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Student Perception of Virtual Collaboration Environments on Teaming Success in an Online Project-Based First-Year Engineering Design Course

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Introduction

Teaming is an essential outcome in the accreditation process for undergraduate engineering programs. Among other requirements, institutions must provide documentation that students' learning outcomes are being met [1]. Teaming is one of the outcomes – and it is one of the requirements which is difficult to "prove." The challenges of meeting this learning requirement were only heightened during the pandemic. To support a rapid shift in course modality, students were often tasked with using a wide range of software tools with a myriad of permutations. The disjointed nature of the software tools was further exacerbated when students were asked to collaborate in a virtual team setting. As such, students devoted cognitive load not only to the tasking at hand for assignments but also to organizing files, communicating with teammates, and managing tasks in virtual team-based activities [2].

Similar studies have been conducted to find a correlation between teaming and Virtual Collaboration Environments (VCE) tools [3]. Virtual Collaboration Environment (VCE) refers to the permutation of software tools used to share information between team members in an engineering project group. VCEs include at minimum a tool to support team communication, a tool to enable file sharing between team members, and a tool to support task assignment. Example components of a VCE might include Google Drive for file sharing, Trello for task management, and GroupMe for communication. This study mainly investigated how using VCE tools influences student perception of their teamwork in the identified dimensions of successful collaboration. In this process, virtual tools would be examined for each theme based on their features and relation to various productivity principles.

There exist a host of software tools to support collaborative file sharing, communication, and task allocation. Among these productivity tools are many commercial or free-source software packages such as Trello, Google Drive, Microsoft SharePoint, Outlook, Gmail, Trello, and Monday.com. These tools exist in parallel with less sophisticated systems or solutions, such as physical media sharing (memory cards), tasking spreadsheets, written lists, or simple mobile texting options. There are relatively few all-in-one software platforms that provide all three of the task management components identified as necessary for successful collaborative teamwork in the program of study. Microsoft Teams is such a software platform. MS Teams is a commercial software package that is popular in many industry contexts. MS Teams has native file sharing through Sharepoint or Onedrive, has native chatting and video meeting capabilities, and MS Planner for task management. Additionally, MS Team allows for integration of third-party apps, such as Trello.

Empirically, students in the program of study tend to select platforms other than MS Teams to support collaborative work, with many favoring Google Drive for file sharing, and selecting more common communication platforms such as GroupMe, Snapchat, or iMessage. Students

tend to opt for tools that are familiar and that are supported by word of mouth. MS Teams, while powerful and feature-rich, is often viewed as not as user-friendly as many other components of VCEs. In this study we hypothesized that using a self-contained VCE, such as MS Teams would enable students to devote more cognitive energy to project execution, and less on project management itself. In this paper, we examine student perception of collaborative teamwork and correlate these results with their choice of VCE components.

Research Goal

This study aims to explore the impact of virtual collaboration environments on the collaboration of first-year engineering students in an engineering design course as measured by student perception of team success and collaboration. Results from this work have the potential to generate insights into how to improve the current use of VCE in an engineering design course, supporting engineering students' teamwork and educators' teaching practices. Our hypothesis was that prepacked VCE tools like the Microsoft Teams platform would facilitate teamwork as all required teamwork components (file sharing, communication, and tasking) were collocated within the platform whereas ad hoc student-determined tool collections would lead to increased cognitive load in terms of process creation.

Methods

Survey Development

To simplify the experience for the students, the team examined and reviewed a series of online collaboration tools and, after a down-selection process, identified Microsoft Teams as an effective VCE for students to use in the study. The determination of MS Teams as a VCE was based on having all dimensions (file sharing, communication tools, and a task management system) present in a single user environment. After the decision to evaluate the effects of MS Teams as a VCE was made, the Microsoft Team's group design process proceeded and is described in more detail in the methodology section of this report.

A survey was developed to measure the student's perceived collaboration in a VCE scaffolded team using previous literature [4] [5]. The survey consisted of fifteen questions related to collaboration in group work in engineering project teams and two questions collecting information about participant demographics (Table 2). The survey was developed by an engineering education research team consisting of two undergraduate researchers and two faculty members. Dimensions of effective work and collaboration were identified (e.g., file-sharing, communication, and task management), and questions for each dimension were developed through iteration (Table 1). Additionally, to keep track of questions during analysis, each question was mapped to its dimension and assigned a code. Response options for all questions were arrayed on a five-point Likert scale from 1 to 5. The positive and negative scales describe

which direction the question is asked in. For example, the answer choices of a positively scaled question on a Likert scale would have 1 being “Strongly Disagree” and 5 being “Strongly Agree.” Juxtapose, the answer choices of a negatively scaled question on a Likert scale would have 1 being “Strongly Agree” and 5 being “Strongly Disagree.” It is essential to shuffle the question scale on the survey's audience to answer each question mindfully.

Table 1. Survey Overview

#	Dimension	Question	Code
1	Communication	It was easy to communicate with my groupmates.	C1
2	File-Sharing	File sharing within our team was straightforward.	F1
3	File-Sharing	I felt class-related resources were readily available to me.	F2
4	File-Sharing	Real time editing within virtual collaboration environments worked seamlessly.	F3
5	File-Sharing	Real time editing within virtual collaboration environments worked with few problems	F4
6	Task Management	With the online tools I used, I found it difficult to work remotely.	T1
7	Task Management	I feel that tracking tasks has helped my past teams stay organized.	T2
8	Task Management	I feel that tracking tasks has helped my team complete tasks on time.	T3
9	Communication	Virtual collaboration environments have elevated the standards of my group's work.	C2
10	Task Management	Working in a virtual environment led my team to procrastinate on assignments and projects.	T4
11	Task Management	My teams in the past have successfully divided work equally.	T5
12	Communication	Remotely structured teams created challenges within the group.	C3
13	Communication	Past groups have worked disjointedly which impeded my work.	C4
14	Communication	I would say that my past groups have worked together successfully.	C5
15	Communication	Working in an engineering project environment is more difficult than other kinds of teams.	C6

Participants and Procedure

Data for this study was collected with students enrolled in a first-year general engineering program at a suburban mid-Atlantic R1 institution. All participants were enrolled in different sections of an introductory engineering design course, where students were introduced to different engineering concepts and the engineering design process. The course was taught in a fully online synchronous modality due to Covid-19 precautions. All participants were required to complete an assignment that outlined the basic function of their design teams, including

individual member roles, solutions to potential team conflicts, and the different components of their virtual collaboration environment. The participants were divided into self-designated VCE groups and Microsoft Team's groups, which different instructors taught. The self-designated VCE group determined the component tools of their team's VCE. Still, it was required to identify a communication tool, a file sharing platform, and a task management tool. Students in the Microsoft Team's group were instructed to use the Microsoft Teams ecosystem for their VCE and received introductory instruction on how to operate within that environment.

The survey was distributed at the beginning and end of the semester. A total of 406 participants were enrolled in the study and submitted survey information during the beginning of the semester survey in the spring of 2021, and 405 student responses were received at the end of the semester. The self-designated VCE group had 199 responses at the end of the semester. The Microsoft Team's group had 201 responses, and 5 students' group identifications were uncategorizable due to incorrectly filling out the survey. The survey questions were identical from the beginning to the end of the semester, with only the survey prompt changing. The beginning of the semester (BOS) was distributed within the first two weeks of the semester, and the end-of-semester survey (EOS) was during the last three weeks of the semester. Table 2 shows participants' demographic information. As shown in Table 2, the participants' demographics have a male majority population with a majority ethnic background identifying as white with non-Hispanic origin.

Table 2. Participant demographics

Gender	Students	Representation
Female	93	22.20%
Male	308	73.51%
Genderqueer	6	1.43%
Agender	2	0.48%
Transgender	6	1.43%
A gender not listed	2	0.48%
Did not respond	2	0.48%

Identified Racial/ Ethnic Background	Students	Representation
White with Hispanic origin	36	8.20%
White but not Hispanic origin	244	55.58%
Black or African American	33	7.52%
American Indian or Alaskan Native	6	1.37%
Asian or Pacific Islander	101	23.01%
Other mixed Heritage	8	1.82%
Prefer not to say	9	2.05%
Did not Answer	2	0.46%

Data Analysis

After the final data was collected from the end-of-semester survey, it was compiled in a database and processed. Answers for each question from the Likert-survey were assigned a score on a discretized point system of 1-5 [6]. A score of 1 indicated the lowest aptitude for the defined successful collaboration criterion, whereas a 5 showed the highest aptitude. Each question was assigned either a positive or a negative scale based on its specific inquiry. All survey responses

were translated into the corresponding score and recorded in a database. The average scores from all individual questions for each group were compiled to generate an aggregate score [7].

Results and Discussions

Aggregate Evaluation

The BOS survey results were compiled, and the aggregate scores between the self-designated VCE and Microsoft Team's groups were compared using a two-sample t-test yielding a p-value less than 0.05. This demonstrates that the two populations did not start with the same experience or predisposition to collaborative success that this study measured. This limitation will be further elaborated on in the limitation section of this paper.

The aggregate scores evaluating *perceived collaboration success* in a project team for the self-designated VCE group and Microsoft Team's group were compiled, and a two-sample t-test was performed to compare the distribution at the beginning of the semester (BOS) and end of the semester (EOS) survey data for each group. Figure 1 presents the distribution of the self-designated VCE group's EOS and BOS survey results. The self-designated VCE group had 211 responses from the EOS survey, and the aggregate mean changed from a BOS score of 3.951 to an EOS score of 3.813. A two-sample t-test yields a p-value of 0.000<0.05. suggesting a statistically significant net change of -0.138.

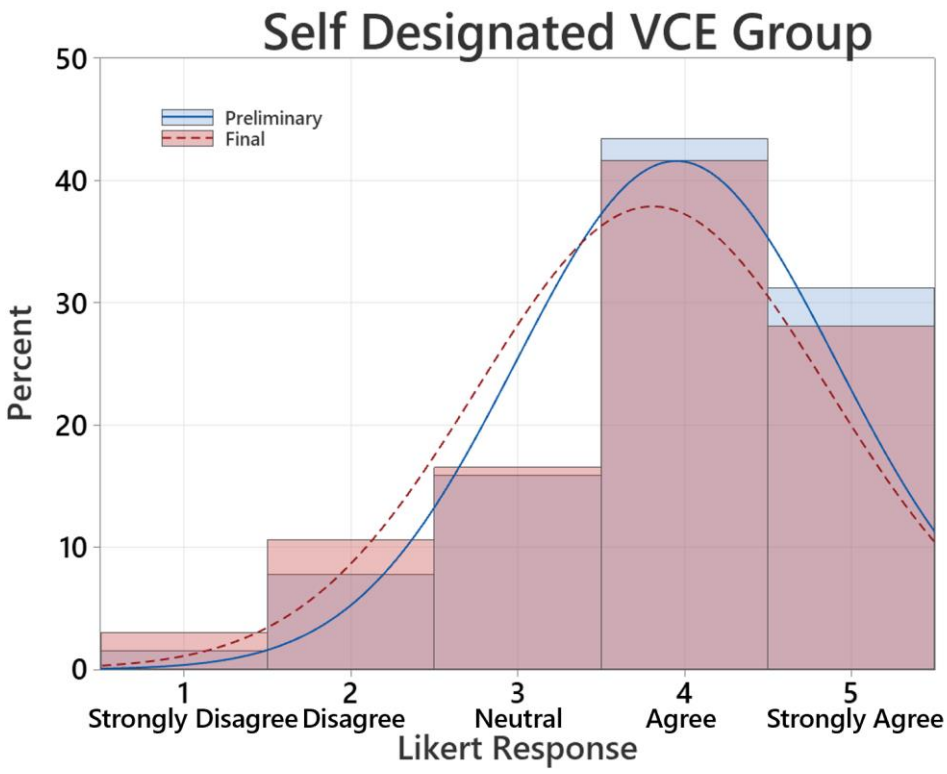

Figure 1. Composite score of the self-designated VCE group responses from the survey

Shown in Figure 2 are the aggregate scores from the Microsoft Team's group's BOS and EOS survey results. After a t-test, it was found that the change in means yielded a p-value of 0.365>0.05, indicating that the change in the mean was not statistically significant for the aggregate mean. This implies that overall, the use of MS teams as a VCE did not impact students' *perceived collaboration success* in their project team.

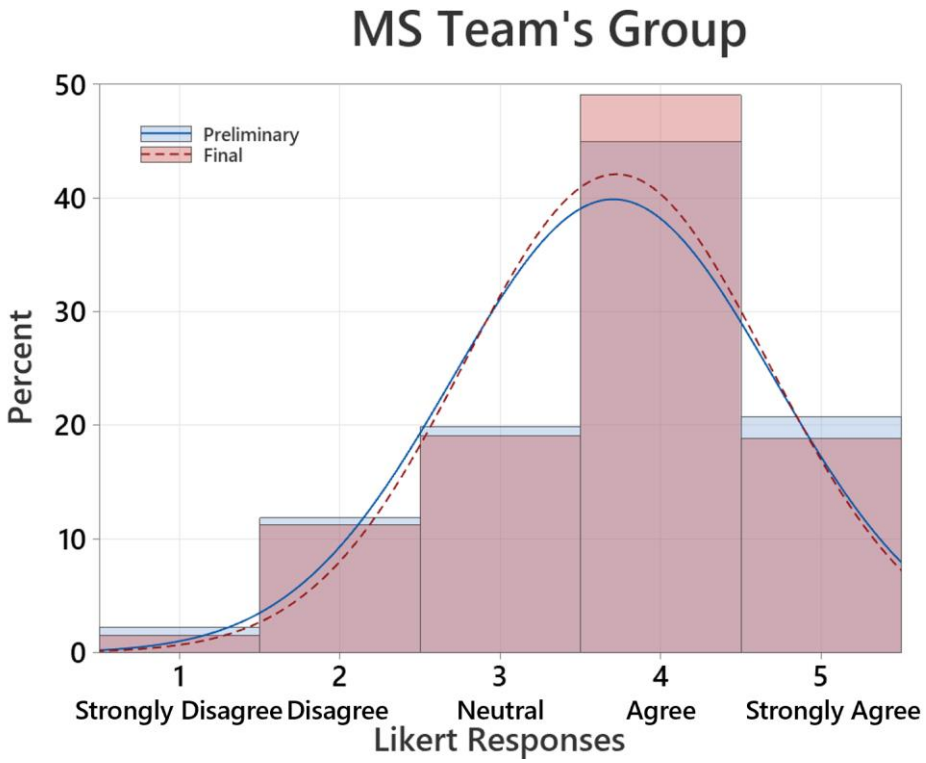

Figure 2. Composite score of the Microsoft Team's group responses from the survey

The aggregate score responses suggest a change in the negative direction for participants in the self-designated VCE group that did not use MS teams as a structured VCE for their project team. The aggregate score also shows no measurable change in the Microsoft Team's group, which implies that MS teams did not improve or hinder the *collaboration success* of the project teams with this structured VCE. Unfortunately, due to a limitation in data collection, a paired-sample evaluation cannot be performed on the before and after conditions. For this reason, it is more enlightening to examine the net responses of the two groups on a question-by-question basis.

Question-by-Question Analysis

To better understand the nature of the changes in student perception, students' responses were examined for each of the separate questions on the survey. From these results, it is possible to begin to understand in which of the pillars of the VCE students felt more or less supported when using MS Teams as opposed to a VCE of their choosing.

Summary

For the question-by-question analysis, a two-sample t-test with a 95% confidence interval was performed on each question, evaluating the average score change from the beginning to the end of the semester for the self-designated VCE and the Microsoft Team's groups, respectively (Figure 3). The results are presented graphically in Figure 3, where values found above the line of statistical significance are questions where the p-values yielded magnitude above 0.05, indicating a statistically insignificant change.

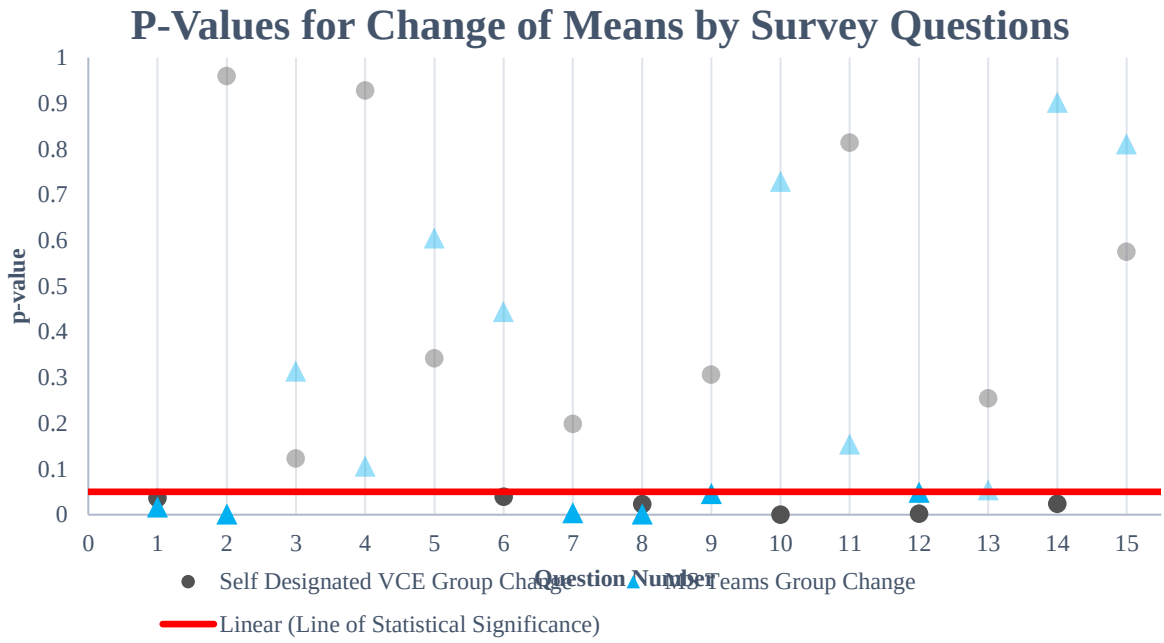

Figure 3. P-values for change of means by survey questions

Questions where statistically significant change occurred were examined. The change direction was recorded as either positive (↑), negative (↓), or neutral (–) for each question. The positive change demonstrated that the mean score increased from the beginning to the end of the term. The negative change exhibited a decrease in the mean over the semester, while a neutral change conveyed that no statistically significant change occurred from beginning to end. The results are shown in Table 3 and provide a side-by-side comparison of each question change for the self-designated VCE and Microsoft Team's groups responses. When comparing the performance of the self-designated VCE and Microsoft Team's groups, only the direction of the change is evaluated because there is no comparable data in the literature to evaluate the scores against. Therefore, the magnitude of the change was not evaluated in this study. For example, if one group scores neutral, indicating a change of zero and one group with a positive change, the group with the positive change outperformed the group with zero change.

Table 3. Visual representation of the change in survey question means for the self-designated VCE and Microsoft Team's groups from the beginning to the end of the semester.

Question	Self-designated VCE	Microsoft Team's
C1	↑	↓
F1	–	↓
F2	–	–
F3	–	–
F4	–	–
T1	↓	–
T2	–	↑
T3	↑	↑
C2	–	↑
T4	↓	–
T5	–	–
C3	↓	↑
C4	–	–
C5	↑	–
C6	–	–

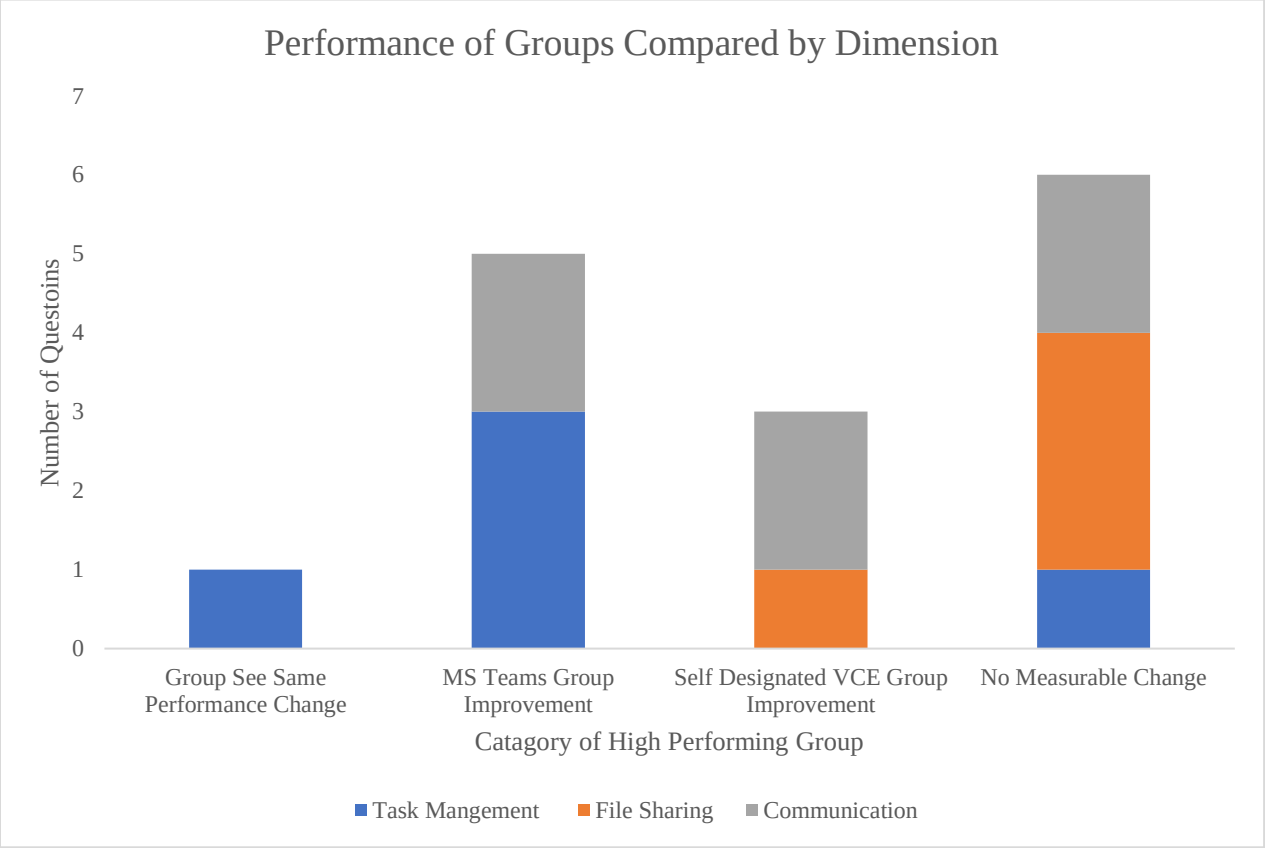

Figure 4. Performance of groups compared by dimension

What did not Change

Not every question saw a measurable change for either group. The two-sample t-test performed for questions F2, F3, F4, T5, C4, and C6 yielded a zero change across the semester for both the self-designated VCE and Microsoft Team's groups. These questions may reflect the general conditions of teamwork or reflect the class's layout. For example, question F2 read, "I felt class-related resources were readily available to me." It could be viewed as more dependent on the instructor's use of LMS or file sharing rather than the file sharing within the participant's team. This would reflect the course rather than the effectiveness of the VCE or the student's choice of VCE in this study. This will be further expanded upon in the limitations section of this paper.

Another noteworthy observation would be the unnoted change in questions F3 and F4, which read "Real time editing within virtual collaboration environments worked seamlessly." and "Real time editing within virtual collaboration environments worked with few problems," respectively. The absence of change here indicated no change in students' perception of real-time file editing, which was surprising to the instructors proctoring the courses. Anecdotally, the instructors received many complaints about MS teams having many problems with having multiple collaborators trying to work on documents simultaneously and not having access to different file types in the MS team's ecosystem. This anecdotal information conflicts with the survey results; however, the data collected indicates that there was not enough of an issue to inhibit the collaborative success of the team.

What Changed for both Groups in the same Direction

Both groups indicated that tracking tasks were critical in moving the team to complete tasks on time. This was indicated by both the Microsoft Team's and self-designated VCE groups seeing a statistically significant increase in their scores in the positive direction for question T3, which reads, "I feel that tracking tasks has helped my team complete tasks on time." This indicated that students learn to complete tasks on time in a first-year project-based learning course regardless of their VCE. Incidentally, the dimension of task management was one of the least addressed topics within the Microsoft Team's group, and neither group had any class assignments directly linked to the use of task management platforms. Students using the MS team's scaffolding were required to the MS teams but were allowed to use the Microsoft native tool *Planner* or *Trello*.

Where was there a Net Increase in the Self-Designated VCE Group?

Most notably here, the self-designated VCE group also saw a more significant change in perceived collaboration success for question F1, which read, "File sharing within our team was straightforward." This question measured the dimension of file sharing. The Microsoft Team's group did not see a greater increase in perceived collaboration success than the self-designated VCE group in any questions measuring file sharing. Again, this shows teams that chose their VCE felt that sharing files was more accessible and straightforward than the participants who used MS teams as a VCE to share files.

For the two communication-related questions where the change in the self-designated VCE group improved more significantly than the change in the Microsoft Team's group, read as follows. "It was easy to communicate with my groupmates." and" I would say that my past groups have worked together successfully." Anecdotally, chatting was one of the most significant complaints students brought to instructors when working with MS Teams instead of social media communication platforms (GroupMe, Snapchat, etc.).

Where was there a Net Increase in the Microsoft Team's Group?

The Microsoft Team's group was a more significant change in perceived collaboration success for three questions related to task management. The self-designated VCE group did not see a more significant change in any questions related to task management. This shows that groups using MS teams as a VCE felt that the scaffolding provided for task management in MS teams helped the groups to stay organized and track their tasks. These task management questions read, "With the online tools I used, I found it difficult to work remotely," I feel that tracking tasks has helped my past teams stay organized." and "Working in a virtual environment led my team to procrastinate on assignments and projects." which shows that they were cornered around remote work. This implies that the Microsoft Team's group noted more ease in engaging remotely. The Microsoft Team's group also felt that the VCE tended to elevate the standards of the product of the teamwork. These changes emphasize the original hypothesis of this study. We predicted that the all-in-one natural VCE components in the MS Teams framework would support remote work better than an ad-hoc collection of tools with no cross-functionality. Overall, these changes indicate that MS Teams led to easier remote work, better task organization, higher perceived quality of work products, and less procrastination.

Conclusion, Limitations, Implications, and Future Work

Conclusion

In conclusion, with a study limited to only studying one VCE, the question most often asked is, "What online tools are the best for collaboration in first-year engineering?" The fairest answer to that question is, "there is no way to tell after this study." However, when asked, "Is MS teams a viable VCE to allow students to collaborate and organize themselves in a first-year engineering-based project course?" the ability to organize and track tasks in MS teams scaffolded students' collaborations. When students choose their VCE, they could feel more successful when sharing files than students in the Microsoft Team's group who used the MS teams' SharePoint file-sharing system. However, there appear to be some positive elements of communication that MS teams furnished for students in a first-year project team. Most notably, students who used MS Teams as their VCE had a higher perceived level of success when examining their task management within their team.

After review of the survey responses on both an aggregate and question by question basis, it appears that the groups using MS teams as a VCE showed a higher score for *perceived collaboration success* than students left to develop their VCE. Unfortunately, only one VCE has been studied so future studies will examine the details.

Limitations

A particular challenge not accounted for in this study was when student teams met in person during the semester-long project, as the survey initially assumed an all-online modality. Some first-year students lived on campus and anecdotally informed the instructors that they would host meetings while wearing masks in an in-person modality. Others took classes back home and remotely connected with teammates during this project. As a result of students conducting meetings over different mediums, the online tools were used on a case-to-case basis.

Also, different instructors taught the Microsoft Team's and self-designated VCE groups. Although the same curriculum was used, it is impossible to ensure that the two professors used the same teaching style.

Another limitation of this study includes the inability to perform paired-sample t-tests on the data. When collecting survey data, the de-identification method to protect student anonymity precluded comparison on a student-by-student basis for the before and after conditions. We can only explore the following change in the cohorts' perceptions of performance rather than a more accurate and meaningful comparison of individual student changes in the test.

Implications

Since the pandemic, 80% of companies have chosen to provide or require that workers move to a completely or partially online modality for work [8]. Naturally, the education system will adopt a similar approach. However, naturally providing tools to students may not give them the setup for success that they could have. Using tools to offload cognitive load, stay organized, collaborate better, and find a better work-life balance amid the post-covid world's craziness. Studies like this indicate that providing scaffolding for students to collaborate virtually allows them to feel more successful in their work. Future studies and branches from this work could provide insight into what tools could maximize that offload to maximize the stress relief for students in education and best prepare them for industry.

Future Work

This research project has another study planned for the spring 2022 semester. It will be similar to the previous study we conducted during the spring 2021 semester that tested if Microsoft Teams was a viable virtual collaboration environment for first-year engineering students to manage a semester-long project effectively. Previously in the spring 2021 study, students in the Microsoft Team's group were instructed to use Microsoft Teams as their VCE while the self-designated VCE group let individual teams decide their VCE. In the spring 2022 study, all the student teams will get to choose their VCE but must document their choice in a team agreement at the

beginning of the semester. In addition, the same survey as the spring 2021 study will be administered at the beginning and end of the semester to all the students. The subsequent study will investigate the qualities of a VCE that participants find the most effective for facilitating collaboration and organization in a first-year engineering project team.

References

[1] ABET, "abet.org," [Online]. Available: https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2022-2023/#GC3.

[2] S. Williams van Rooij, "Scaffolding project-based learning with the project management body of knowledge (PMBOK®)," *Computers & Education,* vol. 52, no. 1, pp. 210-219, 2009.

[3] R. Buchal and E. Songsore, "USING MICROSOFT TEAMS TO SUPPORT COLLABORATIVE KNOWLEDGE BUILDING IN THE CONTEXT OF SUSTAINABILITY ASSESSMENT," in *Canadian Engineering Education Association (CEAA)*, 2019.

[4] B. Rosen, S. Furst-Holloway and R. Blackburn, "Training for virtual teams: An investigation of current practices and future needs," *Human Resource Management,* vol. 45, pp. 229-247, 2006.

[5] J. Lumseyfai, T. Holzer, P. Blassner and B. A. Olson, "Best Practices Framework for Enabling High-Performing Virtual Engineering Teams," *IEEE Engineering Management Review,* vol. 47, no. 2, pp. 32-44, 2019.

[6] A. Gosavi, "Analyzing Responses from Likert Surveys and Risk-adjusted Ranking: A Data Analytics Perspective," *Procedia Computer Science,* vol. 61, pp. 24-31, 2015.

[7] Kent State, "kent.edu," 21 January 2022. [Online]. Available: https://libguides.library.kent.edu/spss/pairedsamplesttest. [Accessed 26 January 2022].

[8] Harvard College, "hbs.edu," [Online]. Available: https://hbswk.hbs.edu/item/how-much-will-remote-work-continue-after-the-pandemic. [Accessed 8 December 2021].