

# **Before and After: Team Development in Virtual and In-Person Transfer Student Engineering Design Teams**

## **Abstract**

This Evidence-Based Practice paper contains the similarities and differences in team development among first-year engineering design teams containing transfer students in the online Fall 2020 and in-person Fall 2021 semesters. These two different course environments were expected to produce different experiences in team development between the two cohorts. While this study involves only transfer students, based on currently available data, a similar study could be conducted after the Spring 2021 semester with first-year students who began college at their current institution.

My research question is:

- How do team development experiences differ under virtual and in-person conditions, respectively and in comparison?

The conceptual framework for this inquiry is based on the Tuckman model of team development. This model consists of four stages that Tuckman and others have demonstrated that teams exhibit during their duration: Forming, Storming, Norming and Performing. This model originated with adult teams in the workplace, but is equally applicable to non-self-selected engineering student design teams.

Team members tend to view themselves as individuals rather than as part of a cohesive unit in the Forming and Storming stages. As they transition to the Norming stage, they accept the premise that the team can accomplish more together than if each member acted in isolation. Even if a team forms a contract or charter during the Forming stage, which states how they will operate as a team, the ways in which they actually operate tend to become apparent during Norming. By the time that a team reaches the Performing stage, each member has a clear vision of what the team does and can do, and uses the relationships among team members to accomplish tasks more or less efficiently.

The five- or six-member student design teams were assigned through a skills and personality assessment at the beginning of the fifteen-week semester, using the CATME<sup>®</sup> team formation survey. The CATME results were checked against the students' self-reported data about their current skills in writing, speaking, and engineering graphics before the students were formally assigned to their teams.

Research methods followed an explanatory sequential design, in which the results of one or more quantitative methods are used to inform the choice of one or more qualitative methods to collect and analyze data. Quantitative data were collected and analyzed using a 32-question survey about team development stages, followed by qualitative analysis of team-based written artifacts. Available written artifacts included the following:

- a team contract, developed by the team during Week 4 of the semester;

- a CATME® peer review, administered online during Weeks 7 and 8;
- team-based commentary about the results of the team development survey, noting similarities and differences among team members' results, as part of a project and team status update submitted during Week 12;
- team-based commentary about additional progress toward team development since Week 12, as part of the final project and team status update submitted during Week 15, and
- a final CATME® peer review, administered during Weeks 14 and 15.

By Week 12, many online and in-person teams in both cohorts were in strong agreement about their team's development stage as either Norming or Performing. This is a positive outcome, given that the teams had only three weeks remaining to complete the design project and the course. Both types of teams also provided evidence of the following attributes of successful teams, as identified in recent literature: collective efficacy, psychological safety, resilience, individual performance, and communication.

However, extensive response bias in survey responses and team-based evaluations indicated that certain online and in-person teams may have been viewing their team's development less realistically because they were required to report on similarities and differences among team members' survey results as part of a homework assignment, and wanted to omit negative results. Certain survey questions were also reported to have been interpreted in different ways by team members.

## **Introduction**

This section contains the purpose of this study, background information about team development, recent ramifications of the COVID-19 pandemic on team dynamics, and the limitations of this study. The conceptual framework consists of Tuckman's team development model, consisting of four stages: Forming, Storming, Norming, and Performing [1], [2].

### *Study Problem and Purpose*

The ability to operate as a productive and useful member of a team is important to the engineering profession as well as to other professions [3]. For this reason, both first-year engineering courses and senior design courses often contain a learning objective for students to develop this ability. In addition, these courses are often constructed around a one-semester or two-semester design project pursued by interdisciplinary teams. There are numerous challenges to learning how to develop effective teamwork at both the first-year and senior undergraduate levels, and these challenges have been exacerbated in both academia and the workplace by the conditions imposed by the COVID-19 pandemic [3]–[5].

In particular, these previously hands-on, in-person design courses were forced into a partially or totally online environment for a period of time, as institutions of higher education responded to public health concerns associated with the virus [6]. As a result, "lessons learned" have already been published about the barriers faced by student and professional teams in the academic and non-academic workplaces, respectively [3]–[5]. This study is intended to contribute to this

emerging body of knowledge about the behavior of virtual and in-person student design teams operating under pandemic-induced conditions.

*Background*

Team development can be described in terms of Bruce Tuckman’s four stages, which he developed in the mid-1960’s based on an extensive review of the literature, and re-visited in 1977 [1], [2]. These four stages are described in Table 1 below:

**Table 1: Tuckman’s Team Development Stages and Their Key Characteristics [1], [2], [7]**

<i><b>Tuckman Team Development Stage</b></i>	<i><b>Key Characteristics of This Stage</b></i>
Forming	Orientation through testing: identifying boundaries for behavior; developing relationships with other team members; adherence to standards; recognizing interdependence.
Storming	Catharsis: questioning due to interpersonal issues; exhibiting emotional responses to tasks; resisting group influences.
Norming	Focus: overcoming resistance to promote cohesiveness; adopting new standards and roles; expressing opinions within mutual psychological safety.
Performing	Purposive: exert flexibility in roles to complete tasks; structure supports task completion; team energy is focused on completing tasks.

Team members establish ground rules for operation but only become minimally acquainted in the Forming stage, exhibit resistance and question their leader and each other during Storming, adopt a team-based mindset through cooperation during Norming, and exercise a sufficient level of trust in other team members to exert flexibility in response to the demands of task completion when Performing [8].

Two recent studies about the limitations and consequences of teamwork, one involving senior undergraduate design teams and the other with health care teams, offered descriptions of the positive and negative dynamics of working under pandemic conditions in early 2020 [3], [5]. Senior design teams, operating during the Spring 2020 semester, were forced to curtail their in-person activities and complete their project and course online immediately after their 2020 spring break. The health care teams identified and reported certain dynamics and consequences of in-person operation under continuing pandemic conditions in both 2020 and 2021 [3], [5]. What these two studies have in common is that factors affecting individual behavior and resulting team dynamics were strongly affected by the pandemic and its resulting stressors, even though the senior design teams ended their work virtually, and the health care teams continued to work in an in-person workspace. Both studies yielded useful study constructs, which are listed in the Data Analysis section. Additional constructs for measures to mitigate pandemic-influenced team behavior are also included in the Data Analysis section from a set of recommendations for business operations during the earliest stage of the pandemic in 2020 [4].

### *Limitations to This Study*

This study is limited to the engineering transfer students at a single institution, in the Fall 2020 and Fall 2021 semesters. In addition, data collection involved two quantitative surveys with fixed-response questions, and written artifacts in which the format and guidelines for the scope were specified, but the content was a free-response short essay.

### **Experimental Methods/Materials/Project Approach**

The context for this study, a description of the participants, and data collection and analysis methods are included in this section. Data were collected and analyzed using a 32-question team development survey, along with selected sections of essays in which teams described their collective understanding of their current team development stage, based on the survey results for each team member. The essays also contained evidence of five teamwork-related constructs identified in the literature as collective efficacy, psychological safety, team resilience, individual team member performance, and communication behavior [3]–[5].

### *Study Context*

Transfer students at our institution have the option to enroll in a one-semester introductory engineering course which replaced a similar two-semester course sequence intended for first-year students. Many of these transfer students had already declared an engineering or computer science major, and were taking second-year courses concurrently. The course was conducted online in Fall 2020, due to significant institutional concerns about exposure to Covid-19 and its consequences, which were mitigated in Fall 2021 with mandatory vaccination and masking in order to enable in-person course delivery, along with the less severe behavior of the Covid-19 disease during the summer and fall of 2021.

The learning objectives for the one-semester course contain the teaching and practice of both individual and team-based skills to enable its students to be able to do the following:

1. Use guided design methodologies to **analyze** engineering problems in order to achieve an optimal solution.
2. **Identify** and **analyze** holistic issues that impact engineering solutions, e.g., ethical implications, stakeholder needs and interests, and constraints.
3. **Collect** and **analyze** data and information to support/inform engineering decisions.
4. **Use** mathematical, graphical, and physical models in solving engineering problems.
5. **Use** various engineering tools, including algorithm development, procedural programming, and graphical communication to solve engineering problems.
6. Actively **contribute** to the solution of an engineering project in a team setting requiring management of people, materials, and other resources.
7. **Produce** and **deliver** documentation which develops and presents the evidence necessary to support an engineering decision.

The fulfillment of learning objective #6 is of concern in this study, particularly the ways in which each team operated with respect to the Tuckman team development stages. Team-based activities were focused on the design and construction of a physical prototype as a solution to an engineering problem, as well as practice in the development of effective teamwork skills. While individual teamwork skills could be assessed through the results for peer reviews using CATME®, this type of research is beyond the scope of this study. Instead, I was interested in overall similarities and differences among team members' perceptions of their Tuckman team development stage at in the fourth quarter of each of two semesters, where teams operated totally online in one semester, and totally in person in the second.

### *Participants*

The study sample contained 89 students (16 teams) who completed the course totally online in Fall 2020, and 88 students (15 teams) who completed the course in person in Fall 2021. Each non-self-selected team contained 5 or 6 students. Teams were assigned based on the results of the CATME® team formation survey, and with the results of a course-specific informational survey containing a self-assessment of current skills in writing, speaking and engineering graphics, as well as questions about personality traits and interests.

### *Data Collection*

Quantitative data were collected from participants' responses to a 32-question Tuckman team development stage survey published by Catalyst Mediation Training [8]. Each survey question was indicative of one of the four Tuckman stages: Forming, Storming, Norming, or Performing. A Likert scale was provided for scoring each question as follows:

- Almost Never (1)
- Seldom (2)
- Occasionally (3)
- Frequently (4)
- Almost Always (5)

The survey was administered during the twelfth week of each 15-week fall semester course. Participants submitted their survey results online as part of a homework assignment, and shared their results informally with other members of their teams. The survey instructions also contained a table containing a list of associated question numbers for each stage [8]. Each participant entered their scores for each question, and were asked to add their scores together according to a key showing which questions were associated with each of the four stages [8]. The range of possible sums of the eight questions for each stage was 8 to 40 [8]. The largest value among the four sums indicated a team member's perception of their team's development stage.

Each team then analyzed their members' scores and provided a commentary about them in two subsequent essay assignments, which provided some of the available qualitative data described later in this section. The survey questions and their associated stages are shown in Table 2 below.

**Table 2: Tuckman Team Development Survey Questions Associated with Each Stage [8]**

<i>No.</i>	<i>Questions for the Forming Stage:</i>
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.
	<i>Questions for the Storming Stage:</i>
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 seem unrealistic.
31	There is a lot of resisting of the tasks at hand and quality improvement approaches.
	<i>Questions for the Norming Stage:</i>
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.
	<i>Questions for the Performing Stage:</i>
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.

Qualitative data were collected from the following sources:

- Team contracts composed during Weeks 3 and 4, as part of a project and team formation homework assignment;
- A short team-based essay, composed during Week 12, about the Tuckman survey results for each team in terms of how closely the team members agreed or disagreed upon a common Tuckman stage, and their reasons for agreement or disagreement;
- A second short essay, composed at the end of the course and project, about whether and how the team adjusted their ways of working as a result of the survey results, and
- CATME® peer evaluation results (Weeks 8 and 15) to inform anomalies among team

members' Tuckman survey scores.

### *Data Analysis*

The quantitative data were analyzed through a summary of the Tuckman team development survey data. Survey scores were tabulated according to the scoring scheme given by Catalyst Mediation [8], in order to determine team members' evaluations of their team development stage at Week 12.

The qualitative data were then analyzed against the following five constructs of interest, as informed by available literature, all of which could apply to either virtual or in-person teamwork [3]–[5]:

- Collective efficacy: the belief that the team can succeed
- Psychological safety: willingness of team members to share their issues without reprisal
- Team resilience: an ability to trust and thrive under unpredictable circumstances
- Individual team member performance: commitment toward working as a team
- Communication behavior: factors that help or hinder effective communication

These constructs are of interest because they identified the differences in team development stages among team members, as well as the differences between the overall development of virtual vs. in-person teams.

Both types of results were then compared for evidence of similarities and differences in team members' perceptions of their team's Tuckman development stage, using examples of team harmony and/or conflict, as described by the teams. While each team had submitted written summaries of their overall perception of their team's Tuckman stage during Weeks 12 and 15, individual team member results were expected to vary to some extent.

## **Results and Discussion**

The results of the Tuckman team development survey are summarized for both online and in-person teams in this section. These results are followed by the qualitative analysis of the written artifacts describing each team's development stage and teambuilding efforts as of Week 12, in terms of the study constructs. Based on these results, recommendations are also given for future studies.

### *Team Development Survey Results*

The quantitative results appear in Tables 3 and 4, respectively, on the next page. For 69% of the Fall 2020 online teams, 67-100% of their members chose the Performing stage, while 53% of the Fall 2021 in-person teams revealed that 67-100% of their members had chosen the Performing stage. Therefore, it would appear that being forced to operated totally online was not necessarily detrimental to team development, as originally expected.

**Table 3: Team Development Survey Results for Online Teams, Fall 2020**

Key: F = Forming; S = Storming; N = Norming; P = Performing; M = Member

<i>Team ID</i>	Team Members' Chosen Team Development Stage						Percentages for Each Chosen Stage					
	<i>M 1</i>	<i>M 2</i>	<i>M 3</i>	<i>M 4</i>	<i>M 5</i>	<i>M 6</i>	<i>F</i>	<i>S</i>	<i>N</i>	<i>N+P</i>	<i>P</i>	<i>Other</i>
FB-20	P	P	P	P	P	P					<b>100</b>	
HS-20	P	P	P	P	P	N			17		<b>83</b>	
HF-20	P	P	P	N+P	P	P				17	<b>83</b>	
TS-20	P	P	P	P	N+P	P				17	<b>83</b>	
UH-20	P	P	P	P	N	P			17		<b>83</b>	
CC-20	P	P	P	P	N+P	N/A				20	<b>80</b>	
HI-20	N+P	P	P	P	P	N/A				20	<b>80</b>	
TD-20	P	P	S+P	P	P	N/A					<b>80</b>	20% S+P
GD-20	N+P	P	N+P	P	P	P				33	<b>67</b>	
HV-20	N+P	N+P	P	P	P	P				33	<b>67</b>	
LS-20	P	P	S+N+P	N+P	P	P				17	<b>67</b>	17% S+N+P
CA-20	N+P	N+P	P	P	N/A	N/A				<b>50</b>	<b>50</b>	
HB-20	P	P	F	N+P	N	P	17		17	17	<b>50</b>	
HH-20	N	N+P	N+P	N+P	P	N/A			20	<b>60</b>	20	
KI-20	N+P	P	N+P	N	F+N+P	N/A			20	<b>40</b>	20	20% F+N+P
BE-20	N	N+P	P	N	N	N			<b>67</b>	17	17	

**Table 4: Team Development Survey Results for In-Person Teams, Fall 2021**

Key: F = Forming; S = Storming; N = Norming; P = Performing; M = Member

<i>ID</i>	Team Members' Chosen Team Development Stage						Percentages for Each Chosen Stage					
	<i>M 1</i>	<i>M 2</i>	<i>M 3</i>	<i>M 4</i>	<i>M 5</i>	<i>M 6</i>	<i>F</i>	<i>S</i>	<i>N</i>	<i>N+P</i>	<i>P</i>	<i>Other</i>
HN-21	P	P	P	P	P	P					100	
WE-21	P	P	P	P	P	P					100	
WI-21	P	P	P	P	P	P					100	
VS-21	P	N+P	P	P	P	P				17	83	
WW-21	P	P	P	N+P	P	N/A				20	80	
CD-21	P	P	N+P	N+P	P	P				33	67	
JT-21	P	N+P	P	P	P	N+P				33	67	
KD-21	N+P	P	P	P	P	N+P				33	67	
RP-21	N+P	N+P	P	P	P	F+N				33	50	17% F+N
TB-21	P	N+P	P	P	N+P	N			17	33	50	
WM-21	N	S	N+P	P	P	P		17	17	17	50	
JM-21	N+P	P	F	N+P	F+N+P	P	17			33	33	17% F+N+P
RZ-21	N+P	N+P	P	N+P	N+P	N+P				83	17	
SC-21	N+P	N+P	S+N	S+N	P	S+N				33	17	50% S+N
WC-21	S	S	S	S	S	S+P		83				17% S+P

However, individual team members' results contained variations in perceptions of team development due to any number of individual and interactive dynamics. These dynamics were revealed by the qualitative results, as given below.

*Results of Qualitative Analysis of Team-Based Short Essays*

Results from emergent coding of the abovementioned written artifacts are summarized in Tables 5 and 7 for the Fall 2020 online teams, and in Tables 6 and 8 for the Fall 2021 in-person teams, all of which follow on the next two pages.

**Table 5: Qualitative Trends for Online Teams with Members in 67+% Agreement with Team in the “Performing” Stage**

<b>ID</b>	<b>Reasons for Agreement According to Identified Constructs</b>
FB-20	<i>Resilience:</i> Sharing the responsibility for team success or failure <i>Individual performance:</i> Agreeing on objectives and how to plan work
HS-20	<i>Collective efficacy:</i> Positive attitude for all team members <i>Psychological safety:</i> Share what's going on in members' lives <i>Resilience:</i> Established methods for conflict resolution <i>Individual performance:</i> High reliability among members
HF-20	<i>Psychological safety:</i> Giving everyone a safe place to offer honest feedback <i>Resilience:</i> During hardest times, meetings used to cheer up as well as accomplish work <i>Individual performance:</i> Some members exert more leadership skills than others
TS-20	<i>Collective efficacy:</i> Take initiative to fulfill roles above expectations <i>Psychological safety:</i> team members want to hear from each other <i>Individual performance:</i> all members adhere to Team Contract
UH-20	<i>Collective efficacy:</i> team did not discuss how to distribute the work among members to ensure successful completion; lack of agreement about level of quality and effort necessary for successful project completion <i>Communication:</i> limited to meeting online, which is difficult for teambuilding activities; little coordination of effort NOTE: certain disagreements were based on interpretation of survey question(s)
CC-20	<i>Collective efficacy:</i> All members contribute to the project with equivalent effort <i>Psychological safety:</i> Get to know each other to be comfortable together and to identify individual strengths; members seldom argue or interrupt
HI-20	<i>Collective efficacy:</i> completion of agreed-upon goals <i>Psychological safety:</i> Talk about personal “stuff” after work has been completed <i>Individual performance:</i> Individuals take leadership role when needed
TD-20	<i>Collective efficacy:</i> Members share common goals and expectations for success <i>Psychological safety:</i> Members accepted each other as part of the team <i>Resilience:</i> Each member accepted all members' strengths and weaknesses
GD-20	<i>Collective efficacy:</i> Deadlines are important for staying on track <i>Psychological safety:</i> everyone accepts each other as teammates. <i>Communication:</i> keep each other informed about progress
HV-20	<i>Collective efficacy:</i> all members share together in responsibility for team success or failure <i>Psychological safety:</i> team members enjoy working together; personal issues are also shared among team members
LS-20	<i>Collective efficacy and Resilience:</i> Confidence and trust rose after Mid-Project Presentation – it was a turning point <i>Individual performance:</i> All members agreed on a shared leadership

**Table 6: Qualitative Trends for In-Person Teams with 67+% of Team Members in Agreement About the “Performing” Stage**

HN-21	<p><i>Psychological safety:</i> everyone able to express thoughts without hurt feelings or consequences</p> <p><i>Resilience:</i> member took extra initiative to overcome barriers to learning CAD</p> <p><i>Individual performance:</i> team leader has a strong work ethic</p>
WE-21	<p><i>Collective efficacy:</i> Set and keep intermediate deadlines for deliverables</p> <p><i>Psychological safety:</i> Participate in social activities as a team</p> <p><i>Resilience:</i> Ability to become friends helped to defuse conflict</p> <p><i>Individual performance:</i> willingness to help struggling members with their tasks</p>
WI-21	<p><i>Collective efficacy:</i> Meeting together to accomplish complex or difficult tasks</p> <p><i>Resilience:</i> Shared leadership and initiative for completing tasks</p> <p><i>Individual performance:</i> each member had a voice in the work</p> <p><i>Communication:</i> Use the online platform for both work-related and social interactions</p>
RZ-21	<p><i>Collective efficacy:</i> members learned to work together and cover for each other when needed for team’s greater good</p> <p><i>Psychological safety:</i> all team members strive to understand on another</p> <p><i>Resilience:</i> team never failed to adapt to the struggle</p> <p><i>Individual performance:</i> awareness of team members’ styles of work and communication</p>
RP-21	<p><i>Collective efficacy:</i> ensure that everyone is on the same page and doing their best work</p> <p><i>Resilience:</i> team never gave up and completed the project in time despite obstacles</p> <p><i>Individual performance:</i> diversity of skill levels led to peer teaching</p> <p><i>Communication:</i> this would be the team’s greatest asset</p>
KD-21	<p><i>Psychological safety:</i> conduct a fun atmosphere while still working</p> <p><i>Individual performance:</i> members go above and beyond to help other members when requested</p> <p><i>Communication:</i> team had confidence in the ways in which they communicate</p>
JT-21	<p><i>Collective efficacy:</i> all work is reviewed prior to submittal to ensure quality</p> <p><i>Psychological safety:</i> everyone has an equal say in how the project is conducted; listening to each other’s’ ideas and allowing everyone to do their part without interference.</p> <p><i>Resilience:</i> showing persistence and dedication to getting work done</p>
WW-21	<p><i>Collective efficacy:</i> all deliverable reviewed for quality before submittal</p> <p><i>Psychological safety:</i> high team morale and camaraderie</p> <p><i>Individual performance:</i> work is divided evenly among team members</p>
SC-21	<p><i>Psychological safety:</i> advice and feedback freely given among members</p> <p><i>Resilience:</i> two members provide solutions and direction when other team members become confused or work does not go well.</p>

**Table 7: Qualitative Trends for Online Teams with <67% of Members in Agreement About the “Performing” Stage**

<i>ID</i>	<i>Reasons for Disagreement According to Identified Constructs</i>
CA-20	<i>Psychological safety:</i> Certain, but not all, members were willing to share their ideas and show initiative <i>Individual performance:</i> leader delegated work to keep everyone’s workload equitable <i>Communication:</i> members in different time zones led to difficulty in working together
HB-20	<i>Psychological safety:</i> improvement is needed in making the team environment more comfortable for everyone <i>Communication:</i> lack of clearly understood goals, procedures, and plans
HH-20	<i>Collective efficacy:</i> All members have and do their jobs for the team to be successful <i>Psychological safety:</i> All members enjoy collaborating and understanding each other. <i>Individual performance:</i> Team leader assigns tasks and deadlines in sufficient time to complete them.
KI-20	<i>Psychological safety:</i> team members differed in their willingness to ask for help from other members; variations in levels of trust among members were evident <i>Communication:</i> inconsistent, because members miss team meetings
BE-20	<i>Psychological safety:</i> Conflicts were resolved promptly and with respect to all parties <i>Individual performance:</i> All members adhered to established team roles and delegation of work to achieve equitable workloads and foster ownership of work

**Table 8: Qualitative Trends for In-Person Teams with <67% of Team Members in Agreement about Team Development Stage**

RP-21	<i>Collective efficacy:</i> All members believed that they could produce a high-quality solution. <i>Psychological safety:</i> Sharing meals outside of class, team meetings, and work sessions. <i>Resilience:</i> Difficulties in scheduling meetings and work sessions due to conflicting commitments among members. <i>Individual performance:</i> Shared leadership through individual initiative to produce comprehensive work
TB-21	<i>Collective efficacy:</i> Words of encouragement provided motivation to succeed <i>Psychological safety:</i> Entire team supported each member’s ideas <i>Resilience:</i> Assigned work based on members’ strengths to avoid conflicts over difficulties <i>Individual performance:</i> members led within their respective roles and specialties
WM-21	<i>Collective efficacy:</i> team members were not coordinating their efforts, which increased the probability of conflict <i>Psychological safety:</i> team needed to improve in considering all members’ inputs and views
JM-21	<i>Individual performance:</i> teamwork could have been improved if members showed up for every class <i>Communication:</i> not fully effective at this stage in the team’s duration NOTE: response bias affected Tuckman survey scores
RZ-21	<i>Collective efficacy:</i> Differences in approach to work: either do it promptly or wait longer to start it <i>Individual performance:</i> Team has established procedures that every member follows <i>Communication:</i> Team leader monitors everyone’s progress closely
SC-21	<i>Psychological safety:</i> Members trusted one another and gave advice and opinions freely <i>Resilience:</i> Two members who readily addressed difficult tasks and conflicts between members to resolve issues. <i>Individual performance:</i> Members committed to completing work on time and to best of ability.
WC-21	<i>Collective efficacy and Communication:</i> team members were not unified in their conception of success in the project NOTE: certain disagreements were based on interpretation of the survey question(s)

Both types of teams reported examples of how their team’s behavior exhibited two or more of the qualitative constructs, which are shown in italics in Tables 5 through 8. For example, in Tables 5 and 7, teams with high agreement that their team was operating in the Performing stage stated that they agreed about team goals for project completion, shared responsibility for success,

and reviewed their work prior to submittal. Conversely, Tables 6 and 8 show how certain teams in lesser agreement about operating in the Performing stage were not as successful in coordinating their efforts for success, or how to distribute the necessary work equitably. Similarly, teams that practiced psychological safety enjoyed a free exchange of ideas and showed respect for all views and inputs, resulting in greater team harmony and trust.

For both types of teams, Week 8 peer evaluation data for the teams with  $\leq 50\%$  agreement about the Performing stage were inconclusive in predicting a lack of progress toward that stage, due, in part, to the fact that written comments were not required for data collection. There were only two teams in each of the two semesters whose peer evaluation data indicated difficulties in working as a team. The reluctance of the other teams with  $\leq 50\%$  agreement could be attributed to a reluctance on the part of these teams to report negative results, for fear of grading reprisal.

#### *Validity and Reliability Issues with the Tuckman Survey, and Recommendations for Future Work*

The written artifacts also revealed that teams with wider disagreement in their survey results, such as HB-20, LS-20, KI-20, JM-21, WM-21, and WC-21, reported that some of their members did not interpret certain survey questions in the same way as other members, leading to a skewing of their scores toward the early development stages. This disparity, along with the possibility of response bias, reflects negatively on the validity and reliability of the Tuckman survey with respect to the study participants.

The dearth of qualitative data about team performance by teams with  $\leq 50\%$  of members in agreement about their Tuckman stage indicates a recommendation for additional guidance in prevented and resolving conflicts among team members. While not all teams indicated evidence of conflict or widely differing opinions in their members' perceptions of their team's development stage, the timing of additional guidance in effective teamwork after the midpoint of the course, when conflicts are more likely to arise, would be beneficial to all teams.

A more careful administration of the Tuckman team development survey is also recommended, in order to address the limitations mentioned earlier. Before the survey is administered, the instructor should brief the participants about the meaning of each team development stage, and then ask them to respond, individually and in writing, to this question: "In which of the four Tuckman development stage(s) is your team currently operating?" These responses should be collected prior to administering the survey. Before the participants complete the survey, the instructor should also ascertain that everyone understands what is being asked, in order to prevent misunderstandings leading to non-authentic responses.

## References

- [1] B. Tuckman, "Developmental sequence in small groups," *Psychological Bulletin.*, vol. 63, no. 6, pp. 384–399, 1965.
- [2] B. Tuckman and M. Jensen, "Stages of small-group development revisited," *Group Organizational Studies*, vol. 2, no. 4, pp. 419–427, 1977.
- [3] J. Wildman, D. Nguyen, N. Duong, and C. Warren, "Student teamwork during COVID-19: challenges, changes, and consequences," *Small Group Research*, vol. 52, no. 2, pp. 119–134, 2021.
- [4] M. Reeves, N. Lang, and P. Carlsson-Szlezak, "Leading your business through the coronavirus crisis," *Harvard Business Review*, vol. 27, pp. 2–7, 2020.
- [5] S. Tannenbaum, A. Traylor, E. Thomas, and E. Salas, "Managing teamwork in the face of pandemic: evidence-based tips," *British Medical Journal Quality and Safety*, vol. 30, pp. 59–63, 2021.
- [6] E. Lutz, A. Aufrichtig, C. Smart, A. Sun, R. Harris, and G. Gianordoli, "A guide for Covid-19 risk in your county," *The coronavirus pandemic*, Feb. 08, 2022.  
<https://www.nytimes.com/interactive/2021/us/covid-risk-map.html> (accessed Feb. 08, 2022).
- [7] L. Zurcher, "Stages of development in poverty program neighborhood action committees," *Journal of Applied. Behavioral Science*, vol. 5, no. 2, pp. 223–258, 1969.
- [8] Catalyst Mediation, "Tuckman's team development stages," *Catalyst Mediation Training*, 2018.  
[https://www.catalystmediation.co.uk/web/datafiles/uploaded/resource/res\\_28\\_Tuckman%27s%20Team%20Development%20%20Stage%20Questionnaire%2018012017.pdf](https://www.catalystmediation.co.uk/web/datafiles/uploaded/resource/res_28_Tuckman%27s%20Team%20Development%20%20Stage%20Questionnaire%2018012017.pdf) (accessed Feb. 03, 2022).