

## Supporting Equitable Team Experiences Using Tandem, an Online Assessment and Learning Tool

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## **Supporting Equitable Team Experiences using Tandem, an Online Assessment and Learning Tool**

This paper provides an overview of the design and implementation of an educational tool, Tandem, designed to support student teams. As attendees will know, teamwork pedagogy has the potential to be incredibly powerful, increasing student motivation and providing a more authentic context for the learning of core professional skills associated with engineering, such as communication and teamwork. However, attendees will also be familiar with research findings of both explicit sexism and racism as well as more systemic patterns in how identity shapes experiences in engineering, perhaps especially in teamwork. This paper discusses the tool itself, our goals for its further development, and ethical questions we have encountered while working to help design this teamwork support tool to detect and push back against systemic inequities in teamwork experiences.

### **Background**

Teamwork pedagogy is common in engineering courses, especially in first year (cornerstone) and senior year (capstone) design courses, but also across the curriculum. Faculty have multiple goals for teaching using teams, including improving students' teamwork skills as a core engineering competency as well as pedagogical goals like increased learning and motivation. However, in our goal to create inclusive classrooms, we realized that students' experiences in teams were a space with enormous potential for harm [e.g., 1]. Studies of teamwork find gender effects on teamwork satisfaction [2], talk time and conversational roles in teams [3, 4], perceptions of voice safety [5,6] and task allocation [7-10]. We are aware of fewer studies investigating how race/ethnicity affects student team experiences in undergraduate engineering, but Cross and Paretto [11] find African American men report feeling hypervisible on their teams, needing to disprove negative stereotypes, and feeling less likely to develop close friendships with teammates. Cohen and Garcia [12] note that African American students are at heightened risk of receiving disconfirming messages regarding whether they belong in academic spaces.

In response to these inequities in students' teamwork experiences and to create a more inclusive classroom, in a scholarship of teaching and learning (SoTL) approach [13], we began collecting student information throughout a team-based design project to better understand potentially fraught experiences (e.g., to what extent did you feel your ideas were heard and taken seriously in the team meeting?) as well as relating that information to more typical peer and self-assessments.

Recognizing that power is unevenly distributed within teams, and wanting to forward a more socially just classroom, we added critical readings highlighting ways that power and privilege influence student teams and team-based design, as well as short reflections asking students to apply such lenses to their teamwork experiences, following emancipatory pedagogy suggestions of Freire [14], hooks [15], and others. For example, we assigned a reading on group conversational characteristics, which led to a number of interesting reflections from some students about how much they enjoy "ritual opposition" (a method of testing ideas by tearing them down, which Tannen [16] claims is common amongst men) and from other students about how those same interactions make them feel unsafe and silenced. Most reflections indicated

students realize that neither conversational pattern is inherently “right” and that they would be more aware of how teammates might be experiencing team conversations going forward.

Recognizing that rich information existed as artifacts of this pedagogy but in multiple spaces (reflections were housed as text entries in our learning management system, Canvas; peer and self evaluations were housed in one common peer assessment tool, the Comprehensive Assessment of Team Member Effectiveness [CATME] and later in Qualtrics; surveys were housed in Qualtrics), we proposed a teamwork support tool to the Center for Academic Innovation (CAI) at our institution. Collecting rich teamwork information in a single tool allows for the application of learning analytics methods to better understand patterns of oppression and privilege in teamwork. Our vision incorporated self- and peer-assessment, formative feedback on teamwork patterns, and tailored readings and reflections on teamwork experiences; we were informed by ideas of experiential learning, emancipatory pedagogy, and our own understandings of marginalization in engineering student teamwork.

Importantly, the tool is built with the presumption that participation in a team is inherently a social and subjective experience. There is no such thing as objectivity, and there are many successful strategies for collaborative success. The tool has a goal to detect systemic inequities and to raise awareness, both for participants in teams and for faculty supporting teams. We recognize that we are attempting to address a wicked problem, and our goal is to build a technological tool that takes social justice concerns seriously.

### **Tandem, current state**

With partners in our Center for Academic Innovation, this system of surveys, targeted readings, and reflections from a single first year engineering course was modified to be more applicable to many contexts, and it is now in use by >1500 students engaged in teamwork at our institution this semester. The tool aims to support faculty in supporting teams and individuals with equitable team experiences; it also enables faculty to weave social justice into the core curriculum. While explicitly a tool for promoting equity in teamwork, it also facilitates supporting teams at scale (helping faculty see which teams are struggling most and where to put their limited resources).

The Center for Academic Innovation provides the infrastructure to make audacious ideas into reality. Specifically, we have worked with expert software developers, behavioral scientists, user-experience specialists, graphic designers, and educational researchers to develop the tool. Important changes from our initial vision included significant simplification of surveys (based on appropriate usability concerns) and replacement of external readings with custom, personalized and shorter messages. Honestly, this last negotiation is a significant source of tension for the decision-making team, as some of us are most interested in incorporating validated scales of a number of important engineering and teamwork characteristics and experiences (e.g., goal orientation, engineering identity, belongingness) and others are interested in balancing such goals with legitimate concerns of survey fatigue.

In Fall 2018, we piloted portions of the tool in our own introductory engineering class (~60 students). In Winter 2019, Tandem’s alpha-version launched, again for only our first year course (~60 students). The Center for Academic Innovation expands access each semester in ways to intentionally stretch the tool as a way of pushing development of features (for example, in Fall

2019 it was supported in two other classes, one large enrollment [~650 students] and one a graduate-level studio course). It now is in use by about 1500 students in about 15 courses, and our goal is to continue to expand.

Expansion, of course, introduces new questions and opportunities. Behavioral scientists at the Center for Academic Innovation have conducted discovery cycles as new courses are added. Because our goal is that this tool intentionally supports equitable teamwork, user discovery has included conversations with university Diversity, Equity, and Inclusion (DEI) Officers as well as student alumni of target courses. To date, the team-related DEI-related issues we have identified in other disciplines and other courses have aligned closely with those we anticipated based on the literature and on our experiences in undergraduate engineering classrooms.

Students interact with Tandem in three formats: surveys, team checks (typically weekly but can be at other instructor-defined cadence), and lessons. Other institutional information, such as demographic information, GPA, or concurrent course load, can be gathered via institution datasets.

**Surveys.** Some of Tandem’s surveys perform similar functions to other team assessment tools. While our goal is to minimize changes over time, so that student responses from earlier semesters can be combined with current data, these items are currently still being iterated. Tandem’s surveys include:

- A **“beginning of term” survey** (before students have met their teams) that asks about individual characteristics relevant in teamwork literature, such as personality characteristics, as well as about teamwork preferences and previous teamwork experiences. Items probe, among other topics, goal orientation, perceived belongingness at the course level, and logistics such as preferred availability for out-of-class teamwork.
- An **“early check” survey** (administered after one or two team meetings) that asks students to rate themselves and their teammates on a variety of behaviors. This survey is designed to understand students’ initial perceptions of each other as well as to detect imbalances in power and communication concerns, such as students who do not feel their ideas will be valued by teammates. Items probe, among other topics, perceived voice safety and perceived voice enactment.
- A **“mid-project” assessment** (which can be administered multiple times during a semester as desired) that asks students to rate themselves and their teammates on a variety of behaviors. Behaviors are chunked into “contributions to the team work product” and “pro-teamwork behaviors” such as listening to teammates and contributing ideas. This survey also includes open-ended feedback on self and teammates, including what each should be most proud of and what each should work on.
- An **“end of project” assessment** that asks students to rate themselves and their teammates on a variety of behaviors, again chunked as above. This survey also includes open-ended feedback on self and teammates, again including what each should be most proud of and what each should work on. Finally, this survey also repeats items from the beginning survey, including teamwork preferences, engineering identity, and perceived belongingness in class, to understand how students’ teamwork skills and attitudes might have changed as well as how their teamwork experiences might be related to changes in engineering affect over the semester.

**Team checks.** To get more frequent indicators of overall team health, team checks are provided weekly to students by default; they are designed to be mobile friendly and fast. Team checks ask students to **rate the team overall on five items** (overall “working well,” “sharing of work,” “sharing of ideas,” “team confidence,” and “logistics/challenges.”) If a student rates any of those lower than the midpoint, they see a second page with some boxes that can be checked (if particular common problems apply) as well as an optional text-entry space to alert instructors regarding issues the team is facing.

**Lessons.** Because Tandem is designed as a formative feedback system, much thought went into the creation of information that is presented to students. These replace the external readings and reflections described above, and they prompt reflections as part of each lesson. Instructors can determine how many to use (with a few exceptions explained below) and whether to require or incentivize them. In our own first year engineering context, teamwork is an explicit and formal learning goal; we require Tandem lessons and they total to about 10% of a students’ grade.

A few “lessons” are required for every context that uses Tandem; these include reflections that provide students’ own and aggregated peer responses to mid-project and end of project assessments (i.e., students see bar graphs showing how they rated themselves and how others rated them, as well as text, tailored based on score [high/middle/low] and relationship between self-rating and received ratings). Students are prompted to use these “lessons” as formative assessment, highlighting for them their current strengths as team members as well as encouraging them to work on areas their teammates or they suggest they are weaker.

All other lessons can be selected and assigned (or not) by faculty. Faculty can assign by week (e.g., all students see a lesson on Imposter syndrome in week 4) or by the system (e.g., all students see a lesson in week 4; the system prioritizes which is displayed to each team based on an algorithm that uses information provided in the weekly team checks and students’ beginning surveys. For example, a team that marks low scores on “sharing the workload” might see a lesson on dividing up tasks fairly and efficiently; a team with a member who marked low scores on “expecting to fit in” and “having relevant skills” on the beginning survey might see a lesson on Imposter syndrome, with slight variations for people Tandem categorizes as likely experiencing Imposter syndrome and for people Tandem categorizes as teammates-of-someone having this experience.)

Lessons are also tailored to individuals. That is, while all students might see a lesson on dividing up tasks fairly and efficiently, students who indicated high confidence in a number of relevant skills would see messaging on how they might serve as a teacher or mentor to teammates and how this will help them as well as the team. Students who indicated low relevant skills and a fear of not belonging might see a message on building their “tool kit,” some reminders that others may project confidence based on an unwillingness to be vulnerable rather than on their supreme relevant knowledge, and information on resources (both within the team and through the instructional team).

Lessons include reflection prompts, many asking students to comment on intended actions moving forward (based on behavioral interviewing strategies [17]). Some lessons also include

more specific close-ended items, such as rating of particular conversational characteristics in the lesson on group communication. Finally, lessons all include rating items at the end asking students how relevant this lesson was for them at this point in the teamwork process, and how useful the ideas in the lesson were for them. We are now in our fourth semester of this tool, with iteration built into the process. This feedback lets us prioritize revisiting of algorithms used to assign lessons as well as revise lesson content.

**Data and algorithms.** Most importantly for this write-up, Tandem is envisioned as a tool to assist our institution and classrooms in our goals of inclusive teaching and promoting diversity, equity, and inclusion goals across the College of Engineering. Tandem’s messaging often includes gentle equity nudges such as reminding teams to make space for quieter voices, and it sometimes includes more explicit diversity, equity, and inclusion (DEI)-related messaging, such as messaging regarding how more diverse groups make better decisions. Tailored messaging within lessons makes use of information from the initial survey (BoT) and other identity information.

Going forward, we hope to incorporate DEI goals into some of Tandem’s “decision-making” algorithms. For example, Tandem alerts faculty when teams might be “approaching trouble;” teams with a stranded person of a minoritized gender or race can be categorized as one to watch with a different threshold of student responses, based on literature suggesting faculty should avoid isolating a woman or a student of color on an engineering student team [18]. Teams are assigned messaging based on student responses to the beginning of term survey as well as to the weekly team checks. Teams with an isolated, minoritized individual might be assigned a lower threshold on the survey item “everyone contributes ideas equally” to trigger the “group communication” message, based on research involving voice safety and the difficulty for some women and students of color in feeling safe speaking up in a group [19]. Based on the minority voice literature [6], teams can be pointed to group strategies that can make distribution of speaking time and power more equitable.

However, all of Tandem’s current algorithms must currently be pre-determined by its developers. That is, Tandem is not (yet) responsive to systemic inequities evidenced by the data. While a goal is to use machine learning to better understand patterns of marginalization in teams, that goal is still somewhat far off. Eventually, though, we hope the tool can be used to predict outcomes for individuals and for teams, and to detect patterns of advantage and disadvantage. Machine learning will enable the tool to illuminate patterns that have escaped human researchers; only by understanding patterns of marginalization can we hope to mitigate them.

The faculty interface of Tandem is evolving and will look different by the time people are reading this description/ seeing a conference presentation. It is designed to provide on the landing page an overview of the course, with a summary of team check data from all of a course’s teams on the front page, a box highlighting patterns across the class, and a set of teams and individuals sorted by the tool as “approaching trouble” based on team check data. Faculty can click on teams or individuals to drill down and better understand specific experiences. This summer, we intend to add additional instructor-facing documentation, highlighting common patterns of team dysfunction as well as possible strategies instructors might use to disrupt such trajectories.

### **Tandem, goals**

While Tandem's algorithms and messaging can detect and respond to known patterns of marginalization in teams, we are excited at potential opportunities Tandem allows to move the understanding of student teamwork further. Tandem is a research tool, allowing large-N studies with the richness of many qualitative data sets. Learning analytics methods can be employed on Tandem data to better illuminate the experiences of students, who are embedded on teams, which are embedded in courses, which are embedded in contexts. As Tandem expands, its large dataset of actual learners engaged in authentic team experiences enables studies that are otherwise difficult or impossible. The large size of the dataset is important for studies that desire to better understand experiences of groups that are very underrepresented, for example, as well as for studies intending to better consider intersectional experiences.

Tandem is still in "draft form;" we meet biweekly with representatives from development, behavioral science, and User Interface teams at the Center for Academic Innovation to prioritize next steps. We hope to continue to push Tandem to better detect inequitable experiences and to better support students and faculty, with the dual goals of improving student team experiences in the specific team context using Tandem as well as assisting students in forming strategies to push back against inequities, which they might use in this specific context but also that they can transfer to new contexts.

### **Ethical issues in the design of this EdTech**

There are a number of important ethical issues that we have grappled with, and continue to, in the design of this tool.

**(In)equitable assessment.** Often, when educational technology is viewed through an equity lens, the goal is in modifying an assessment so that it does not yield systemic differences by identity groups such as gender and race. In many ways, that is a noble goal. Faculty often use peer assessment as a mechanism for assessing effort and contributions on group projects, and this information may then be used to affect student grades. Therefore, it would be problematic to find systematic differences based on identity.

However, it is also important to realize that race and gender still affect students' options and experiences in our world. An assessment can be built to ask questions that uncover these differences, or to leave them covered in the name of equity. We have selected the first path, while recognizing that this is an ethical choice that we need to continue to explore. It is our belief that calling attention to systemic inequities, while providing faculty and students with strategies and scripts for pushing back, is a step in the right direction. Critically, Tandem needs to provide faculty with recommendations guiding attention to these important concerns.

**Collecting and using demographic data.** Tandem currently includes a few demographic questions at the end of the Beginning-of-Term survey (which was a surprise to the first author, who thought she remembered we had decided to exclude these items). Our logic for initially excluding them was the same as the reason demographic items are usually at the end of other surveys: by asking respondents about demographics, we are priming those characteristics. Respondents are no longer answering just as "themselves," but as a gender, and race/ethnicity,

etc. We worry that, by asking students to think about their demographic characteristics as they answer this initial survey about their goals, expectations, and concerns for teamwork, we are emphasizing for them that they are not just a student on a team, but a woman or a White person, etc.

Interestingly, the demographic items were added to the end of the BoT survey because it is unclear whether our institution's rules allow us to use institutional data like race or gender to affect student educational experiences. This rule makes sense: we would be concerned if our institution designed a specific course for members of specific identity groups, for example. However, this rule also suggests, then, that we need to ask students to disclose demographic information again, in this specific context, in order to use it to make decisions like not-stranding women on a team. We are in ongoing discussions with our institutional review board and data stewards regarding appropriate ways to proceed in this case.

**Design team.** The three faculty members from the College of Engineering who initially proposed the tool all identify as middle class, cis-gender White women. Many of our collaborators at the Center for Academic Innovation also share this identity. We recognize that our understanding of marginalization on student teams is likely especially sensitive to particular experiences and ignorant of others. While our CAI partners have been excellent at convening discussions with diverse stakeholders and user groups, it is important that we do better going forward at making sure the folks “at the table” are more representative of the users of this tool.

**Using algorithms.** As Ruha Benjamin [18] and others have noted, “big data” has the potential to uncover and dismantle systemically-oppressive barriers as well as to instead reinforce them (Benjamin terms this “the new Jim Code”). It is imperative that we continually examine algorithms, especially any “discovered” via machine learning. A diverse group of critical faculty must make careful choices behind any defaults in Tandem, and the messaging surrounding these choices (both for faculty and for students) must be carefully considered. As in the previous paragraph, while the decision-makers have taken this responsibility seriously, we intend to formalize this process and intentionally widen the group of decision makers going forward.

## **Conclusion**

We are excited at the opportunity to present a fairly early version of our tool and to get feedback from a group of critical educators. We hope that conversations at ASEE and especially following via the online discussion board will help shape the tool in pedagogically useful and socially just ways with the goal of making engineering education more explicitly inclusive.

Our ultimate goal is to create a tool that guides students through teamwork experiences, thoughtfully highlighting inequities and barriers and actively instructing the whole team in how to push back against barriers and allow each team member to enthusiastically participate on the team.



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