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Evaluating Project Management Skill Development in Engineering and Agricultural Curricula

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Evaluating project management skill development in engineering and agricultural curricula

Abstract

Project management is the use of specific knowledge, skills, tools, and techniques to deliver something of value to people [1]. STEM programs desire to prepare their students to provide something of value to society. Developing project management skills not only aids in this but also translates to applications in their personal life, such as overall planning, organizing, and time management. With that desire, we have reason to research if these project management skills and concepts are being taught effectively enough to prepare students for senior-level capstone courses and future careers. Degree programs that do not heavily focus on management principles may impact students' abilities to obtain manager-style roles. Outside the classroom, there are opportunities to obtain this experience, such as through internships and studying abroad. Data collected stem from a self-efficacy questionnaire administered to 811 students and voluntarily completed by 361. The survey was issued at the beginning of the semester for nine fall courses through 15 different majors and intended to take approximately 15 minutes to complete. The questionnaire holds 36 questions for students to assess their background, demographics, academic career, and project management skills/opinions. The results were examined to determine the current knowledge of project management as a baseline measure and to explore relationships between student characteristics and confidence in project management. Initial findings show that overall confidence in managing a project from beginning to end is relatively low compared to their confidence in individual aspects of project management, possibly indicating that students are comfortable and confident with a few aspects of project management but are less confident with their ability to lead and manage all aspects of a project. Further analysis of the obtained results, in addition to ongoing data collection, will guide the next phase of research.

Introduction

Teaching project management to undergraduate students has traditionally been a challenge due to time constraints. Within the confines of a 2-, 3-, or 4-credit-hour course, it becomes difficult to teach students about project management concepts while also giving them an opportunity to exercise their project management knowledge on a real project. Some students learn pieces of project management through registered student organizations and clubs, internships, and undergraduate research projects, but seldom gain formal knowledge about the entire process through these avenues while also being able to execute all parts of managing a project. However, it is worth asking the question, ***Are we sufficiently teaching our students project management skills and concepts in our curricula in order to prepare them for their senior-level coursework and beyond?"***

Project management (PM) is an area of study that has been gaining attention for its wide variety and flexibility of applications across many different subject areas and disciplines. For this study, project management is defined as the application of skills, knowledge, and experiences to achieve specific project objectives determined by a finite timescale and budget. Project management can be applied in almost any discipline as the term "project" has a broad definition. Most college graduates who are entering the workforce will have some type of "project management" duties, even if they are not specifically defined as such. Educating

students on the concepts of managing a project can help better prepare them for success upon starting a career in an industry, regardless of their major.

The majority of project management education research has focused on professional settings, observing different training methods and activities used by companies to train their employees in project management. It was seen that project managers who are trained using leadership-heavy roles are more likely to retain information [2]. While most research has been conducted in professional settings, one study conducted in a classroom setting showed that goal-based activities in courses helped undergraduates gain project management skills and competence [3].

It is realized that it may be too much to assume that students are adequately prepared to complete these project management roles, or perhaps they can be better prepared to do so if provided more formal training in project management during their first three years of study. Some preliminary research has been conducted to begin understanding this [4]. This preliminary research focused on two disciplines; one engineering (agricultural and biological engineering) and one non-engineering (engineering technology and management for agricultural systems). The research leveraged self-efficacy surveys at the start and end of a required fourth-year project management course, followed by the same survey at the beginning and end of senior capstone course. The first of the four surveys provided an indication of the baseline project management knowledge of students after completing the first three years of their studies. The second survey provided a measure of how much project management skills and knowledge were learned during the project management course, while the third and fourth surveys provided a similar measure for the capstone course. Results showed that students tend to increase their knowledge and comfort with dealing with factors outside of their control and safety throughout the capstone course, while they tend to increase their knowledge and comfort with teamwork and time management through the project management course. These results have a direct relation to findings by Agbejule and Lehtineva [5], which showed the importance of teamwork on success within project management.

The specific objectives of this work in progress paper are to (1) assess students' perception of their current project management knowledge and skills, (2) analyze trends and possible differences between students based on race and gender, and (3) explore differences between students in their first/second years of study versus their third/fourth years of study and those from engineering versus agricultural programs.

Methods

The survey was conducted at the start of the fall 2023 semester. Instructors for each of nine courses were provided a PowerPoint slide with brief instructions and justification for the study that they could share with their students. The slide also contained a weblink and QR code to the survey. Instructors were asked to administer the survey within the first three weeks of the semester (for pre-survey). Engagement and motivation tend to increase when students take part in project-based learning [6], so courses that contain a project or group activity that spans multiple weeks of the semester were asked to also complete the same survey at the end of the semester (post-survey). Since this paper is a work-in-progress, methods and results will only target the preliminary findings of the pre-survey responses.

Bandura & Adams [7] determined that self-efficacy can be an accurate predictor of performance, so this study uses a self-efficacy questionnaire designed to understand what level of self-efficacy students feel towards project management, including specific areas within project management such as leadership, time management, multitasking, overcoming obstacles, having a backup plan, researching past projects, testing systems, and data analysis. The questionnaire also aims to determine their experiences in their past coursework, registered student organizations, and work experience that have helped them gain an understanding of how the concepts of project management integrate to create a successful project. For first-year courses, the survey asks about experiences in high school and prior to beginning college, while the fourth-year survey will focus primarily on experiences obtained since the first year in college.

Figure 1. Sample question from self-efficacy survey administered to undergraduate students.

Participants complete this questionnaire within the first 3 weeks of each course followed by a second time within the last week of the course for courses that include a project or group activity. This questionnaire was administered online as a Google Form. The Google Form was created with the goal of being completed in approximately fifteen minutes. It includes a combination of academic (major of study, approximate GPA, when they began their college career, etc.), project management specific, and demographic questions. The project management specific questions are structured as either Likert-scale questions or short responses. A sample of a Likert-scale question and a short free-response question are shown below:

> Ex. 1: How confident are you in your ability to manage a project, from beginning to end, by yourself? This would include research, budgets, deadlines, time management, and stakeholder communication and satisfaction.
>
> Not at all confident 1   2   3   4   5   Completely confident

> Ex. 2: In one sentence, how would you define project management in your own words?

Since this is a work-in-progress paper data and collection is ongoing, a full statistical data analysis has not yet been completed. However, an initial exploration of statistical differences has been completed for Figures 5 and 7, which evaluate differences between gender (Figure 5) and year of study (Figure 7). The statistical evaluation included a check for normality by looking at histograms of the data, all of which indicated a normal distribution. Then, an F-test was used to determine if variances were equal or unequal, and all of them, except one, showed equal variance. A standard t-test for equal variances and Welch's t-test for unequal variance were then used to determine if the mean differences were statistically significant. Statistical differences are noted in the Results and Discussion using a p value of 0.05.
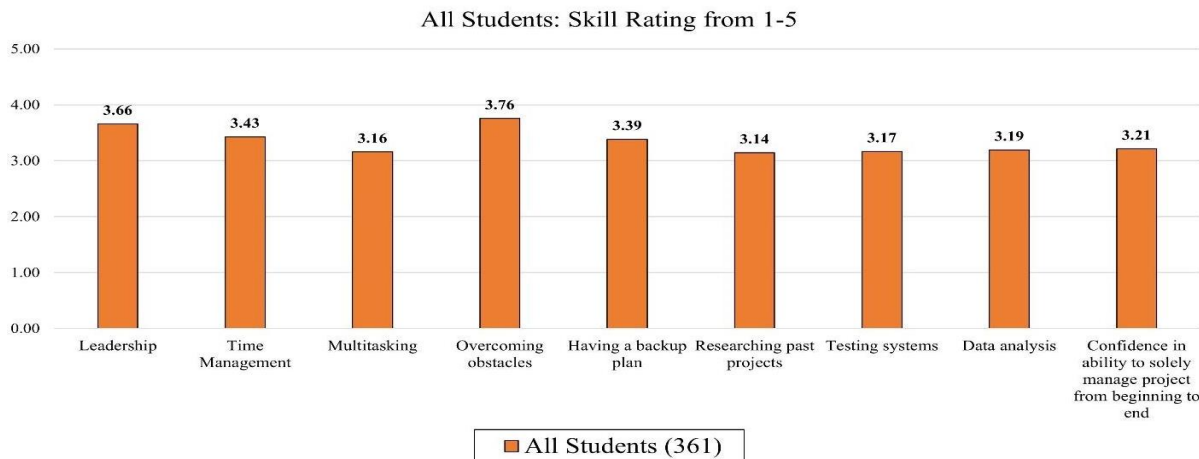
Results and Discussion

This work-in-progress paper details findings from the first semester of data collection that aims to better understand the current state of project management knowledge and skills among engineering and agricultural students at a large land-grant institution, while also exploring trends and differences in self-efficacy scores based on attributes like gender, race, and year of study within a major of study. During the fall 2023 semester, the pre-survey was administered to 811 total students, which was determined by summing the enrollments for the eight courses currently participating in the study. Responses from 361 students were collected, providing a 45% response rate. Figure 2 shows the number of responses in each participating class. While nine courses agreed to participate in this study, student responses were received from only eight courses, so results refer to only these eight courses.
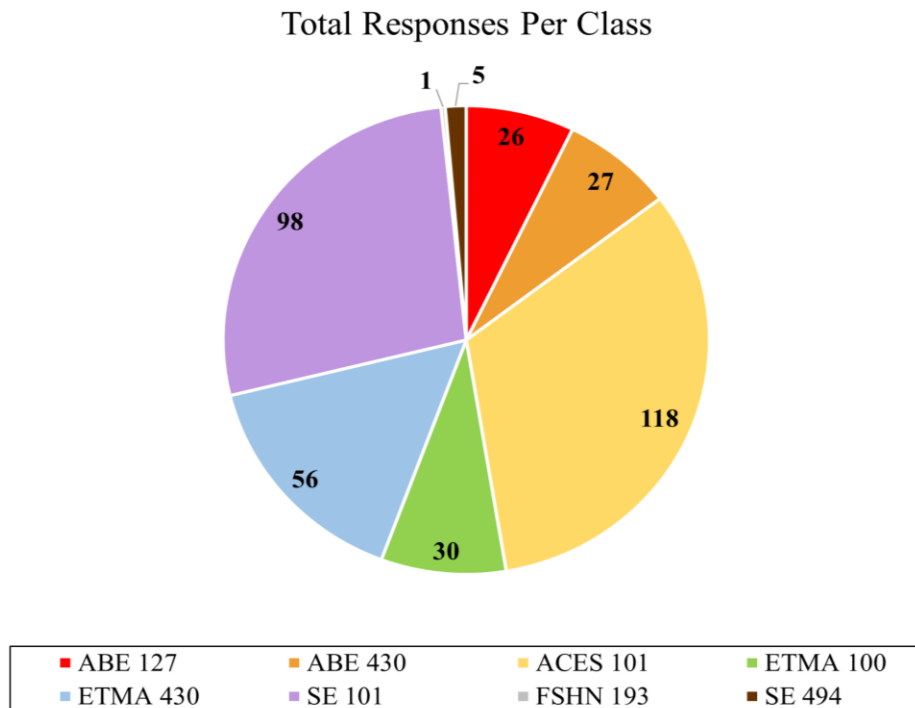
Figure 2. Distribution of pre-survey responses by individual course. One course did not contribute any responses, so only 8 courses are displayed.

What is the current state of project management knowledge and skills (Objective #1)?

Figure 3 provides an overall snapshot of project management knowledge and skills for all 361 students who responded. The score for each specific area within project management is the mean of all students who responded to the Lickert-scale question, with 1 being poor and 5 being excellent.

All Students: Skill Rating from 1-5

| Leadership	Time Management	Multitasking	Overcoming obstacles	Having a backup plan	Researching past projects	Testing systems	Data analysis	Confidence in ability to solely manage project from beginning to end
3.66	3.43	3.16	3.76	3.39	3.14	3.17	3.19	3.21

■ All Students (361)

Figure 3. Overall snapshot of the current state of project management knowledge and skills for all 361 students who responded to the pre-survey during the Fall 2023 semester.

Data seem to indicate that students are more confident (higher self-efficacy score) in areas they have gained exposure to, either in high school (for first year students) or through various campus and extracurricular activities in college. Overcoming obstacles, leadership, time management, and having a backup plan are all things that are likely familiar to students, regardless of having any formal training in project management. However, students seem to be relatively less confident in more nuanced areas like data analysis, testing systems, multitasking, and researching past projects – things that are typically emphasized in project management courses and other courses requiring projects and group activities that span many weeks of a course. The last question, which intends to gauge students' confidence in their ability to solely manage a project from beginning to end, is one that targets a student's holistic evaluation of their own ability to lead a project and everything that a project entails in their mind. It is worth noting that overall confidence is relatively low compared to some of the more specific questions, possibly indicating that students are comfortable and confident with a few aspects of project management but are less confident with their ability to lead and manage all aspects of a project.

Are there distinguishable differences between students based on race and gender on project management knowledge and skills (Objective #2)?

As we strive for a more equitable educational experience, it is worth exploring any differences between or trends among students of different races or genders. In the self-efficacy survey, these were optional questions since we wanted students to complete the project management specific questions regardless of their willingness to provide demographic information. Students were able to select more than one race – these students are reported in Figure 4 as multiracial.
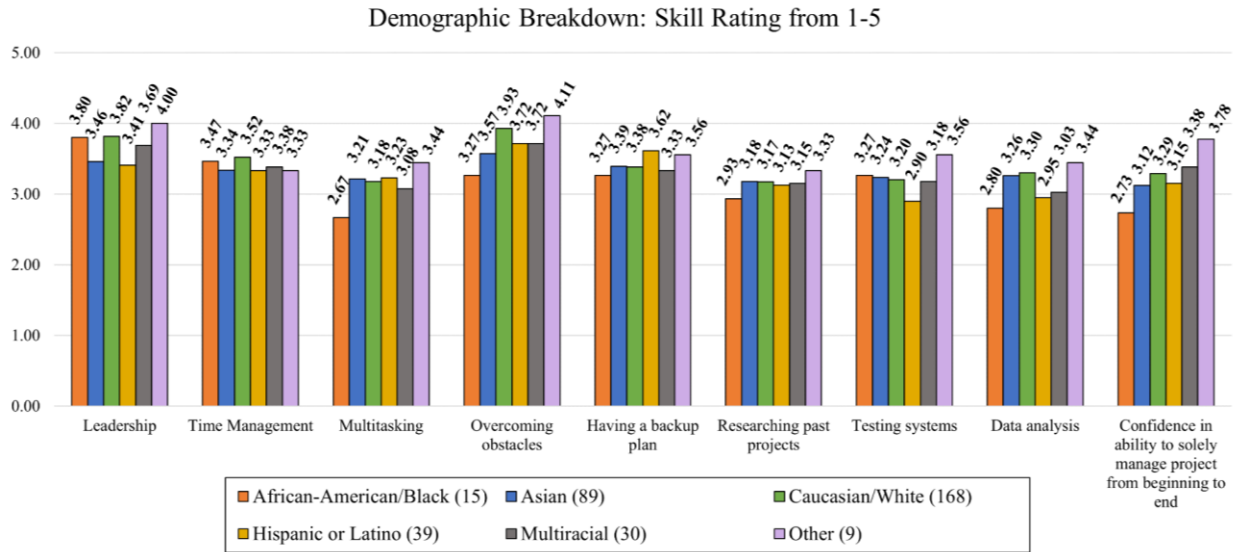
Figure 4. Mean self-efficacy scores for each of the project management specific questions, in addition to the overall question about confidence in managing a project from beginning to end, separated by reported race. Race was an optional question in the survey. Students were able to select more than one race – these students are reported in this figure at multiracial. A total of 350 students responded to this question.

Figure 4 contains a vast amount of information for all respondents. It is worth noting here that these data are preliminary and will contribute to a larger, multi-year effort to collect these same data over time. However, initial takeaways from the separation of data by race indicates that African-American/Black students have a perceived weakness in multitasking, overcoming obstacles, data analysis, and overall confidence in their ability to manage a project from beginning to end. It should be emphasized that these are perceived strengths and weaknesses, since these responses are self-efficacy, meaning that students are indicating how they believe they should score themselves in each respective category. In contrast, African-American/Black students perceived themselves as being strong in the areas of leadership, time management, and testing systems. Hispanic or Latino students scored the opposite from African-American/Black students; they have a perceived strength in multitasking, overcoming obstacles, and researching past projects, while scoring lower in leadership, time management, testing systems, and data analysis. Asian students have a perceived strength in multitasking, researching past projects, testing systems, and data analysis while having a perceived weakness in leadership and overcoming obstacles. Caucasian/White students have a perceived strength in leadership, time management, multitasking, overcoming obstacles, data analysis, and overall confidence in their ability to lead a project from beginning to end, while having a perceived weakness in testing systems. Multiracial students scored near the middle of the groups for each category, while students identifying as Other race have perceived strengths in nearly every category, except time management. Additional context will be helpful for better understanding why some of these similarities and differences exist. Some of this context will be explored later in this paper, while considerations will be explored later in the larger, multi-year project.

Figure 5 provides a simple comparison of results based on the provided gender by each student respondent. In the survey, students were asked "What gender do you identify with?" and were given the options of female, male, or other.
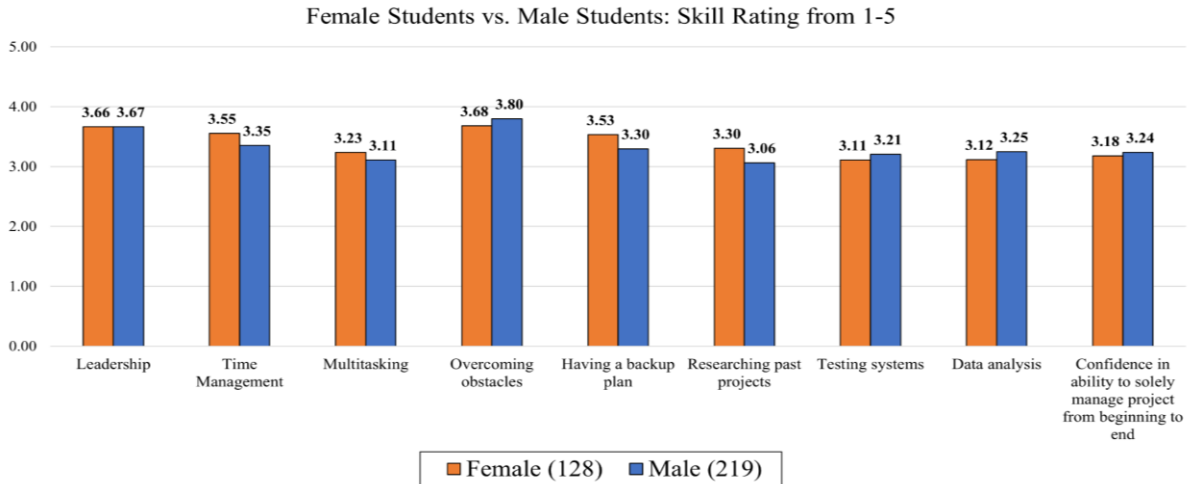
Figure 5. Mean self-efficacy scores for each of the project management questions, separated by reported gender. There were two students who responded "Other", so those data are not shown in this figure due to an insufficient sample number.

A total of 347 students across all groups provided a response regarding gender. Self-efficacy scores are quite similar for leadership and overall confidence in managing a project from beginning to end. However, female students have a perceived strength in time management (females are 6% higher than males), multitasking (4% higher than male students), having a backup plan (7% higher than male students, which is a statistically significant difference), and researching past projects (8% higher than male students, which is also a statistically significant difference). Male students have a perceived strength in overcoming obstacles (3% higher than female students), testing systems (3% higher than female students), and data analysis (4% higher than female students). Figure 6 further separates the data broadly by discipline, either engineering or agriculture.
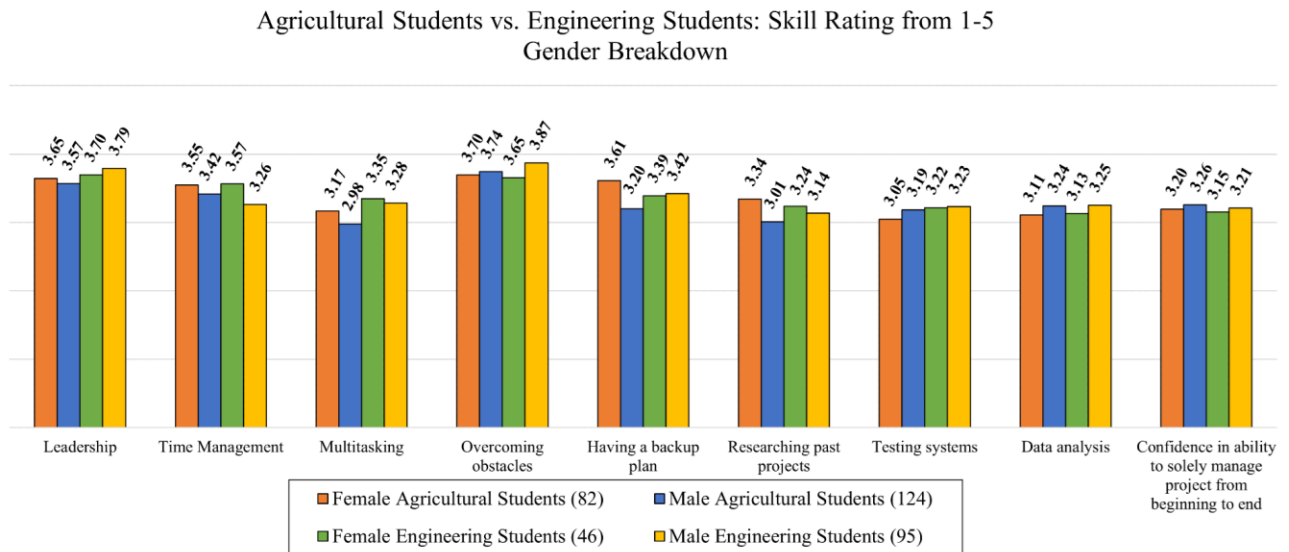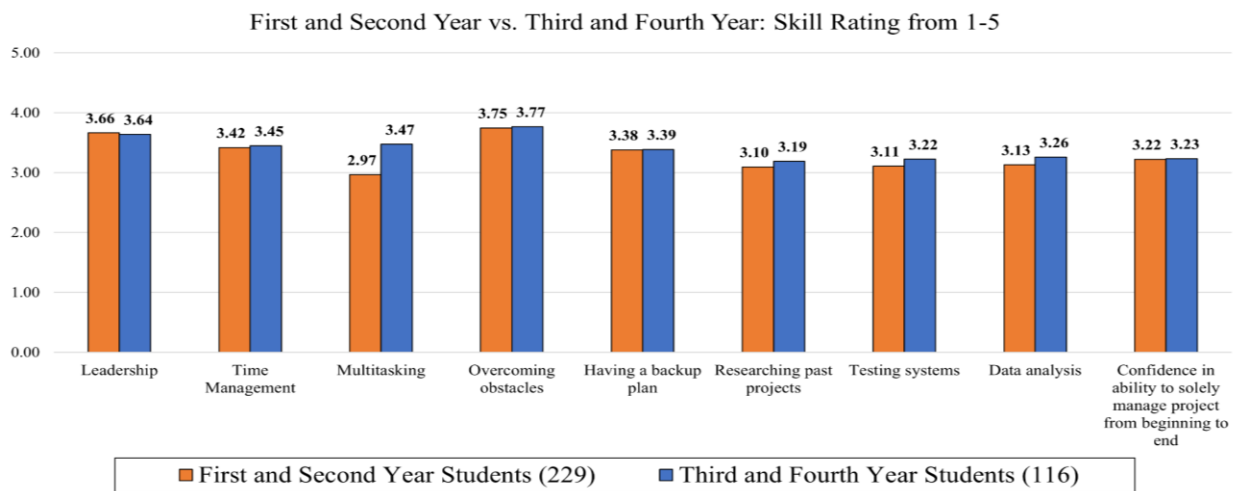

Figure 6. Mean self-efficacy scores for each of the project management specific questions, separated by reported gender and broad field of study (engineering or agriculture).

Initial observations of the data indicate that female students have a perceived strength in time management across both agricultural and engineering students. Male engineering students are most confident in overcoming obstacles, while female agricultural students are most confident in having a backup plan and researching past projects. In general, both female and male engineering students are more confident in multitasking. Overall, though, there is little to no difference in how students scored themselves for their confidence in their ability to manage a project from beginning to end.

Do students perceive an improvement in their project management knowledge and skills throughout their college experience, and is there a difference between agricultural and engineering majors (Objective #3)?

It seems reasonable that students will improve many project management skills as they progress through their college careers, simply by gaining experiences in the classroom, through extracurricular activities, and also through additional time living independently and balancing the many responsibilities that come with providing for oneself. In addition, some disciplines inherently incorporate project management knowledge and skills, specifically those that encourage or require extensive class projects or group activities. Future data collection will provide context for the impact of extracurricular activities, so the current focus is on specifically looking for differences between progress through a student's program of study (Fig 7) and the combined effect of progress through program of study and the student's broad discipline (Fig 8).

Figure 7. Mean self-efficacy scores for each of the project management specific questions, in addition to the overall question about confidence in managing a project from beginning to end, separated by first/second year and third/fourth year.

Perhaps somewhat surprising, first/second year students have the same confidence in leadership and ability to manage a project from beginning to end as third/fourth year students. Some initial reasons for these findings could be that first/second year students do not yet fully grasp the complexity of larger and more nuanced projects leading to an inflated confidence, and on the flip side, third/fourth year students may have a better understanding of the many challenges that projects can present and are therefore underestimating their abilities (or have

more realistic expectations). Figure 7 also shows similarities in time management, overcoming obstacles, having a backup plan, and researching past projects. The largest difference is in third/fourth year students' confidence in multitasking, which is statistically higher, followed by their confidence in researching past projects, testing systems, and data analysis. These findings seem to make sense with students' increase in experience as upperclassmen.
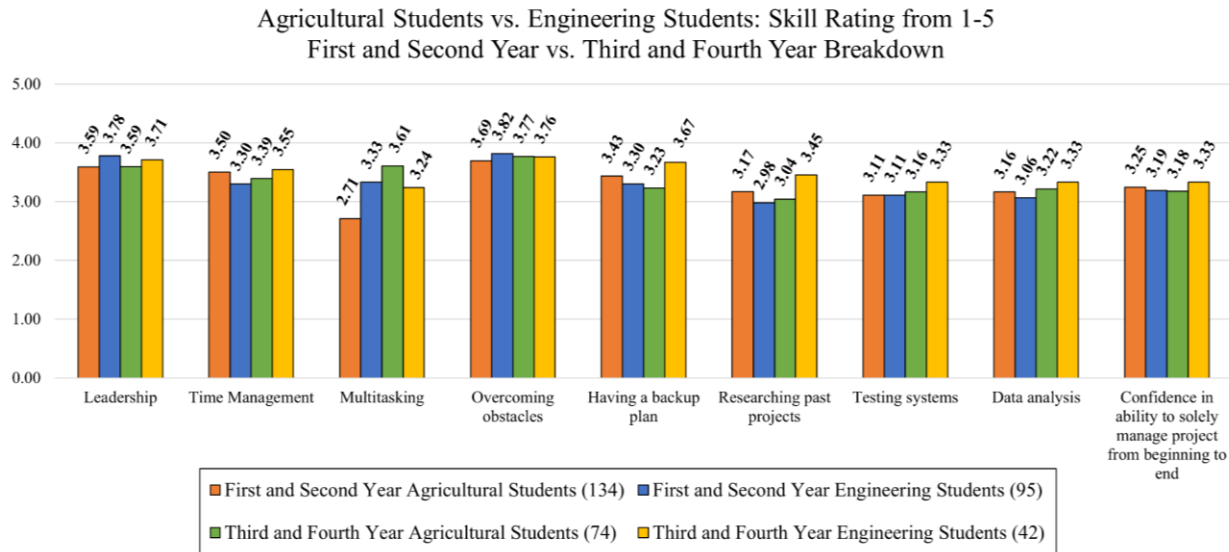
Figure 8. Mean self-efficacy scores for each of the project management specific questions, in addition to the overall question about confidence in managing a project from beginning to end, separated by first/second year students versus third/fourth year students and broad field of study (agriculture or engineering).

Engineering students have a higher confidence for both first/second year and third/fourth year students in leadership, even though their scores decrease slightly over time. Engineering students also show an 8% increase in confidence in time management from first/second year to third/fourth year. Third/fourth year agricultural students have the highest confidence in multitasking and show a 33% increase from first/second year to third/fourth year. Surprisingly, there is a decrease in confidence across years for agricultural students for time management, having a backup plan, and researching past projects. Similarly, there is a decrease in confidence across years for engineering students for leadership, multitasking, and overcoming obstacles. Third/fourth year engineering students have the highest confidence in their overall ability to manage a project from beginning to end, however, students in all four categories scored nearly the same on this question.

Conclusions and Future Work

This work-in-progress paper details findings from the first semester of data collection, which includes responses from 361 undergraduate students. When analyzing responses from all students together, overall confidence in managing a project from beginning to end is relatively low compared to some of the more specific questions, possibly indicating that students are comfortable and confident with a few aspects of project management but are less confident with their ability to lead and manage all aspects of a project. When analyzing responses only by year of study, first/second year students have the same confidence in leadership and ability to manage

a project from beginning to end as third/fourth year students. Some initial reasons for these findings could be that first/second year students do not yet fully grasp the complexity of larger and more nuanced projects leading to an inflated confidence, and on the flip side, third/fourth year students may have a better understanding of the many challenges that projects can present and are therefore underestimating their abilities (or have more realistic expectations). Ongoing data collection will be critical in better understanding these trends. Additionally, individual interviews with a subset of students are planned for this larger study and will add context to the self-efficacy scores and help tease out reasons for differences between groups.

Acknowledgements

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