Initial Validity Evidence for a Survey of Skill and Attitude Development on Engineering Teams

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Abstract
This research paper discusses an emerging project that 1) seeks to gather validity evidence for a survey of engineering student teaming attitudes and skill development and 2) identifies what skills and attitudes engineering students develop over time and to what degree. Given teamwork's importance in engineering education and practice, teamwork is essential for engineering students to learn. As we have explored the teamwork literature, we have identified that teamwork, as the discipline has defined it, lacks specificity, thus leaving open the criterion for assessment. This project emerged as an opportunity to both "measure" and precisely define teamwork skills and attitudes. In the summer/fall of 2023, we developed a pilot survey of engineering teaming attitudes and skills and administered it at two mid-Atlantic institutions. Our pilot administration led to a sample size of n=606 with representation across years, discipline, race/ethnicity, gender, socioeconomic background, (dis)ability and neurodivergence identities, military background, and sexual orientation. Our validity work focuses on factors that we have newly adapted to our context or engineering altogether. This paper focuses on exploratory factor analysis. We used parallel analysis to determine the number of factors present across our items, followed by exploratory factor analysis to identify those factors and their makeup. In this paper, we will share our present findings and our future plans.

Keywords: Teamwork, attitudes, skill development, equity, exploratory factor analysis

Introduction

Engineering educators are tasked with teaching their students how to function effectively on teams. This task is encapsulated by ABET Criterion 5 which states that an effective team includes "members [who] together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives" (2023). For the most part, this education in practice consists of combining students into groups and letting them explore teamwork dynamics through self-determination (i.e., figuring it out as they go). This sort of situational, experiential education mimics to some extent what happens in the engineering workplace, where individuals with unique skill sets are tasked with working together to achieve a common goal. However, the outcomes of this educational approach can be highly variable, resulting in students who have either very positive or very negative experiences working together (usually as the result of team conflicts). As a result, we argue that individual students may come away from team experiences with very different individual and collective attitudes about teamwork in general. Further, it is unknown whether engineering education on the whole leaves students with more positive feelings towards teamwork post-graduation than they would have had otherwise. The extent to which students even need to have positive attitudes towards teamwork to function effectively on a team is also an open question. As such, it is of general interest to develop assessment tools that include attitudinal components toward teamwork. The current tools for teamwork assessment, such as CATME (Laughry et al., 2007) tend to focus on the situational evidence of teamwork (i.e. how a student performs in the context of a single teaming experience). However, like all skills, we argue that teamwork is honed over time, and thus it should be possible (and we argue, necessary) to measure quantitatively a student's teamwork attitudes and skills as a function of their experience level.

To date, there are exceedingly few studies (Polly et al., 2018, Farland & Beck, 2019, Wei, Zhou, & Ohland, 2021, Pee & Chue, 2022; to name just a few), that focus on continuous development of teamwork skills, most of which utilize CATME (Laughry et al., 2007) for teamwork assessment. While CATME is an excellent tool for peer evaluation in specific groups, its assessment of teamwork skills is reflexive, and highly situationally dependent (i.e. scores rely explicitly upon the rating information provided by one's peers as a function of that peer group's performance). Thus, it is difficult to detach the individual's skill development from the group's development (or more problematically, their opinions and biases). As such, our focus is on the development of an instrument that can longitudinally track teamwork attitudes and skills independently of any specific team context. Such an instrument must be grounded in specific, and tangible qualities that define the teamwork skill set and the psychosocial constructs that contribute to teamwork attitudes. As we have explored the teamwork literature, we have identified that teamwork, as the discipline has defined it, lacks specificity, thus presenting an opportunity to both "measure" and precisely define teamwork skills and attitudes. This paper presents the initial findings of an exploratory factor analysis (EFA) performed on a unique set of such qualities and constructs, with the goal of narrowing the field of possible factors that may affect engineering teamwork skills and engineering teamwork attitudes.

Positionality Statement

The authors of this paper are both engineering educators with several years of experience teaching team-oriented engineering practices. The first author is an assistant professor of engineering education with two years of post-secondary teaching experience and nearly a dozen in the K-12 sector. The second author is a senior lecturer in chemical engineering with seven years of teaching experience. Both authors identify as cis-, white males, and one author is a member of the LGBTQ+ community; the other author identifies as having a background in poverty and is part of multiple disability communities. Both have observed and have had varied experiences of engineering teamwork in the past, both as educators and as students themselves, and are sensitive to the often overlooked nature of inclusion as an important aspect of teamwork. As such, inclusion forms a major aspect of the frameworks discussed below, with a special emphasis on less-often included factors such as socioeconomic status and neurodivergence.

Teamwork Framework

To develop an instrument of engineering teamwork skills and attitudes, it is necessary to outline the factors/frameworks we operationalize as important facets of these concepts. As a starting point, we utilize the ABET Criterion 5: "an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives." (ABET 2024). In each case below, this criterion is interpreted as a need for students to develop these skills longitudinally as they progress through their engineering programs. It is also hoped that these students are more positively disposed towards these aspects by the end of their education than they were at the beginning. The following section outlines what we consider to be the broad definitions of each concept in ABET Criterion 5, along with particular constructs that we feel exemplify each definition.

What does it mean to provide leadership? Broadly speaking, team leadership can be broken down into six styles (Anderson & Sun, 2017): transformational (i.e., causing changes in social systems), delegative (i.e., a leader delegates tasks to other members to promote autonomy), authoritative

(i.e., single dictator-like leader with all the power), transactional (i.e., exchange of skills, knowledge, and resources amongst leaders and subordinates), participative or democratic leadership (i.e., subordinates provide feedback and influence the process), and servant leadership (i.e., leading from behind in pursuit of a greater good amongst the team; Northouse, 2016). Within the context of engineering teams, some styles are more relevant than others. Three which are of particular importance for engineering students to gain experience with are: participative, servant, and delegative leadership styles. In participative leadership, also known as democratic leadership, each member of the team is involved in the decision-making process (Northouse, 2016). In delegative or laissez-faire leadership, a team leader relies upon the initiative of their individual team members, allowing individual team members to utilize their experiences to get the job done. In servant leadership, a team leader focuses on developing the skills and attributes of their team members, putting their needs first (Northouse, 2016). These three leadership styles are singled out as most-important due to their emphasis on communication, trust, autonomy, and growth mindset (Schell et al, 2019). In contrast, there is a desire to avoid situations where students exhibit overly authoritative or transactional leadership styles, wherein individual contributions to the team are centered around reward-and-punishment and a lack of autonomy.

What contributes to the creation of an inclusive, collaborative environment?

An inclusive environment consists of a highly engaging space wherein there mutual trust, support, and respect for each team member and their personhood (Miller & Katz, 2018). Factors which support trust and respect include the acknowledgement of implicit bias (Isaaac et al., 2023), understanding of microaggressions (Kim & Meister, 2023; Masta et al., 2022), and fostering a sense of belonging through open communication (Sedgwick & Yonge, 2008; Campbell & Klotz, 2021). Non-Cognitive development (Khine & Areepattamannil, 2016) includes factors such as a person's sense of belonging (Hoffman et al., 2002), their engineering identity development (Godwin et al., 2016; Rodriguez et al., 2022), their meaning and purpose, motivation (Schell & Husman, 2008; Kirn & Benson, 2015), mindset (Dweck, 2016), and social skills such as self-control (Maloney et al., 2012), patience (Schnitker, 2012), and mindfulness (Van Dam et al., 2010).

What does it mean to communicate effectively?

Effective communication is one of the cornerstones of effective teamwork (Tenopirr & King, 2004), and consists of both internal communication (i.e., listening and responding to feedback from team members) and organizational communication (i.e., interacting with superiors such as instructors). Effective communication includes verbal and written communication, as well as the ability to collaboratively make decisions and resolve team conflicts, both on internal and organizational levels. Looking outward, it is also very important for teams to be able to disseminate information clearly - both among themselves and to wider audiences.

What does it mean to complete tasks?

The final major aspects of teamwork are the mechanical aspects - i.e. establishing goals, planning and executing tasks and meeting objectives (Shafipour Yourdhahi et al, 2022; Murphy, 2014). Traditionally, these are the primary aspects of focus when assessing teamwork, and for us they represent the skills of teamwork that should be present in order for teamwork to be successful in terms of task completion.

What other factors might it be important to consider?
Teams are made up of individuals with their own attitudes and beliefs. These attitudes and beliefs may impact how they go about engineering and how they might, in turn, be successful (Scheidt et al., 2021). Understanding the individual as a member of the team may be an important way to understand how team development happens.

Purpose and Research Question
The passages above describe our attempt to initially frame teamwork based on the ABET criterion. In this study, we sought to identify whether we could create and gather validity evidence for a survey of skills and attitudes we believe contribute to effective teaming over time per that framework. We thus sought to answer the following research question (RQ): *What initial validity evidence is there for a survey of engineering skills and attitudes that benefit teaming?*

Methods
We sought to develop and administer a pilot survey of engineering skills and attitudes that more accurately portrayed growth in teaming than what is currently available. On the whole, we consider how teamwork development may impact the individual just as much as the collective. That is, we wonder how students develop individually on teams just as much as the team develops. The following sections describe the important components of our study.

Survey Development
We developed a survey that we believe accurately depicts many of the skills and attitudes we described above. Many of the skills and attitudes we chose are also guided by parallel, in-progress qualitative work with students who have described what they feel makes a team experience effective. From these responses, we extracted potential skills and attitudes. We describe included factors further below. Given that this work is a pilot study, we focused mostly on pre-existing items and factors we felt best aligned with our framework. We expect this work will grow in future iterations allowing us to develop new and different items than just those encased in this work.. This survey was built and administered via the platform Qualtrics. Included constructs and our reasoning and described below. Items can be viewed within each construct in Appendix A.

Factors included:
Big5 Personality (15 items)
Big5 is a series of five personality constructs (Openness, Conscientiousness, Extroversion, Agreeableness, and Neuroticism). More aligned personality traits are less likely to have teaming conflicts (Judge et al., 1999), justifying inclusion of the constructs. Our inclusion is also justified by students discussion of team member's personality and cohesion in our parallel, in progress, qualitative work. We included a five-factor, 15-item scale from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students.

Patience (11 items)
Patience in teaming is not covered by the Big5. Patience is important for students to have, given they must deal with difficult situations and difficult teammates. Our inclusion is also justified by students discussion of patience in our parallel qualitative work. We included a three-factor, 11-item scale from Schnitker (2012) which covers interpersonal patience, life hardships patience, and

daily hassles patience. This scale does not yet have evidence of validity with engineering students and is being tested by our study.

Mindfulness (4 items)
Students who are more mindful are more likely to be successful in light of challenges (Brown & Ryan, 2003). We wondered, based on our parallel qualitative work, if mindfulness would hold with teaming experiences. We included a single-factor, 4-item scale from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students.

Mindset (8 items)
Students who have a mindset that is more growth-aligned are more likely to believe that intelligence can be developed rather than stay fixed (Dweck, 2016). We wonder whether this mindset orientation influences teaming conflict and other attitudes. We included a two-factor, 8-item scale from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students. Their later work found these factors might be better represented as a single factor; we tested both.

Meaning & Purpose (3 items)
We wonder, based on our parallel qualitative work, whether students with a stronger sense of thriving are more likely to be successful on a team considering challenges and conflicts. Meaning & Purpose in life is one of many important constructs of thriving considered by Scheidt et al. (2018, 2019) and refers to one's sense they have meaning and purpose to their life long-term (Brown & Ryan, 2003). We included a single-factor, 3-item scale from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students.

Team Gratitude (6 items)
Students with a strong sense of gratitude are more likely to feel capable and supported (Renshaw & Bolognino, 2016). We wondered, based on our parallel qualitative work, if, in a team setting, that gratitude towards one's team may be indicative of feelings of capability and support by one's team. We adapted a single 6-item factor from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students. Items were adapted to refer to one's team and instructor of the team.

Self-Control (8 items)
We wondered whether students with strong perceptions of self-control, specifically that they could manage restraint and impulsivity, worked better on teams (Maloney et al., 2012). We included a two-factor, 8-item scale from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students. The items cover both impulsivity and restraint in self-control.

Leadership (15 items)
Leadership is an essential skill for engineering students. Different forms of leadership fall differently across levels of authoritarian and systemic thinking according to Wielkiewicz (2000). We included a shortened form of their 28-item, two-factor scale that we felt was pertinent to student teaming experiences. Our version was 15 items that we felt should still map onto two factors. We test this two factor scale in this study.

Team Conflict & Contributions (22 items)

Our project, in part, centers around what goes positively and negatively on a team. Conflict and contributions to teaming, in our mind, is representative of teaming outcomes. As such, we included and adapted pre-existing measures of conflict and contributions. These scales, unpublished until now, were first developed and tested unsuccessfully by Kirn & Colleagues at the University of Nevada, Reno (refer to Bridgers project). More about this work can be found in existing literature (Rodriguez-Simmonds et al., 2018; Langus et al., 2018; 2019). There is initial validity evidence for the included items (exploratory factor analysis). We expect to use this work to gather further evidence for the scale's use.

Motivation (22 items)

Students who have stronger motivations are more likely to be successful in many academic contexts (Kirn & Benson, 2015) We wondered whether these motivations might influence their actions with teaming. We included a five-factor, 22-item scale from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students. Items over two motivation frameworks, future time perspective and expectancy-value theory, and help us discern how students' views of their future success drive their actions on teams in the present.

Engineering Identity (12 items)

Like motivation, students with stronger identity beliefs are more likely to be successful in many academic contexts (Godwin et al., 2016), likely because of the interrelatedness of motivation and identity (Godwin & Kirn, 2020). We wondered whether students' perceptions of themselves as engineers, or as someone who can do engineering, influence the dynamics of the engineering team they are on. We included a three-factor, 12-item scale from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students.

Belonging & Faculty Caring (20 items)

Belonging is an essential human need that has been identified as one of the key, if not the most key, predictor of student success (Hoffman et al., 2002). Hoffman et al., (2002) also suggest belonging is highly correlated with Faculty Caring. We wondered whether these two factors, together or alone, could influence teaming – particularly if a student feels less or more like they belong with their peers on and off the team. We included a single-factor 7-item scale of belonging from Scheidt et al. (2018, 2019) that already has strong validity evidence with engineering students. We also included a two-factor 13-item scale of faculty caring that includes both comfort with faculty and empathetic faculty understanding from the same author.

Discrimination (25 items)

Discrimination is an active process that influences belonging in engineering (McGee, 2020). To account for this potential, we adapted and included five items across five different identity-axes (race/ethnicity, gender, sexual orientation, (dis)ability, and socioeconomic status) from Bahnson et al.'s (2022) work on discrimination in engineering graduate student experiences.

Comfort and Team Inclusion (19 items)

We believe feelings of discrimination and differences in belonging are also seen through students' comfort and inclusion on their team. As such, we included items based on these topics. Like others above, these scales are unpublished. The scales were first developed and tested unsuccessfully by

Kirn & Colleagues at the University of Nevada (refer to Bridgers project). More about this work can be found in existing literature (Rodriguez-Simmonds et al., 2018; Langus et al., 2018; 2019). There is initial validity evidence for the included items (exploratory factor analysis). We expect to use this work to gather further evidence for the scale's use.

Survey Administration

We administered the above items as a single survey via Qualtrics to engineering students at two mid-Atlantic institutions. The survey was first sent out to the entire engineering student body at both institutions. Thereafter, the authors organized time with instructors of over two dozen first- through fourth-year courses to allow for students to complete the survey in these courses. All instructors offered participation points or extra credit worth up to 1% of the students' grades. An alternative assignment was available to all students who were concerned about participating. The final list of all participants for both types was sent to instructors to apply grades accordingly in their gradebooks. The entire study was approved by the Institutional Review Board at both involved institutions.

Correlation, Kaiser-Meyer-Olkin, and Bartlett Tests

To prepare for factor analysis, we first checked that all items, per construct, were sufficiently correlated. Specifically, we checked that no items were correlated above 0.9, which could cause issues with (multi)collinearity in factor analysis. After checking correlations, we conducted Kaiser-Meyer-Olkin tests (KMO;1974) to ensure we had enough data for factor analysis for each construct. We conducted this test as a safety net procedure given we already had more than enough data given the sample size of ten per item "rule of thumb" (Nunnally, 1967). Finally, we conducted Bartlett's test (Tobias & Carlson, 1969) to check for sphericity, that is, that no matrix was an identity matrix.

Parallel Analysis

Once we knew that items and data met initial assumptions, we then conducted parallel analysis on each construct to see how many factors were present. We specifically looked at the "elbow" of the plot and used the factor value accordingly to drive our initial exploratory factor analysis.

Exploratory Factor Analysis

Following parallel analysis, we finally conducted exploratory factor analysis (EFA) on each construct and its involved items, ensuring said items had consistent validity evidence with our population. We first tried a promax rotation with each set. In cases where a promax rotation did not work, we instead tried a varimax rotation. We sought a 0.4 cutoff for loadings and a commonality (h2; sum of square factor loadings) value cutoff of 0.3 until the remaining items all met the loading cutoff. We first removed items that did not meet the cutoff, then we removed dual-loading items. Finally, we removed items that did not meet the commonality cutoff. With our final model in place, we finally looked at the Tucker-Lewis Index (TLI) of each factor to be above 0.95 (minimum 0.9) and the Root Mean Square Error of Approximation (RMSEA) to be under 0.08. We used these measures to assess the quality of our models.

Results

A total of n=606 students both completed the survey and passed all attention checks present in the survey. Demographics for this sample are shown in Table 1. Half of the data set, n=303 which we

ensured had the same demographic regularities as the full set, was used for EFA processes outlined above in this study, ensuring we can save the other half for pilot confirmatory work (*in progress).*

Table 1. Demographics of survey sample.

Group		Count	%
Race/Ethnicity			
	American Indian or Alaskan Native	19	3.1
	Asian	73	12.0
	Black	35	5.8
	Biracial/Multiracial	16	2.6
	Hispanic	85	14.0
	International	≤ 5	≤ 1.0
	Middle Eastern or North African	26	4.3
	Hawaiian Islander or Pacific Islander	≤ 5	≤ 1.0
	White	295	48.7
	Another Race	14	2.3
Gender			
	Woman	130	21.5
	Cisgender	52	8.6
	Man	344	56.8
	Transgender	≤ 5	≤ 1.0
	Agender	≤ 5	≤ 1.0
	Another Gender	≤ 5	≤ 1.0
	Non-Binary	6	≤ 1.0
Sexual Orientation			
	Heterosexual/Straight	411	67.8
	Homosexual/Gay/Lesbian	10	1.7
	Bisexual	43	7.1
	Pansexual	15	2.5
	Asexual	≤ 5	≤ 1.0
	Another Sexuality	8	1.3
Identifies with a disability			
	Yes	78	12.9
	No	393	64.9
Identifies as neurodivergent			
	Yes	167	27.6
	No	307	50.7

NOTE: Given opportunity for multi-select, percentages will not add up to 100%.
NOTE: Sample sizes ≤ 5 are redacted to protect our participants.
NOTE: Disability and neurodivergence were collected as broader categorizations but coerced down into Yes/No in this table to protect participants.

Assumptions Testing & Parallel Analysis

All constructs passed our assumptions tested with correlations, KMO, and Bartlett testing meaning our data and their formats were appropriate for factor analysis. Via parallel analysis, all items returned expected factor sizes (refer to item lists in Methods) via parallel analysis plots.

Exploratory Findings

The totality of our findings are shown in Appendix A. While some were shortened, in the end, all factors worked as expected except for the Big 5 personality scale. The Big5 personality scale broke down and its issues could not be rectified. The remainder of this section describes each of the scaled items and their resulting factors and validity evidence.

Big5 Personality

The constructs initially split into 5 factors as expected. However, as items were removed to agree with communality, the factors no longer split as expected (expected constructs). The process was repeated, and failed, with a varimax rotation instead. Further work is needed to determine underlying construct issues impacting the performance of the personality factors.

Patience

Items relating to patience split as expected and resulted in two successful factors with seven total items. First was interpersonal patience (five items), which describes one's patience working with other people ($\alpha = 0.8$). Second was life patience (two items), which describes one's patience with other life events such as traffic or waiting in lines ($\alpha = 0.59$). Interpersonal patience performed much better than life patience, as expected with this population and their age. The final TLI of this model was 0.91 with a RMSEA of 0.09.

Mindfulness

The four mindfulness items loaded onto a single factor (Mindfulness) with strong reliability ($\alpha = 0.81$). The final TLI of this model was 0.97 with a RMSEA of 0.08.

Mindset

All eight mindset items successfully loaded onto two factors with four items each (Fixed and Growth Mindset). Each factor had very strong reliability ($\alpha = 0.86$; $\alpha = 0.9$; respectively). We are aware of confirmatory issues discussed by Scheidt et al. (2019). We did try and test the factor as one and had little luck in an exploratory format. We look forward to confirming these results ourselves. The final TLI of this model was 0.94 with a RMSEA of 0.11.

Meaning & Purpose

The three meaning and purpose items loaded onto a single factor (Meaning & Purpose) with strong reliability ($\alpha = 0.9$). TLI and RMSEA could not be computed for this model given its size.

Team Gratitude

We had high hopes for Team Gratitude and the factor performed well. Across our six items, all items loaded onto a Gratitude Towards Teaming factor with exceptional reliability ($\alpha = 0.91$). The factor describes gratitude towards teammates, instructors, and the experience of teaming. The final TLI of this model was 0.89 with a RMSEA of 0.17.

Self-Control

Five of the eight items loaded onto two factors of self control. The first factor, Impulsivity, had three items load onto it resulting in weaker reliability than other constructs ($\alpha = 0.56$). Opposingly, restraint had two items load onto it with stronger reliability ($\alpha = 0.72$). The final TLI of this model was 1.00 with a RMSEA of 0.00.

Leadership

Leadership performed exceptionally well and resulted in two factors as expected: hierarchical and systemic thinking. Six total items loaded onto hierarchical thinking resulting in strong reliability ($\alpha = 0.87$). Similarly, five total items loaded onto systemic thinking with also exceptional reliability ($\alpha = 0.78$). The final TLI of this model was 0.90 with a RMSEA of 0.07.

Team Conflict

We were unsure how Team Conflict items would load, so our EFA was indeed exploratory. We found that six of the 12 total items loaded onto two factors: Team Frustration and Conflict Resolution. Team Frustration described argument and conflict about the project, particularly related to roles and work. The factor had strong reliability ($\alpha = 0.79$). Second, Conflict Resolution included two opposingly loading factors (one negative and one positive) which described resolution of conflicts by either the team members or the instructor. This second factor had weaker reliability ($\alpha = 0.57$). The final TLI of this model was 0.97 with a RMSEA of 0.06.

Team Contributions

Team Contributions was also exploratory for us. We found that eight of the items loaded successfully across three factors: Team Time Management, Attendance, and Contribution Difficulties. Team Time Management was amongst the strongest factors with strong reliability ($\alpha = 0.83$) containing four of our items. Next was attendance which had stronger reliability ($\alpha = 0.7$), but strange loadings across two items that we expect may break down in confirmatory work. Finally was contribution difficulties which had weaker reliability ($\alpha = 0.59$). We also wonder whether this final factor will break down throughout confirmatory work. The final TLI of this model was 0.93 with a RMSEA of 0.08.

Motivation

Twenty-two of our 23 total motivation items loaded successfully across the five expected constructs: Expectancy, Perceptions of Future, Connectedness, Instrumentality, and Value. Each of these constructions resulted in strong reliability ($\alpha = 0.92$; $\alpha = 0.87$; $\alpha = 0.77$; $\alpha = 0.85$; $\alpha = 0.74$; respectively). The final TLI of this model was 0.93 with a RMSEA of 0.06.

Engineering Identity

Twelve of our 14 total items loaded successfully across the five expected constructs: Performance-Competence, Interest, and Recognition. Each of these constructions resulted in strong reliability ($\alpha = 0.87$; $\alpha = 0.89$; $\alpha = 0.83$; respectively). The final TLI of this model was 0.96 with a RMSEA of 0.06.

Belonging

The seven belongingness items loaded onto a single factor (Belonging) with strong reliability ($\alpha = 0.93$). The final TLI of this model was 0.84 with a RMSEA of 0.22.

Faculty Caring

Eleven of our 13 items loaded successfully across the two expected constructs: Empathetic Faculty Understanding and Comfort With Faculty. Each of these constructions resulted in strong reliability ($\alpha = 0.85$; $\alpha = 0.86$; respectively). The final TLI of this model was 0.94 with a RMSEA of 0.22.

Team Inclusion

Team Inclusion was yet another one of our exploratory factors. Seven of our 14 total team inclusion items loaded onto a single factor, Team Awareness, with strong ($\alpha = 0.86$). The factor describes a student's process of listening to other teammates, being inclusive, and changing attitudes as needed to be a better teammate. The final TLI of this model was 0.80 with a RMSEA of 0.16.

Comfort

Comfort was also an exploratory factor. Of our comfort items, only those three items related to faculty loaded onto a single factor, Faculty Inclusion. The factor has strong reliability ($\alpha = 0.81$). We are interested in confirmatory work to learn whether the factor performs similarly, or is correlated to, the Comfort with Faculty factor above. The final TLI of this model was 0.90 with a RMSEA of 0.14.

Discrimination

Finally, our last exploratory factor, Discrimination, performed better than we expected it might. Of the 25 total items, 22 items loaded across two factors: Faculty Inclusion and Peer Inclusion. These factors both had strong reliability ($\alpha = 0.98$; $\alpha = 0.96$; respectively). Given the repeated nature of the questions across subgroups and the exceptionally high reliability measures, we expect the results of this measure to change in exploratory work. We are also very interested in how peer inclusion relates to team inclusion, and how faculty inclusion relates to both comfort factors described above. The final TLI of this model was 0.66 with a RMSEA of 0.22.

Discussion & Implications

Our study sought to identify what initial validity evidence there is for a survey of teaming skills and attitudes given as a pilot. Of our 17 tested constructs, 16 were found to work appropriately. All items loaded above 0.4, communalities were above 0.3, and resulting reliabilities were appropriate. Observing the TLI and RMSEA of the final models, TLI was met on 11 while RMSEA was met on seven. While concerning at first, we find this okay given Scheidt et al.'s (2018) original work showing that a similar outcome occurred. We expect our models to trim slightly with confirmatory work, especially our exploratory constructs, leading to stronger fit indices.

We are surprised, however, that Big5 did perform as poorly as it did. We expect to test the fit further using EFA as well as confirmatory faculty analysis (CFA) in future work to determine whether what we found was simply a mishap, or whether it is part of a broader issue of confirmatory validity for the personality construct.

In the end, we believe there is strong validity evidence for our survey, pending confirmatory work. The implications of our findings are promising for our work investigating changes to student teamwork skills and attitudes over time. With a working scale (as known so far), we can revisit our student population over the coming years to determine whether the factors hold and whether changes can be observed. We are most interested in students' development of patience, leadership, conflict, contributions, gratitude, inclusion, and comfort, as well as changing perceptions of whether peer and faculty inclusion are maintained. With a better understanding of how these skills and attitudes grow and change over time, we may be able to determine how students' growth in teamwork happens, if at all.

Conclusions & Future Work

Our future work will continue to confirm this work using confirmatory factor analysis. Thereafter, we will seek to identify whether there are relationships between certain attitudes and skills, such as whether certain leadership styles lead to stronger team contributions and conflict, using structural equation modeling. Nascent work describes skills and attitudes related to teaming and their effects on the teaming process. We believe identifying whether these relationships exist is important for identifying the next stages of our work in this space.

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Appendix – Exploratory Factor Analysis Results

Patience	Interpersonal Patience	Life Patience	Uniqueness
How accurately do the following describe you now?; 1 = Very inaccurately ; 7 = Very accurately			
Cronbach's Alpha	**0.8**	**0.59**	
a. My friends would say I'm a very patient friend.	0.455		0.525
b. I am able to wait-out tough times.	0.436		0.669
c. Although they're annoying, I don't get too upset when stuck in traffic jams.		0.703	0.570
d. I am patient with other people.	0.716		0.379
e. I find it pretty easy to be patient with a difficult life problem or illness.			
f. In general, waiting in lines does not bother me.		0.609	0.641
g. I have trouble being patient with my close friends and family.			
h. I am patient during life hardships.			
i. When someone is having difficulty learning something new, I will be able to help them without getting frustrated or annoyed.	0.626		0.690
j. I get very annoyed at red lights.			
k. I find it easy to be patient with people.	0.882		0.325

Mindfulness	Mindfulness		Uniqueness
Indicate how frequently or infrequently you currently have each experience. Please answer according to what really reflects your experience rather than what you think your experience should be. Please treat each item separately from every other item.; 1 = Almost never ; 7 = Almost always			
Cronbach's Alpha	**0.81**		
a. It seems that I am "running on automatic," without much awareness of what I'm doing.	0.800		0.359
b. I rush through activities without being really attentive to them.	0.745		0.446
c. I do jobs or tasks automatically, without being aware of what I'm doing.	0.678		0.541
d. I find myself doing things without paying attention.	0.646		0.583

Mindset	Fixed Mindset	Growth Mindset	Uniqueness
Please answer the following with the answer that best describes you.; 1 = Strongly disagree ; 7 = Strongly agree			
Cronbach's Alpha	**0.86**	**0.9**	
a. I don't think I personally can do much to increase my intelligence.		0.404	0.476
b. Regardless of my current intelligence level, I think I have the capacity to change it quite a bit.	0.662		0.528
c. I can learn new things, but I don't have the ability to change my basic intelligence.		0.648	0.512
d. With enough time and effort I think I could significantly improve my intelligence level.	0.789		0.177
e. My intelligence is something about me that I personally can't change very much.		0.961	0.226
f. I believe I can always substantially improve on my intelligence.	0.968		0.165
g. I believe I have the ability to change my basic intelligence level considerably over time.	0.788		0.304
h. To be honest, I don't think I can really change how intelligent I am.		0.591	0.277

Self-Control	Impulsivity	Restraint	Uniqueness
To what extent do you agree or disagree with the following statements: ; 1 = Strongly disagree ; 7 = Strongly agree	**0.56**	**0.72**	
Cronbach's Alpha			
a. I do certain things that are bad for me, if they are fun.		0.636	0.665
b. Pleasure and fun sometimes keep me from getting work done.		0.591	0.529
c. Sometimes I can't stop myself from doing something, even if I know it is wrong.			
d. I often act without thinking through all the alternatives.			
e. I am good at resisting temptation.			
f. I have a hard time breaking bad habits.	0.508		0.458
g. I wish I had more self-discipline.	0.926		0.326
h. People would say that I have very strong self-discipline.	-0.469		0.695

Leadership	Hierarchical Thinking	Systemic Thinking	Uniqueness
Please indicate your level of agreement with the following statements regarding leadership and teams. ; 1 = Strongly disagree ; 7 = Strongly agree	**0.87**	**0.78**	
Cronbach's Alpha			
a. Individuals need to take initiative to help their team accomplish its goals	0.723		0.494
b. Leaders should encourage innovation	0.762		0.434
c. Leadership involves the participation of all team members	0.736		0.454
d. Leadership activities should foster discussions about the future of the team and project	0.786		0.386
e. An effective leader develops members of the team	0.708		0.471
f. Good leadership requires that ethical issues have high priority	0.605		0.630
g. A leader must control the team		0.543	0.696
h. A leader should take charge of the team.		0.663	0.468
i. The main task of a leader is to make the important decisions for the team		0.739	0.465
j. The main task of a leader is to make and then communicate decisions		0.645	0.593
k. It is important that a single leader emerges in a team		0.609	0.648
l. The most important members of a team are its leaders			
m. When a team is in danger of failing in its objectives, new leaders are needed to fix its problems			
n. Leaders are responsible for the well-being of team members			
o. Leaders are solely responsible for making sure everyone feels included on a team			

Team Conflict	Team Frustration	Conflict Resolution	Uniqueness
Please indicate how frequently you have thought or experienced the following on project teams:; 1 = Not at all; 7 = Frequently	**0.79**	**0.57**	
Cronbach's Alpha			
a. If given the choice, I would choose to work alone			
b. It is better to work with your friends than it is to work with strangers			
c. I feel tense when I work on a team			
d. Members argue	0.653		0.556
e. Members disagree about our work	0.869		0.243
f. Members have conflicting ideas about the project	0.775		0.400
g. Members leave meetings angry		0.653	0.438
h. Members successfully resolve conflicts		-0.672	0.537
i. Instructors intervene to resolve conflicts			
j. Members disagree about the distribution of roles in team projects	0.480		0.612
k. Members agree on who should complete certain project tasks			
l. Members struggle with time management as it pertains to certain tasks			

Team Contribution	Team Time Management	Attendance	Contribution Difficulties	Uniqueness
Please respond to the following items to the best of your ability.; 1 = Not at all true of me; 7 = Very true of me	**0.83**	**0.7**	**0.59**	
Cronbach's Alpha				
a. I rarely find time to review my team's work prior to submitting it.				
b. My team meets where we can concentrate on our group's activities.	0.624			0.540
c. I make good use of my time with teammates.	0.758			0.377
d. My team makes good use of our time.	0.864			0.240
e. I make sure I keep up with weekly team project deliverables.	0.593			0.485
f. I find it hard to stick to my team's schedule.			0.567	0.601
g. I often find that I don't contribute enough to my team because of other coursework or commitments.			0.691	0.507
h. I attend class regularly.		0.492		0.670
i. I attend team meetings regularly.		0.981		0.003
j. I generally find it easy to make and execute plans in a group environment.				

Meaning & Purpose	Meaning & Purpose	Uniqueness
We would like to know about how you perceive yourself in terms of your perceived experiences. Please indicate your agreement or disagreement with each of the following statements using the scale below:; 1 = Strongly disagree ; 7 = Strongly agree	**0.9**	
Cronbach's Alpha		
a. My life has a clear sense of purpose	0.866	0.251
b. I have found a satisfactory meaning in life	0.878	0.230
c. I know what gives meaning to my life	0.859	0.262

Team Gratitude	Gratitude Towards Teaming	Uniqueness
Please answer the following with the answer that best describes you.; 1 = Strongly disagree ; 7 = Strongly agree		
Cronbach's Alpha	**0.91**	
a. I appreciate the opportunity to engage in teamwork experiences at school	0.764	0.416
b. I appreciate the things I have learned in my team-based college experiences	0.790	0.377
c. I am grateful for my team-mates	0.829	0.312
d. I feel grateful to my professor(s) for guiding my team through our learning experience	0.806	0.351
e. I feel thankful to my professor(s) for putting me and my teammates together	0.811	0.343
f. I appreciate the project my professor(s) gave me and my teammates	0.776	0.397

Motivation	Expectancy	Perceptions of Future	Connectedness	Instrumentality	Value	Uniqueness
The following questions relate to your attitudes and beliefs about your experiences in engineering classes and in your engineering major. Please rate your agreement for each item.; 1 = Strongly disagree ; 7 = Strongly agree						
Cronbach's Alpha	**0.92**	**0.87**	**0.77**	**0.85**	**0.74**	
a. I will use the information I learn in my engineering classes in other classes I will take in the future.				0.678		0.487
b. I am confident about my choice of major.		0.720				0.392
c. Engineering is the most rewarding future career I can imagine for myself.		0.674				0.390
d. My interest in an engineering major outweighs any disadvantages I can think of.		0.806				0.316
e. I want to be an engineer.		0.698				0.371
f. I will use the information I learn in engineering classes in the future.				0.862		0.196
g. What I learn in my engineering classes will be important for my future occupational success.				0.716		0.342
h. I do not connect my future career to what I am learning in my engineering classes.						
i. My future career determines what is important in my engineering classes.						
j. I expect to do well in my engineering classes.	0.760					0.458
k. I am certain I can master the skills being taught in my engineering classes.	0.716					0.361
l. I believe I will receive an excellent grade in my engineering classes.	0.966					0.151
m. I am confident I can do an excellent job on the assignments in my engineering classes.	0.894					0.176
n. Considering the difficulty of my engineering classes, the teacher, and my skills, I think I will do well in my engineering classes.	0.812					0.288
o. It is better to be considered a success at the end of one's life than to be considered a success today.					0.444	0.767
p. The most important thing in life is how one feels in the long run.					0.499	0.684
q. It is more important to save for the future than to buy what one wants today.					0.653	0.571
r. Long range goals are more important than short range goals.					0.651	0.585
s. What happens in the long run is more important than how one feels right now.					0.804	0.387
t. I don't think much about the future.			0.616			0.595
u. I don't like to plan for the future.			0.717			0.488

v. It's not really important to have future goals for where one wants to be in five to ten years.	0.617	0.604
w. One shouldn't think too much about the future.	0.588	0.611
x. Planning for the future is a waste of time.	0.655	0.536

Engineering Identity	Performance-Competence	Interest	Recognition	Uniqueness
To what extent do you agree or disagree with the following statements:; 1 = Strongly disagree ; 7 = Strongly agree				
Cronbach's Alpha	**0.87**	**0.89**	**0.83**	
e. I see myself as an engineer			0.477	0.500
f. My parents see me as an engineer			0.709	0.545
g. My instructors see me as an engineer			0.847	0.319
h. My peers see me as an engineer			0.835	0.325
i. I have had experiences in which I was recognized as an engineer				
j. I am interested in learning more about engineering		0.851		0.386
k. I enjoy learning engineering		0.942		0.167
l. I find fulfillment in doing engineering		0.776		0.214
m. I am confident that I can understand engineering in class	0.742			0.254
n. If you are reading this statement select two				
o. I am confident that I can understand engineering outside of class	0.614			0.394
p. I can do well on exams in engineering	0.988			0.318
q. I understand concepts I have studied in engineering				
r. Others ask me for help in engineering	0.580			0.562
s. I can overcome setbacks in engineering	0.671			0.431

Belonging	Belonging	Uniqueness
We would like to know about how you feel that you fit in engineering and belong in your engineering community.; 1 = Not at all ; 7 = Very much so		
Cronbach's Alpha	**0.93**	
a. I feel comfortable in engineering.	0.864	0.253
b. I feel I belong in engineering.	0.873	0.237
c. I enjoy being in engineering.	0.796	0.366
d. I feel comfortable in my engineering classes.	0.840	0.294
e. I feel supported in my engineering classes.	0.756	0.428
f. I feel that I am part of my engineering classes.	0.849	0.279
g. I feel that my engineering classes are large.		

Faculty Caring	Empathetic Faculty Understanding	Comfort with Faculty	Uniqueness
To what extent do you agree or disagree with the following statements:; 1 = Strongly disagree ; 7 = Strongly agree			
Cronbach's Alpha	**0.85**	**0.86**	
a. I feel comfortable asking a faculty member for help with a personal problem.			
b. Faculty connect relevant topics to my major.	0.443		0.602
c. I feel that a faculty member would be sensitive to my difficulties if I shared them.	0.416		0.828
d. I see faculty members as role models.	0.742		0.471
e. I feel comfortable socializing with a faculty member outside of class.		0.440	0.500
f. I feel comfortable asking a faculty member for help if I do not understand course-related material.		0.852	0.382
g. I feel comfortable seeking help from a faculty member before or after class.			
h. I feel comfortable talking about a problem with faculty.		0.857	0.309
i. I feel that a faculty member would take the time to talk to me if I needed help.	0.45		0.460
j. If I had a reason, I would feel comfortable seeking help from a faculty member outside of class time (i.e., during office hours, etc.)		0.794	0.341
k. I know faculty who are like me.	0.484		0.634
l. I feel that a faculty member would be sympathetic if I was upset.	0.743		0.495
m. I feel that a faculty member really tried to understand my problem when I talked about it.	0.858		0.364

Team Inclusion	Team Awareness	Uniqueness
To what extent do you agree or disagree with the following statements:; 1 = Strongly disagree ; 7 = Strongly agree		
Cronbach's Alpha	**0.86**	
a. I believe team member job assignments should rotate regularly and equally.		
b. I am willing to adjust my problem solving practices to accommodate others.		
c. I experience frustration working with individuals who look different than I do.		
d. I experience frustration working with individuals who behave differently than I do.		
e. It is important to listen to the opinions of one's teammates.	0.753	0.433
f. Teams are made stronger by having multiple opinions or viewpoints.	0.668	0.554
g. Assigning roles on a team should be a collaborative decision.	0.674	0.545
h. I actively try to make sure everyone on the team feels included in team decisions.	0.748	0.440
i. A person's identity (of any kind) should have no bearing on their ability to function on a team.		
j. A person's identity (of any kind) should have no bearing on what ROLE they hold on a team.		
k. I'm confident I can adjust my behaviors to be more inclusive of my teammates.	0.669	0.553
l. I take meaningful time to reflect on my behaviors.	0.622	0.613
m. I try my best to be aware of the effects my words or actions have on my teammates.	0.702	0.507
n. I have had team experiences where I have had to change my behavior to be more inclusive.		

Comfort	Faculty Inclusion	Uniqueness
To what extent do you agree or disagree with the following statements in regards to your experiences in engineering:; 1 = Strongly disagree ; 7 = Strongly agree	**0.81**	
Cronbach's Alpha		
a. I am comfortable discussing engineering or technical topics with my peers.		
b. I am comfortable discussing personal topics with my peers.		
c. In class, faculty answer my questions with respect.	0.637	0.594
d. In class, all faculty treat students equally.	0.901	0.189
e. In class, faculty never talk down to students.	0.757	0.427

Discrimination	Faculty Inclusion	Peer Inclusion	Uniqueness
To what extent do you agree or disagree with the following statements in regards to your experiences in engineering:; 1 = Strongly disagree ; 7 = Strongly agree	**0.98**	**0.96**	
Cronbach's Alpha			
Race/Ethnicity - a. In my experience, my peers treat students of different _____ the same.		0.804	0.316
Race/Ethnicity - b. My peers respect students from different _____ the same.		0.75	0.300
Race/Ethnicity - c. In class, all faculty are respectful of different _____	0.629		0.310
Race/Ethnicity - d. In my experience, faculty treat students from different _____ the same.	0.749		0.255
Race/Ethnicity - e. Faculty respect students from different _____ the same.	0.986		0.132
Gender Identity - a. In my experience, my peers treat students of different _____ the same.		0.858	0.325
Gender Identity - b. My peers respect students from different _____ the same.		0.817	0.341
Gender Identity - c. In class, all faculty are respectful of different _____	0.789		0.226
Gender Identity - d. In my experience, faculty treat students from different _____ the same.	0.923		0.176
Gender Identity - e. Faculty respect students from different _____ the same.	0.954		0.162
Sexual Orientation - a. In my experience, my peers treat students of different _____ the same.		0.879	0.262
Sexual Orientation - b. My peers respect students from different _____ the same.		0.845	0.292
Sexual Orientation - c. In class, all faculty are respectful of different _____	0.822		0.218
Sexual Orientation - d. In my experience, faculty treat students from different _____ the same.			
Sexual Orientation - e. Faculty respect students from different _____ the same.	0.985		0.116
(Dis)ability - a. In my experience, my peers treat students of different _____ the same.		0.831	0.322
(Dis)ability - b. My peers respect students from different _____ the same.		0.817	0.333
(Dis)ability - c. In class, all faculty are respectful of different _____	0.792		0.278
(Dis)ability - d. In my experience, faculty treat students from different _____ the same.	0.922		0.231
(Dis)ability - e. Faculty respect students from different _____ the same.	0.950		0.140
Socieconomic Status - a. In my experience, my peers treat students of different _____ the same.		0.870	0.303
Socieconomic Status - b. My peers respect students from different _____ the same.		0.764	0.321
Socieconomic Status - c. In class, all faculty are respectful of different _____			

Socieconomic Status - d. In my experience, faculty treat students from different _____ the same. Socieconomic Status - e. Faculty respect students from different _____ the same.	0.813	0.351