

Motivation and Value of Diverse Student Teams in Graduate Projects

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Abstract

In many industries, project teams are comprised of people with differing educational backgrounds, work experience, and cultural backgrounds. To better prepare students for these environments, instructors may simulate similar environments in courses through student team projects. A graduate course at Purdue University on sustainability in a STEM program includes lectures, short assignments, tests, and a semester-long project. The project typically includes gap identification and problem statement, ideation, search for alternatives, representation of design alternatives, safety and risk analyses, proposed design solution, cost-benefit analyses of design, and sustainability analyses. This project is completed by student teams with the instructor as advisor. For this project, the instructor intentionally recruits teams from the class members that have similar areas of project interests, but also come from diverse education, experience, and cultural backgrounds. By advocating inclusion of diverse teams, the instructor aims to achieve a more realistic simulation of working in industry, while students bring their own perspectives from their various educational, work experience, and cultural backgrounds. In this paper, the researchers explore these two perspectives in detail. The instructor discusses the motivations behind the use of diverse teams in the class projects, and the students discuss the perceived impacts of being in diverse teams for semester-long projects. The paper includes background information on diverse teams, and sections detailing the project, project team selection, inclusion of diverse backgrounds in project teams, and its value for graduate students.

Introduction

In industries, project teams are comprised of members with differing educational backgrounds, work experiences, and cultural backgrounds. With the inevitability of diversified working and studying environment, students are expected to interact and collaborate with people from different backgrounds. To better prepare students for industry, instructors may simulate similar environments in courses through student team projects. A typical graduate course at Purdue University in a STEM program includes lectures, short assignments, tests, and a semester-long project. The project typically includes gap identification and problem statement, ideation, search for alternatives, representation of design alternatives, safety, and risk analyses, proposed design solution, cost-benefit analyses of design, and sustainability analyses. For the project, the instructor intentionally assembles student teams that have similar project interests, but also from diverse education, experience, and cultural backgrounds. By advocating inclusion and diversity in student teams, the instructor aims to simulate a realistic working environment in industry and allow students to bring their perspectives from various backgrounds. Research to understand the value of diverse student teams may inform educators as to the pedagogical value and provide support for including such teams in graduate courses.

In this paper, the authors explore the reasons of intentionally including diverse student teams in graduate courses, and the value-add for students by participating in such teams. The research team consisted of one graduate-level faculty member and two graduate students. The paper presents the experiences, perspectives, and opinions of the faculty member who intentionally recruits diverse student teams in her courses, and of the graduate students who have participated in multiple such teams. Diversity in terms of cultural background, educational background, and work experience is explored in this paper. This paper may be useful to other faculty faced with teams of relatively equal academic performance, but from diverse educational and/or cultural backgrounds.

Background

This section presents a discussion of literature regarding inclusion of diversity in student teams. One of the primary goals of graduate education is to prepare students for the industry. In engineering industries, project teams are composed of individuals with different educational backgrounds, work experiences, and cultural backgrounds. Graduates are expected to communicate and collaborate with people from different backgrounds. Therefore, it is critical to expose graduates to similar environment by including diverse student teams in class projects.

In the United States, accreditation boards have specified student outcomes for engineering and technology programs that align with industry needs. The Accreditation Board for Engineering and Technology now known as ABET, asserts that student outcomes of baccalaureate engineering program must include “an ability to communicate effectively with a range of audiences” [1]. The requirements for accrediting baccalaureate engineering technology programs assert that graduate students must have “an ability to apply written, oral, and graphical communication in broadly defined technical and non-technical environments” as well as “an ability to function effectively as a member and a leader on technical teams” [1]. Specifically, in aviation programs, according to the Aviation Accreditation Board International (AABI), both baccalaureate and graduate degrees must demonstrate that graduates are able to “work effectively on multi-disciplinary and diverse teams” and “communicate effectively, using written and oral communication skills” [2].

In addition to organizations, researchers have been investigating the relationship between diversity and engineering teamwork. Teamwork is an increasingly important professional and critical skill [4]. With globalization and technological advancement, industries are continuously becoming demographically, geographically, and culturally diverse [5]. Diverse teams tend to be more creative [6] and teams with greater team role diversity tend to perform better [7]. In a case study of 246 undergraduate and graduate students, heterogenous groups were found to be statistically better than homogenous groups at forecasting engineering problems [8]. Working in student teams is beneficial for students as the experience may better prepare for industry environment. To succeed in engineering practice, students must learn to work effectively in multidisciplinary teams [2][9]. Researchers found that when working in teams, students were able to identify gaps in their professional skills in areas of communication, project management, and teamwork [10]. In addition, by working in diverse teams, students may be willing to understand and accommodate differences to facilitate better experiences and improve results [11]. A lack of diversity in student teams is a missed opportunity for students to develop effective leadership and management skills [12].

Therefore, in graduate engineering and technology programs, inclusion of diverse characteristics of student team members can better simulate an industry work environment. Instructors, as many already do, can facilitate this by intentionally recruiting diverse students to form teams for class projects which may benefit graduates in various aspects. This paper explores graduate faculty and student perspectives on the inclusion of diverse student teams in class projects.

Research Questions

In this paper, the research team decided on two research questions to better understand the inclusion of diverse student teams in graduate courses from two perspectives. A faculty perspective was explored to identify the reasons of intentionally recruiting diverse student teams, and a student perspective was explored to identify the value of participating in such teams. Specifically, the two research questions were:

- Research Question 1 (Faculty Perspective): What are the reasons for graduate instructor to intentionally include diverse student teams in graduate class projects?
 - Why Cultural diversity?
 - Why Education and experience diversity?
- Research Question 2 (Student Perspective): What is the value-add for graduate students to participate in diverse teams in graduate class projects?
 - What is the Value-add of Cultural diversity?
 - What is the Value-add of Education and experience diversity?

Methodology

The research team is comprised of a graduate-level course instructor who has taught these courses, and two graduate students who have each taken courses where these teams were implemented. This research is limited to the experiences, perspectives, and opinions of the authors.

Research Question 1 was answered by the instructor. In two graduate-level courses in Aviation Sustainability and Critical Systems Thinking, the instructor includes at least one team project as a critical component of the final grade. It is a requirement for students enrolled in these courses to form diverse teams for these class projects. Students are asked to form teams early in the semester and there are specific instructions for this process. Academic knowledge and skills are considered, but not academic performance level, as these are high performing students in a graduate program. To the extent possible, students from the same country cannot be on the same teams. Similarly, students with same educational background and/or work experience cannot be on the same team. The instructor provides these instructions to intentionally create groups with cultural and educational/experience diversity. Therefore, to answer the Research Question 1, the instructor's reasons for having specific instructions to form diverse student teams were reported.

Research Question 2 was answered by two graduate students that each had participated in each of the courses offered by the instructor. As a result, the graduate students have been part of multiple project teams that were diverse in culture, education, and/or work experience. Therefore, to answer Research Question 2, students' perspectives on the benefits, value-add, and overall experience of being in diverse teams were reported.

Results

The results section is structured to follow the research questions posited earlier in this paper. The first section presents the Faculty Perspective (RQ1) and the second section presents the Students' Perspectives (RQ2).

1. Faculty Perspective (RQ1)

This section details the perspectives of the graduate-level course instructor on intentionally recruiting diverse students in class project teams. The instructor had noticed that students in graduate classes tended to work with other students that they knew or with similar cultural or educational backgrounds. In the graduate level courses in the Aviation and Aerospace Management program, there are typically 10-25 students in classes. Over the years, there are typically students from one of four or five continents, and usually from one of six or more countries. As they are all graduate students, they are typically high achievers in their respective undergraduate academic areas. This contrasts with undergraduate courses where students may be performing at varying levels in their academic majors. The graduate students may have had undergraduate majors ranging from a variety of majors such as accounting, economics, geography, material science, physics, various engineering majors, mathematics, computer sciences, information technology, and aviation majors such as airline management, flight technology, and aeronautical engineering technology. Depending on the class, from $\frac{1}{4}$ to $\frac{1}{2}$ of the students may have graduated from an undergraduate program in the same department as the graduate program.

Since combining teams with students of differing academic achievement levels was not practical as they were all high achievers as they were enrolled in graduate school, the instructor decided to construct the teams in a similar manner she had experienced in her industry and research institute career prior to becoming a professor. She had seen first-hand how it truly takes a village to identify a complex problem, gain agreement on what the problem is, propose and analyze candidate solutions, determine the solution to be implemented, implement the solution, make sure it works and is accepted into the process, and go to the next problem. Complex open-ended problems in industry or in research may require the knowledge, skills, and abilities of many academic or experiential areas of expertise. In order to provide students in her classes with an opportunity to work in teams, she developed 12-14-week projects for the graduate courses. In order for students to gain experience in working with people with backgrounds differing from their own, she decided to require that the teams be comprised of members from different countries, cultures, and academic backgrounds.

The motivation to recruit diverse teams may be summarized as being prompted from these questions: Why study an academic discipline that leads to careers in a global arena and not experience working with people with experiences unlike your own? Why come to the US to study and have this rich mixture of students with varying perspectives and not take advantage of the opportunity to work in diverse teams? How can the course projects address complex problems and provide teams that are more similar to industry (and research) teams? How can this project meet the ABET and AABI needs? The achievement of this is much easier said than done.

In summary, the instructor includes culturally and academically diverse student teams in the course projects because of her personal knowledge of the value of differing perspectives when addressing complex problems. In her industry and research careers, diverse backgrounds were needed in many projects and programs to develop innovative solutions to problems. Certainly, she had seen groupthink, normalizing deviation, sidelining of team members, and cultural/organizational deference on numerous occasions.

In class projects, she encourages team member participation, learning how to divide the tasks and assist each other, and recognizing first-hand the value of other perspectives. Diverse teams may be formed from people who have differing academic backgrounds and cultural backgrounds. In her opinion, the time to start learning more about the value of diverse teams is before one enters a global industry, and a semester-long project is one way to achieve this.

2. Student Perspective (RQ2)

This section details the perspectives of graduate students on the value-add of diverse students in class project teams. The two graduate students in the Aviation and Aerospace Management program at Purdue University have participated in multiple project teams that were diverse in culture, education, and/or work experience. In terms of cultural diversity, the graduate students have participated in project teams with members from different parts of United States, China, Ecuador, and India. These team members had various education/experience backgrounds such as Aviation Management, Industrial Engineering, Mechanical Engineering, Aerospace Engineering, Computer and Information Technology, Flight Technology (FAA certificated pilots), Liberal Arts, and Transportation Engineering. The graduate students report their experiences on the value-add of cultural diversity and education/experience diversity.

Value-add of cultural diversity: The graduate students found professional and personal growth/learning opportunities when working with students from different cultures. When working in culturally diverse teams, students learned details about those cultures, their lifestyles and social philosophies, work approaches and ethics, leadership styles, and social and political issues. Students developed mutual respect and appreciation for different cultures by understanding the differences and identifying some deep-rooted similarities in cultures and social behaviors. Being international graduate students, they learned professional social etiquettes followed in United States and how to build professional relationships with professionals from other cultures. By working in culturally diverse teams for semester-long projects, the graduate students learned some critical professional skills such as effective communication, project management, leadership, and critical thinking. For example, one of the graduate students learned to apply critical thinking to provide unbiased assessments, something which he/she had not experienced in previous education. The graduate students found that they were more aware and respectful of other cultures when working in culturally diverse teams than they would be on a culturally homogenous team.

Value-add of education/experience diversity: When working with team members with diverse education/experience backgrounds, the graduate students found it efficient to distribute tasks based on educational background, thereby effectively utilizing strengths of each team member. For example, in a project focused on reducing runway incursions by implementing Airport Surface Detection Equipment, Model X (ASDE-X) equipment into airport ground vehicles, projects tasks

were divided between FAA certified pilots and engineers. The literature review on lighting systems, interaction with airport managers, and safety risk assessment were assigned to the pilots as they were more familiar to airport equipment and operations. The engineers were responsible for the problem statement, problem solving approach, and technical description as they were more familiar about the mechanism of the equipment. With educationally diverse team members, the graduate students learned to understand the different perspectives of the problem and the safety concerns related to it. For instance, engineers on multiple teams were not aware of the specific regulations at airports, and aviation management or airport planning students were able to identify those problems. The graduate students experienced that teams with diverse educational background attacked the problem from diverse perspectives. This facilitated in achieving an optimal solution to the problem.

By working with team members with diverse educational background and experiences, the graduate students learned different work styles, approaches, attitudes, and ethics. For example, the graduate students experienced that team members with engineering backgrounds strived for best results and settled for most optimal work possible, whereas members with management backgrounds were focused on effective task completion and meeting minimum requirements. The students also learned different leadership styles in diverse teams. They experienced that engineers on the teams were more focused on problem solving, while management students were focused on harmony among team members and maintaining effective and efficient working of the team. Finally, diverse educational backgrounds in teams bring diverse skillsets and strengths.

Working in such teams enabled the students to identify their strengths and weaknesses. Therefore, the team members were able to combine and project their strengths as a team and overcome the individual weaknesses of team members.

Conclusion and Recommendations

In conclusion, the inclusion of diverse student teams in class projects is believed to be beneficial for the overall professional development of graduate students. By participating in culturally diverse teams, students learn about personal, social, and professional aspects of different cultures. Working in culturally diverse teams develops mutual respect, empathy, and understanding of the differences and similarities in various cultures. Students learn critical professional skills such as effective communication, project management, and leadership, which are directly applicable and critical in industry environments. By participating in teams diverse in education/experience background, students learn to identify individual strengths and weakness, and how to overcome individual weakness while projecting team strength. The inclusive environment in education/experiences gives students the opportunity to learn more about interdisciplinary, different work styles, approaches, and ethics. Diverse backgrounds bring diverse perspectives to the problem and diverse skillsets to solve it.

This research discussed the benefits and add-on values of diversity in project teams from the perspectives of the instructor and students. From the students' perspectives, graduate students ought to embrace opportunities of working in diversified groups, especially in case of international students. The experiences of working in inclusive teams not only allow students to adapt to working environment in industries, but also learn professional etiquettes, social aspects, and

communication styles from other cultures. In addition, such exposures also bring them ethics, problem-solving skills, and professional abilities from different perspectives.

Graduate instructors may seek to include diverse teams in semester-long projects. Long term, complex, open-ended problem-solving teams are not for the faint of heart. The instructor may find it useful to see themselves as coach, or as program manager for a group of project teams. This style of team formation allows students from a variety of backgrounds to experience multidisciplinary teams while in a graduate class. This type of teaming may also assist graduates as they begin their industry, agency, or academic professional careers. In disciplines where the expectation is that the industry has a global reach, this inclusion of diverse teams is especially important. In these industries, it is not unusual to have several globally dispersed teams working together to solve pressing and complex problems. More than inclusion, students in these teams may learn to welcome others and their ideas as valuable and necessary for successful project completion.

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