a mere software plugin is an example of how trivialization of another discipline can negatively impact team productivity and attitude. Future research is needed to examine additional mitigation strategies for overcoming false perceptions concerning the value of different knowledge areas. This will require building an inclusive culture that is cultivated from the first moment a student expresses an interest in the interdisciplinary program.

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# Appendix 1

Table 1: Confidence ratings (1 to 10, 10 being Very Confident) of performing discipline-specific tasks as reported by students in one of the other three disciplines.

| | Number of Ratings | Min | Max | Mean | Median | Mode | SD |
|---|---|---|---|---|---|---|---|
| Marketing | 9 | 4 | 10 | 7.7 | 7 | 7 | 3.3 |
| Mass Communication | 8 | 4 | 9 | 6.9 | 7 | 7 | 3.2 |
| Design | 8 | 3 | 10 | 6.6 | 6.5 | 6 | 3.5 |
| Computer Science | 5 | 1 | 4 | 3.4 | 4 | 4 | 2.2 |