Interest-Based Capstone Team Formation

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How might student teams be formed to prioritize individual engagement and motivation, given a cohort of students and a batch of capstone project concepts? For the capstone course in the Computer Science Bachelor's degree at University of Colorado, students rank their top five project preferences and instructors use that indication of interest as the driving factor in forming teams. Students in two years of the CS Senior Projects capstone self-selected to participate in a semi-structured qualitative interview about their experience. This paper investigates how use of student interests as the primary basis for forming capstone teams may influence students' perceptions of their experiences in the capstone project. Themes include legitimacy of real-world projects, engagement of students, and ownership of project decisions.

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Introduction

> *I really liked that it was a project that I was interested in…. I was like, 'I really care about this field! I'm really passionate about it!' And I know that some of my team members were really excited about the domain as well. [Elizabeth[i], 2014-15]*

A challenge faced when implementing a project-based capstone course is determining how to organize a cohort of students into teams and, once organized, how to motivate the students to engage in working on their projects. In short, how do we spark interest in supporting the project?

Processes for organizing capstone students into teams may consider different levels of input from students, from no input (perhaps random assignment), to minimal input (resumes or skills of interest), to maximal input (having students decide their own team members and notifying instructors of their decisions). Each of these options has trade-offs to be considered. For example, team assignment based on instructors matching student backgrounds and skills to project needs may provide a skill-balanced team, but may place students together who do not see the project as relevant to their interests and then struggle to engage. Allowing students to form their own teams may support students in expressing their interests, while potentially resulting in unbalanced teams that struggle to meet the project outcomes.

As the introductory quotation from a student interview conveys, students are aware of their interests and the interests of their teammates. This paper considers the question: **How does using student interest as the primary basis for forming teams influence student experience in their capstone project?**

The Computer Science (CS) department at the University of Colorado (CU) has included a software engineering capstone course as part of the Bachelor's degree since the first senior cohort in the 1987-88 academic year. Since the 2012-13 academic year, this CS Senior Projects capstone has driven team formation primarily by student preferences. To explore the impact of this practice on student experience, I carried out qualitative interviews with capstone participants after the 2014-15 and 2015-16 academic years. During this study, I worked as a teaching assistant for the course. My hypothesis is that primarily interest-based team selection may support student motivation and engagement with their project and team.

Literature related to interest and its role in learning is presented. I review the interest-based team selection process in the context of the CS Senior Projects capstone course. Methods for conducting and analyzing qualitative interviews are briefly presented, followed by interest-related results of the thematic analysis. Discussion about results and possible implications conclude the paper.

Relevant Literature

My working definition of *interest* is "a relatively enduring predisposition to reengage particular contents over time", and "to problem solve and seek out answers to questions"[1]. Interest is "characterized by varying amounts of affect, knowledge, and value"[1]. Specific to CS, researchers investigating students who decide to withdraw from the CS major have found a "nexus of confidence and interest"[2], indicating that loss of confidence and loss of interest may accompany a decision to change majors. For purposes of this paper, the key conjecture is that interested students will tend to be more engaged, will make decisions to persist despite

frustrations, and will exhibit greater confidence[1,2]. When considering interests and engagement in capstone courses, confidence can augment technical skill development[3].

Interest and engagement in learning may be more readily motivated when students find the learning tasks personally meaningful and relevant[4], suggesting that if project assignment is driven by student interests, students may experience an easier path to engaging with their projects and persisting despite challenges and frustrations.

Based on the interest literature, an interest-based team selection process may support deeper engagement and successful experiences in the capstone course. A recent study noted that consideration of student interests during team assignments "aim[s] to give students an element of choice in the project they undertake"[5]. The authors stated that they take student preferences "into account" as one of several factors considered by a panel assigning teams, whereas the team assignment process at CU makes student interests the driving factor in team formation.

The Context

The implementation of the CS capstone course at CU is a software development project that runs for the full academic year. External sponsors propose project concepts, both from industry partners and members of the academic community. The course is directed by an instructor assisted by two teaching assistants as the teaching staff. Together, they mentor teams of four to six students in the practices of software project management.

Sponsors submit a two-page project proposal prior to classes beginning, and attend a Sponsor Fair during the second week of class. The Sponsor Fair is modeled after a job or career fair, with each sponsor organization at a table to recruit for their project. Many sponsors bring technical material related to the project that may help with explaining the scope, such as a previous prototype or part of the system that would be supported by the project.

Students receive the written project proposals during the first week of the class. They prepare and submit their current resume prior to the Sponsor Fair event. At the Sponsor Fair, they practice networking by distributing copies of their resumes to potential project sponsors, and explore the various project options available to them.

Team Formation Process

After the Sponsor Fair, students submit their top five project choices, ranked in order of preference. The preference survey asks about leadership role preference (*strongly prefer to lead* to *strongly prefer not to lead*), intellectual property (IP) rights preference (*strongly prefer to retain IP rights* to *no preference to retain IP rights*), strength of a variety of technical skills (*none, basic, good, proficient*), areas of desired learning (open-ended list of skills), suggestions of who to work with, people who will not work well together, and GPA.

Team Formation Guidelines

Students are assigned to projects by the course instructor and teaching assistants. For the 2014-15 academic year, this involved assigning 72 students across 12 teams of 6 students each. For the 2015-16 academic year, there were 68 students across 12 teams of 5 and 6 students. For each year, the team formation process required about four hours of iterative discussion.

An inviolable consideration is people who will not work together well, as there may be prior bad experiences. The defining factor of team assignment is that iterations are driven by project preferences. The initial iteration of assignments is based on first preference choices, up to 6 students for each team. For partial teams, second (then third, etc.) choices are considered until the team has at least 4 students. Subsequent iterations continue by considering removing students from a placed team so they become candidates for a lower preference project. The guiding rule is to move previously placed students from a higher preference to a lower preference to make room for a student who has not been assigned on one of their higher preferences. This introduces a maximizing function of placing students on their highest preference, while prioritizing placement of students whose preferences are more restrictive.

Teams are announced in the third week of the class. Each team selects their team lead and schedules their first sponsor meeting. From that point, teams refine project scope and requirements, identify risks and tasks, and run their project. Each team meets weekly with a member of the instructional staff.

Research Methods

To investigate the influence of the interest-based project selection on student experiences, students of the 2014-15 and 2015-16 academic years self-selected to participate in semi-structured qualitative interviews about their project's successes and failures. Questions focused on project selection ("What drew you to some projects? What drew you away from other projects?"), external evaluation ("Who evaluated your project? What information was available to them to consider?"), and self-evaluation ("In what ways was your project a success? In what ways was your project unsuccessful?"). These questions allowed students to offer open-ended reflections on their experience. Interviews were conducted by phone or in person, lasted about an hour, and were completed between 1 week and 2 months after the conclusion of the capstone course. Participants received a $5 gift card as a token compensation for their time. Of the 140 students (12% female) enrolled in the

course over the two academic years, 19 students (26.3% female) self-selected to participate in interviews. Demographics such as race/ethnicity or first-year students were not collected.

Analysis of interview transcripts followed the methodology of thematic coding[6], with a research group consisting of the principle investigator and an undergraduate research assistant. To explore themes, the transcripts were read and reread, with regular discussion of possible themes of interest, mainly around what participants expressed as being meaningful about their experience. These themes were developed into a coding dictionary for consistent use across readers in applying the thematic codes. For purposes of this paper, I focus on the role of team interactions and engagement as themes identified in the thematic coding process.

Results

Thematic coding resulted in a variety of concepts related to personal meaning. Specific to the focus of this paper on the role of interest-based project selection are legitimacy of real-world projects, engagement of students, and ownership of project decisions. Here, each of these themes are described with selected extracts from interview transcripts to demonstrate what is captured by each.

Legitimacy of Real-world Projects

Multiple interview participants discussed differences between the capstone experience and previous coursework. Some described previous assignments as not being "teamwork" because of small group sizes (two to three students), short durations, and limited scope. By contrast, the capstone experience team sizes were more authentic to what students anticipated real-world teams to be. Longer project durations require working through team dynamics issues rather than just pushing through to a nearby deadline. In terms of project scope, one student thought about it in the following manner.

> *It was a huge learning experience, building something that was so much larger than anything we had ever done before…. [Capstone] was the first experience that I had had with building something where my project team really had control over all the moving parts, and was tasked with creating each of those moving parts, and making them move together in a way that wouldn't blow up. [Eric, 2014-15]*

Along with noting similarities with real-world software development practices, participants noted that the academic space has limitations to its legitimacy. Examples of key differences include the challenge of managing varied schedules and non-project commitments. A benefit of these limitations was described as follows.

> *It's really nice having it in this school format where if you make a catastrophic screw-up, the worst-case scenario is we get a B in the class…, instead of getting fired, which would actually be catastrophic, or at least emotionally catastrophic. [Samuel, 2015-16]*

While actual impact to grades may be more severe, the academic space around capstone projects does offer a safety net as students work through challenges. In addition to the capstone instructional staff, the course relies heavily on the faculty and university staff to assist with overcoming project obstacles.

Engagement of Students

Several students noted that their team started into the assigned capstone project with excitement and motivation. Four of the nineteen interview participants were team leads. A team lead described his concerns with overseeing individual team members.

> *On more of a personal level in terms of success, … I was looking at, … 'How can each of my teammates contribute and be productive?' So long as everyone was doing everything that they could and being as productive as possible, I didn't really care how far we got, how great the thing looked. I just wanted it to be a great effort. [Thomas, 2014-15]*

Interviews included teams that encountered frustrations and struggled with lack of engagement and low morale on occasions. Despite the struggles, participants noted the value of their interest and engagement on project success.

> *[I]f you're given the option to do something that you care about, you're going to feel better about it, and you're going to produce better work…. [T]he fact that I'm driven and passionate to learn, and that I want to pursue something great, I think that [on] a team, I'll be able to contribute great work to it. [Diego, 2015-16]*

Ownership of Project Decisions

A key difference between capstone experiences and internships is that capstone students carry the responsibility to make project decisions. The following captures this concept of making and defending decisions with respect to the capstone project.

> *My expectations of teams is a little bit colored by … being able to delve into things and talk openly about design, and not have people get offended if you criticize the design decisions, and having your design decisions criticized as well, because that's all in building a good product. [Eric, 2014-15]*

A strong example of team ownership of the project direction was described by Thomas.

> *[H]aving gotten a month or two into [development], and really … digging out the weaknesses of the*

software stack we chose, we all had a serious conversation about it. And at that point…, we're willing to go back on a month of work…, because we know … this is going to help us get to our end goal. [Thomas, 2014-15]

Discussion and Conclusions

This paper describes a process for forming capstone project teams based primarily on ranked student preferences. Qualitative interview data offers evidence of student perceptions of their capstone experiences. For the CS Senior Projects capstone, students interact directly with potential project sponsors at the Sponsor Fair event prior to selecting their project preferences. In addition to the written two-page project pitch, the Sponsor Fair serves to acquaint students with individual sponsors. As such, their project preferences represent informed, not blind, interests. Students have an idea of how well versed the sponsor is in the project concept, how invested they are in its success, and how enthusiastically they speak about the idea. When students submit their project preferences, their initial curiosity about project concepts have matured into full interest and a desire to see the selected projects progress.

Interest-based team formation has its own trade-offs to be considered. In some settings, the time for iteration may be prohibitive. A risk is that the interest-based process may produce teams lacking specific skill sets. On the other hand, a team where all members share a common interest in seeing the project succeed may support stronger collaboration, such that the team may be more successful in overcoming those shortcomings and other challenges such as interpersonal conflicts and team dynamics.

To investigate the influence of interest-based team formation on student experiences and learning, qualitative interviews gather self-reflections on the project outcomes. Relying on interviews with self-selected students results in limitations to this study, including that interviews may not be fully representative of all experiences in the course. Despite this, findings suggest strengths of the approach considered.

Students expressed concerns about balancing efforts across teams in an academic setting, yet most participants indicate that their capstone projects felt legitimately like real-world project work. This balance between academic and real-world settings is consistent with "fertile zones of cultural encounter" as creating an authentic project space that retains its educational focus[7]. Students reported being engaged with the project, and that their peers were engaged on their team. This is consistent with students working on a project that they consider to be relevant[4]. With that engagement, they also reported a sense of ownership or control over the project direction and experience. With continuing concerns about persistence in CS and other STEM disciplines, the role of project ownership may be key in connecting students with a sense of ownership over their learning. As the CS discipline faces an enrollment boom[8], there may be benefit from crafting other classes around this concept, such that the students themselves take ownership of their learning experience as part of responding to increased numbers. Outside of the academic setting, students may not be able to explore and to fail as supported in capstone projects, with the university and faculty as resources to recover from failure.

[i] All participant names have been changed for anonymity.

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