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# How Can We Make This Work? First Year Engineering Design Team Development in Virtual vs. In-Person Environments

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# How Can We Make This Work? Design Team Development in Online vs. In Person Environments


## Abstract

This Evidence-Based Practice paper contains a study about the similarities and differences in team development among first-year engineering students during an introductory design course at a major university in the eastern United States. The study contained ten teams that operated in a totally online environment in Spring 2021, due to COVID-19 restrictions, and ten teams that operated in person in Spring 2022. All teams consisted of students in their second semester of college.

The following research question was explored through this study:

> *How does first-year design team development vary between online and in-person operation?*

Participants were asked to respond individually to a team development survey informed by existing literature. The results indicated that most team members of both online and in-person teams considered their team to be in either the Performing stage or in a transition between the Norming and Performing stages. However, response bias was possible, as demonstrated in a prior study [1]. Examples of response bias included a lack of well-considered responses to survey questions, collaboration between or among team members in completing their survey responses, and different interpretations of certain questions [1]. In addition, the fact that all teams provided a summary of their team's survey results as part of a graded assignment may have caused them to emphasize positive results and omit negative ones. However, the fact that both groups of teams showed a tendency toward the same stages of development indicates that perhaps online team operation is not as disadvantageous as originally thought.


## Introduction

### *Study Problem and Purpose*

Students have been dealing with the uncertainties caused by the COVID-19 pandemic and its implications for their physical, mental and emotional health. These uncertainties have exacerbated the challenges in learning how to work in a productive team at the first-year level, as shown in similar studies with workplace teams [2]–[4]. Our first-year design course depended on hands-on, in-person experiences to enable students to meet learning objectives for both the engineering design process and effective teamwork. Therefore, additional challenges were introduced to both instructors and students when institutions were forced to conduct all courses, including ours, in a totally online environment.

As a result of these uncertainties and the resulting changes in course content and delivery methods, it was reasonable to wonder if design teams at this age level were able to operate as effectively in an online environment as they would be expected to in person. Since remote learning is gaining in popularity, and another pandemic could occur at any time, the results of this study contribute to the growing body of knowledge about the behavior of student teams under alternative conditions, such as totally online operation.

*Background*

The context for this study was a first-year project-based engineering course focused primarily on design and teamwork. Students work in teams on a semester-long project with multiple deliverables, including prototypes, CAD models, progress reports and presentations. The same instructor delivered the same project theme, structure, and major assignments for both the online and in-person offerings of the course.

Team development was studied using the Tuckman model, first popularized in the 1960's for workplace teams and later updated [5], [6]. This model consists of four stages: Forming, Storming, Norming and Performing. Tuckman demonstrated that team members tend to act as individuals during the first two stages, and then realize that, as contributors to a team, more could be accomplished with the team than individually. This realization leads team member performance toward the Norming and Performing stages. A summary of each of the stages and their key characteristics is given in Table 1 below [1], [5]–[7]. This table was adapted from a prior study using similar methods with introductory engineering transfer student teams:

**Table 1: Team Development Stages and Key Characteristics**

| ***Tuckman Team Development Stage*** | ***Key Characteristics of This Stage*** |
|---|---|
| Forming | Orientation: identify boundaries for behavior; develop relationships with other team members; adhere to standards; recognize interdependence. |
| Storming | Catharsis: confront interpersonal issues; exhibit emotional responses to tasks; resist leader and team members' influences. |
| Norming | Focus: overcome resistance in favor of cohesiveness; adopt new standards and roles; express opinions within mutual psychological safety. |
| Performing | Purposive: act flexibly to complete tasks; employ structure toward task completion; utilize team energy to complete tasks. |

## Experimental Methods/Materials/Project Approach

*Study Context and Participants*

The student design teams were originally assigned on the basis of two assessments. One of the assessments was the CATME® team formation survey. The other was a skills and personality assessment that was developed in house. The study description was submitted to the institution's IRB and determined to be not human subjects research. However, the data was de-identified to protect student privacy. The study sample consisted of ten teams that operated in an online environment during the Spring 2021 semester and ten teams that operated in an in-person environment during the Spring 2022 semester. Each team contained five or six members, and the teams were selected randomly from all teams that had completed a Team Development Questionnaire as part of a class assignment. The only condition for selection of the teams was an equal number of teams from each of the two spring semesters. Selection of the teams was also not made in consideration of the CATME® team formation survey.

*Data Collection*

A team development survey, supported by existing literature, was administered to all teams during Week 11 of 15. The survey was obtained from Catalyst Mediation Training, and was originally developed for workplace teams [8]. The survey items (statements) are listed in Table 2 below:

**Table 2: Tuckman Team Development Survey Items Associated with Each Stage** [1], [8]

| ***No.*** | ***Items Indicating the Forming Stage:*** |
|---|---|
| 1 | We try to have set procedures or protocols in place to ensure that things are orderly and run smoothly (e.g., minimize interruptions; everyone gets the opportunity to have their say. |
| 5 | Team members are afraid or do not like to ask others for help. |
| 10 | Team members do not fully trust other members and closely monitor others who work on a task. |
| 15 | We are trying to define the goal and what tasks need to be accomplished. |
| 18 | We assign specific roles to team members (team leader, facilitator, time keeper, note taker, etc.) |
| 21 | There are many abstract discussions of concepts and issues, which makes some team members impatient. |
| 27 | It seems as if little is being accomplished with the project's goals. |
| 29 | Although we are not fully sure of the project's goals, we are excited and proud to be on the team. |
| | ***Items Indicating the Storming Stage:*** |
| 2 | We are quick to get on with the task on hand and do not spend too much time in the planning stage. |
| 7 | The team leader tries to keep order and contributes to the task at hand. |
| 9 | We have lots of ideas but don't use many as we don't listen but reject before understanding them. |
| 16 | Many team members have their own ideas about the process and personal agendas are rampant. |
| 20 | The tasks are very different from what we imagined and seem very difficult to accomplish. |
| 23 | We argue a lot even though we agree on the real issues. |
| 28 | The goals we have established see unrealistic. |
| 31 | There is a lot of resisting of the tasks at hand and quality improvement approaches. |
| | ***Items Indicating the Norming Stage:*** |
| 4 | We have thorough procedures for agreeing our objectives and planning the way we perform tasks. |
| 6 | We take our team's goals and objectives literally, and assume a shared understanding. |
| 11 | The leader ensures that we follow procedures, do not argue, do not interrupt, and keep to the point. |
| 13 | We have accepted each other as members of the team. |
| 19 | We try to achieve harmony by avoiding conflict. |
| 24 | The team is often tempted to go above the original scope of the project. |
| 25 | We express criticism of others constructively. |
| 30 | We often share personal problems with each other. |
| | ***Items Indicating the Performing Stage:*** |
| 3 | Our team feels we are all in it together and shares responsibilities for the team's success or failure. |
| 8 | We do not have fixed procedures, we make them up as the task or project progresses. |
| 12 | We enjoy working together; we have a fun and productive time. |
| 14 | The team leader is democratic and cooperative. |
| 17 | We fully accept each other's strengths and weaknesses. |
| 22 | We are able to work through Team problems. |
| 26 | There is close attachment to the team. |
| 32 | We get a lot of work done. |

Participants responded to the survey items according to a 5-point frequency Likert scale ranging from "Almost Never" to "Almost Always".

*Data Analysis*

The survey data were compiled for all teams by adding the scores for each group of items shown in Table 2 and comparing the subtotals for each set of items. The largest subtotal for each team member indicated their perceived team development stage. The percentage of responses for each development stage was based on the number of responses from each team. A team profile was then revealed by comparing the percentages for each development stage.

## Results and Discussion

Results are summarized in Tables 3 and 4 below:

**Table 3: Team Development Survey Results for Online Teams, Spring 2021**
Key: F = Forming; S = Storming; N = Norming; N+P = between Norming and Performing; P = Performing

| | | | Percentages of Members' Responses for Each Stage | | | | |
|---|---|---|---|---|---|---|---|
| Team ID | No. Members | Sets of Survey Results | F | S | N | N+P | P |
| NI-21 | 5 | 5 | | 20 | | | 80 |
| PA-21 | 5 | 5 | | | | 40 | 60 |
| PH-21 | 6 | 6 | | | | 33 | 67 |
| PT-21 | 6 | 5 | | | | 40 | 60 |
| QT-21 | 5 | 4 | | | | 75 | 25 |
| SE-21 | 6 | 6 | | | 17 | | 83 |
| TM-21 | 6 | 5 | | | 20 | 20 | 60 |
| TT-21 | 6 | 5 | | | | 17 | 83 |
| WB-21 | 5 | 5 | | | | 20 | 80 |
| WD-21 | 4 | 4 | | | | 50 | 50 |

**Table 4: Team Development Survey Results for In-Person Teams, Spring 2022**
Key: F = Forming; S = Storming; N = Norming; P = Performing

| | | | Percentages of Members' Responses for Each Stage | | | | |
|---|---|---|---|---|---|---|---|
| Team ID | No. Members | Sets of Survey Results | F | S | N | N+P | P |
| AD-22 | 6 | 5 | | | | 17 | 83 |
| AR-22 | 6 | 6 | | 33 | | 33 | 33 |
| AS-22 | 6 | 6 | | | 17 | 17 | 67 |
| AW-22 | 6 | 6 | | | | 67 | 33 |
| BF-22 | 5 | 5 | | | 20 | 20 | 60 |
| BS-22 | 6 | 6 | | | | 17 | 83 |
| BU-22 | 6 | 6 | | | 33 | 67 | |
| CH-22 | 6 | 5 | | | | 40 | 60 |
| DA-22 | 5 | 5 | | 20 | | | 80 |
| DS-22 | 6 | 6 | | | | 33 | 67 |

The results indicate that most of the members of the online and in-person teams considered their team to be in the Performing stage, or, to a lesser extent, between Norming and Performing.

Participants who indicated that their team was between the Norming and Performing stages exhibited equal or nearly equal subtotal scores for these two stages. These results are encouraging since both the online and in-person teams had been together for approximately nine weeks, with only three weeks left in which to complete the design project and the course. The choice of both the Norming and Performing stages by certain team members could be explained by perceived differences in the levels of structured interaction among team members to accomplish certain types of tasks [5]. This choice could also indicate the relative necessity to operate within a highly structured environment because these members had not yet developed a sufficient level of psychological safety toward one or more fellow team members [4].

Further evidence for the influence of psychological safety was the assignment of this survey item to the Norming rather than Performing stage: "We often share personal problems with each other." For all types of teams, most members either Disagreed or Strongly Disagreed with this statement. However, the influence of psychological safety on team success was not entirely clear from the survey results, given that most responses to the items "We get a lot of work done" and "We are able to work through team problems" were positive for both types of teams, even if psychological safety was not widely recognized as a factor.

Online teams with one member who disagreed with all other members about the team's development stage included NI-21, SE-21, TM-21, AR-22, AS-22, BR-22, BU-22, and DA-22. The statements about "fixed procedures" and "close attachment to the team" produced common results for the dissenting members of both types of teams, while the "often share personal problems" item yielded more widespread disagreement among the online teams than among the in-person teams.

The answer to the research question about how first-year team development varied between online and in-person operation is that, given these data, both types of teams had reached Tuckman's Norming + Performing or Performing stages by the twelfth week of a fifteen-week semester, as one would expect. However, there was a larger number of in-person teams with one member disagreeing as to the team's development stage than those in the online teams, based on the study sample. Even though the sample was chosen randomly, a larger sample might yield different results.

It may have been assumed that online teams were operating at a disadvantage due to the inability to meet in person, but our results, and those of others, indicate otherwise [1], [2]. The differences that did exist could be explored further, by expanding the study sample and performing a more detailed quantitative analysis. We also have yet to find prior evidence of this survey's validation.

Recommendations for further study include the testing of the survey for validity and reliability, which might also detect possible sources of ambiguity or bias [1]. The possibility of response bias might also be mitigated by administering the survey during class rather than as an off-class assignment. Additional methods for identifying team development and dynamics should also be considered, as well as pilot testing of new and existing survey questions to assure consistent interpretation by all participants. Finally, qualitative analysis of available team-based documents, team contracts, and peer reviews might also reveal additional similarities and differences between online and in-person engineering student design teams.

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