



Understanding and Optimizing Group Dynamics in Case-Based Collaborative Learning: An Educational Quality Improvement Project

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Understanding and Optimizing Group Dynamics in Case-Based Collaborative Learning:
An Educational Quality Improvement Project

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ABSTRACT

Medical educators are increasingly searching for instructional formats that can best prepare their students for the demands of practicing in the team-based modern healthcare system. One novel approach is case-based collaborative learning (CBCL), which Harvard Medical School incorporated into its preclinical curriculum in 2015. While students overwhelmingly embrace the format as stimulating and thought-provoking, some students report that negative social dynamics among group members can adversely impact their experience.

This mixed methods study first characterizes individual students' experiences in CBCL and the social dynamics that arise in their groups. Second, we examined the impact of an intervention intended to improve the learning environment. For this purpose, we assessed the utility of the Team Performance Survey (TPS), a questionnaire validated in other team-based learning contexts, as a diagnostic tool to discriminate groups that perform well from those that may benefit from support.

We collected data from two consecutive cohorts of first-year students, including free response comments on perceived areas of strength or areas for improvement in their CBCL groups and associated TPS scores. Free responses were inductively coded and thematically analyzed to yield a conceptual model portraying functional CBCL group processes. We stratified free response data across different TPS thresholds to distinguish group performance categories. The intervention allowed students to discuss their experiences with their group mates and develop shared norms going forward. We then analyzed TPS scores and free responses after students had undergone the intervention. Individual responses were aggregated to characterize group profiles.

The free responses indicated that students are keenly aware of interactions and processes that do and do not work well for their groups. The resulting model of CBCL group work encompasses both objective behaviors as well as subjective elements of the social environment. The TPS can help identify groups that are experiencing dysfunction. The intervention was well accepted by students and resulted in a significant increase in TPS scores and an improvement in group profiles.

This work demonstrates that CBCL groups can function as interdependent learning teams, but students may benefit from support to ensure they form teams rapidly and reliably. We recommend that interventions addressing group dynamics should be considered a critical supplement for regular CBCL classroom activities. Subsequent work will explore the impact of a more extensive supplement in the form of a year-long curriculum designed to further optimize the learning environment and develop students' interpersonal and communication skills.

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GLOSSARY

CBCL – Case-based collaborative learning

HMS – Harvard Medical School

PAL – Peer-assisted learning

PBL – Problem-based learning

RAT – Readiness assurance test

SD – Standard deviation

TBL – Team-based learning

TPS – Team Performance Survey

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INTRODUCTION

Social Learning in Medical Education

Modern healthcare is undeniably a collaborative endeavor: From the primary care clinic to the operating room to the intensive care unit, physicians are constantly called upon to rapidly and reliably form interprofessional teams (1–4). They must synthesize different perspectives both within and between teams to coordinate multiple components of an individual patient’s diagnostic and treatment plans. Beyond the challenges inherent in solving open-ended questions with uncertain and changing information, the groups themselves are constantly evolving as members rotate in and out. Indeed, managing the team itself is increasingly recognized as a core competency of physicians and a necessity for safe, high-quality patient care (5–7). And all this clinical collaboration is separate from the many other roles in which physicians must utilize teamwork and communication skills, from research to education to administrative duties.

In light of this, medical educators are looking for approaches that can more effectively and efficiently prepare their learners for the demands of their future work (8). Recent decades have seen the incorporation of a number of instructional formats that educators hope will prepare their students for this sort of social learning better than the lecture-based format that has dominated the preclinical period throughout the last century. Many of these novel approaches are rooted in Vygotsky’s theory of social constructivism (9), which describes “learning that occurs in a social setting where students assist each other through a shared culture of knowledge” (10,11). Given that one of the most readily available resources for social engagement is students’ own peers, it makes sense that these approaches seek to leverage relationships between medical students.

Peer-assisted learning (PAL) is described as “the development of knowledge and skill through active help and support among status equals or matched companions” (12). Beyond social constructivism, PAL also relates to the psychological theories of cognitive congruence, which emphasizes similarities in the cognitive views of teachers and students (13), and social congruence, in which similar social roles between learner and teacher foster a more comfortable learning environment (14,15). Although evidence is somewhat mixed regarding PAL’s impact on student performance outcomes, it appears to be at least as effective as instruction by traditional “expert” teachers, and is perhaps most beneficial for the students who do the teaching (11,16). PAL can be conceptualized more as a broad category than a specific format, and given the benefits for learners and the relative ease with which educators can incorporate them, a range of PAL approaches became widely employed in US medical schools by the 1990s (15) and have continued to spread internationally (16,17).

One of the most noteworthy examples of medical students learning not only alongside but even from their peers is problem-based learning (PBL). In this model, a group of eight to ten students work through an open-ended prompt, usually in the form of a patient case, presented by a faculty facilitator. The students collectively define the problem, generate hypotheses, and form learning objectives. They work outside of class to explore those objectives and eventually reconvene to share what they learned and solve the problem (18,19). PBL was initially intended to be an entire curriculum approach, but as it gained popularity across the nation, variants arose such that the activities would occur alongside traditional curricular components like lectures (“hybrid PBL”) (20,21). A notable example of this hybrid approach is Harvard Medical School (HMS)’s *New Pathway* curriculum, first incorporated in 1985 (22). By the early 2000s, 70% of medical schools across the country had incorporated at least some PBL into their preclinical

curricula, but it was still relatively uncommon: of that group, almost half used it for less than 10% of their teaching (19). Unfortunately, PBL had some drawbacks. For one, it was far more faculty-intensive than traditional classroom formats. Furthermore, these approaches—especially hybrid ones that lacked regular surveillance and maintenance—often did not capture the student motivation needed to sustain them and degenerated over time (23). Despite its promise, PBL lacked consistency and was unable to reliably perform to its potential.

Given these shortcomings, around 2000, the medical education community turned its attention to team-based learning (TBL). TBL is an “active learning and small group instructional strategy that provides students with opportunities to apply conceptual knowledge through a sequence of activities that includes individual work, team work, and immediate feedback” (24). In contrast to the largely open-ended, group-dependent nature of PBL, TBL is highly structured with guidance from a faculty member. In response to the vast differentiation that occurred as PBL spread, there were even developed specific “core design elements” to facilitate implementation and ensure the fidelity of TBL (25). The TBL model begins with students studying preparatory materials including readings and video lectures. When they come to class, they complete readiness assurance tests (RATs), first individually and then in their teams of five or six students. Faculty provide feedback to the teams on their RAT performance. Teams next participate in a clinical problem-solving activity, engaging with both their own groups and other groups via class-wide discussions to answer multiple-choice questions. TBL requires fewer faculty preceptors than PBL, and students familiar with both formats viewed TBL more favorably (26).

More recently, HMS developed a variant of TBL called case-based collaborative learning (CBCL) (27). The structure is in some ways similar to TBL in that students study preparatory

material as individuals, complete RATs, and work in groups for problem-solving sessions moderated by faculty members. However, there are noteworthy differences. In terms of structure, CBCL groups are smaller: usually four or sometimes three students. Second, in response to the observation that in TBL, completing the RATs and the providing feedback can take up a significant portion of class time (26,28), CBCL has students complete RATs as pre-work before they convene in class. In terms of content, the problems in CBCL are open-ended enough that students need to generate hypotheses and apply critical thinking, perhaps to a greater degree than for the multiple-choice questions in TBL, but still carefully designed to convey specific learning points, overcoming one of the limitations of PBL. In this sense, CBCL incorporates the best elements of TBL and PBL, while building on their shortcomings (27). However, given the recency of its development, best practices (as have been developed for TBL) are yet to be established.

In implementing the *Pathways* curriculum in the fall of 2015, HMS condensed the preclinical curriculum from two academic years to fourteen months and shifted the vast majority of all class time to CBCL, creating an intensely collaborative first year experience. *Pathways'* flipped-classroom format provides students protected time each afternoon to complete the necessary preparatory readings and RATs for the next morning's in-class activities with their group. Classroom activities alternate between small-group problem-solving periods and large-group discussions. Faculty facilitators present the case information, circulate among the groups to offer help, and moderate discussions, yet they strive to make the sessions as Socratic as possible, often reflecting questions back to students rather than giving them answers.

Each day at HMS, there are four CBCL sessions running concurrently in separate classrooms, each with 40 to 45 students in about eleven groups per room. All of the students

within a classroom section are in the same advising Society and take all of their first-year classes together. *Pathways* involves one course at a time, so students spend every Monday, Tuesday, Thursday, and Friday morning with their group mates (Wednesdays are devoted to clinical training). Student groups are randomly assigned by HMS administrators at the beginning of each course and shuffled within each section after four weeks. Most courses last one to two months. A classroom typically has two or three faculty facilitators, who remain throughout the duration of each course before new faculty come in for the next course. Given the extent of time spent in groups and collaborative nature of the classes, the small group and larger classroom social environments play a major role in shaping students' experiences within the larger HMS context.

It is important to say that students generally enjoy the CBCL format as an engaging and fun way to learn (27); however, the success of CBCL is highly dependent on students' interpersonal and communication skills, and the social dynamics that arise in classroom groups have significant implications on students' ability to engage with the classroom material (29,30). In addition to allowing new levels of growth, the group format also introduces new challenges and potential pitfalls. In the years since the curriculum change, students have also increasingly reported disruption and strife in CBCL groups, including disengagement, disrespect, and interpersonal conflicts, that at times can make learning very challenging for individual students, as reported in confidential conversations with faculty, unpublished course evaluation data, and meetings with student representatives selected to provide feedback on the curriculum.

The degree of these concerns seemed to exceed what students reported in prior years with HMS's PBL curriculum. In PBL, faculty are expected to manage group process, and are known to have a large effect on how well groups work (31). In CBCL, students work through problems on their own by design, with faculty focusing on the discussion-based debrief, akin to case-based

teaching commonly found in law or business schools. In the initial pilot study that compared the effectiveness of CBCL with PBL, the authors remark:

There were fewer explicit instances of asking for or giving information in the CBCL small-group discussions than in the PBL discussions, as well as fewer expressions of uncertainty, respectful disagreement, and reassurance; yet there was a higher incidence of both expression of frustration and lightheartedness (27).

Even if such occasional tensions may be, to some degree, intrinsic to the CBCL format given groups' relative independence, the nature and frequency of students' reports seemed to suggest that we needed to support them in how to work together effectively and professionally.

To more fully explore these issues, we turn to insights from fields beyond medical education. The remainder of this introduction addresses key concepts in organizational and social psychology and presents four questions that guide this investigation. To be sure, as rich as these four questions may be, they serve more as lenses through which we can view the world than a specific roadmap outlining the steps of our research.

Key Concepts in Team Learning and Group Dynamics

To begin, we make a particular note about the term “team,” which is defined by J. Richard Hackman as having a few essential features: “a team *task*, clear *boundaries*, clearly specified *authority* to manage their own work processes, and membership *stability* over some reasonable period of time.” We further emphasize how he distinguishes teams from co-acting groups, which involve individuals working alongside one another on largely independent tasks. A critical element in a team is interdependency—all members are contributing in ways that require the contributions of others toward a collective outcome (32).

Along these lines, L. Dee Fink similarly distinguishes different types of group learning formats. Cooperative learning—akin to what Hackman would call co-acting groups—involves highly structured activities meant to provide students a more socially immersive way of engaging with the material. True team learning, on the other hand, is transformative: It takes individuals and converts them into a new entity that is more than the sum of its parts (33). Fink sets forth a number of recommendations regarding the group organization and classroom supports that are most conducive to each format (33). Under this framework, the number of students working together, the duration of their interactions, and lack of grading of group work seem to make CBCL more amenable to cooperative learning than team learning (Table 1). Given that these structural features are stacked against true team learning’s favor, we reach our first guiding question: *Do CBCL groups really function as interdependent teams?*

Fink’s “transformation” relates to the fact that as individuals become a team, there arises an entirely new set of actions that can occur on the level of the collective (34). One of these team-level activities, Chris Argyris and Donald Schön explain, is “learning,” which is broadly defined as the acquisition of new information for the sake of improving the group’s performance over time. Similarly, Amy Edmondson explains that such team “learning behavior consists of activities carried out by team members through which a team obtains and processes data that allow it to adapt and improve” (35). While the specific tasks of team learning behavior (“seeking feedback, sharing information, asking for help, talking about errors, and experimenting”) can certainly apply to improving individual work, the important note is that they also occur on the relational and interdependent processes of *group* work for sake of improving *group* outcomes. Whereas engaging in learning behaviors takes time and resources and may not be helpful for routine, repetitive tasks, it can especially facilitate performance for individuals and

teams in changing or uncertain situations (35). Argyris and Schön further elaborate on two types of learning in which groups can engage. Single-loop learning involves a group improving its performance within the confines of its previous underlying assumptions, values, and strategies (collectively called “theories-in-use”). Double-loop learning, on the other hand, means that they entirely revise their organization and approaches (34).

While the purpose of medical school is necessarily to promote individual students’ learning, it is critical to recognize that in CBCL, a significant portion of students’ learning—particularly the application and consolidation of knowledge—occurs in the setting of groups. There is some evidence that TBL can improve student performance compared to traditional formats (36–38). By allowing students to more effectively engage in their interdependent work, it is reasonable to conclude that optimizing CBCL groups’ learning behaviors can also improve individual outcomes. *How might medical educators help student groups recognize their dynamics, reflect on how well they are serving the group’s purposes, and ultimately change them if needed?*

Understanding the interpersonal dynamics that arise in medical school learning groups is critical to anticipate the sorts of learning behaviors in which they will need to engage. In a setting that has typically valued and rewarded intelligence and achievement, students may be hesitant to ask a potentially embarrassing question or propose a wrong solution to a problem (29). However, taking such risks may yield major benefits to individual and group learning. This willingness to put one’s own status on the line for the potential benefit of the team closely relates to what Edmondson calls psychological safety: “a shared belief that the team is safe for interpersonal risk taking” (35). While this concept was developed in the context of healthcare teams (39) and has been examined within the clinical domains of medical education (40,41), it

has been largely overlooked in the context of medical schools' preclinical learning environments. Social congruence theory and the underlying assumption of PAL that peers are "status equals" (12) would imply that placing students in groups with peers might promote psychological safety and help them feel less risk averse. However, anecdotal evidence gathered from students about interpersonal conflicts in their CBCL groups may suggest otherwise. *Is it true that peer learning is safe?*

Psychological safety is not the same thing as group cohesiveness; in fact, too much cohesiveness can actually decrease the likelihood of expressing disagreement and challenging others' views—both behaviors that psychological safety seeks to promote (35). Along those lines, a second issue relevant to the CBCL context is what Irving Janis describes as "groupthink":

A mode of thinking that people engage in when they are deeply involved in a cohesive in-group, when the members' striving for unanimity override their motivation to realistically appraise alternative courses of action (42).

Although Janis explains the phenomenon in the setting of public policy, it is just as relevant to medical teams formulating differential diagnoses or deciding on treatment approaches (43).

Learning how to avoid groupthink is a prime example of a learning behavior that may benefit groups. *How can medical educators foster close relationships among medical student learning groups while also promoting dissent and critical thinking?*

Motives

This project set out to examine the interpersonal dynamics that occur within the context of CBCL at HMS. We analyzed the situation at two levels: from the perspective of individual students as well as the perspective of their small groups. We wanted to identify whether they

demonstrate the features of true teams, including interdependence and group-level processes such as learning behaviors. From these analyses, we developed a model underscoring the processes of functional CBCL groups and to design an intervention that can support students in achieving optimal performance. To measure CBCL group dynamics, we applied the Team Performance Survey (TPS), an instrument specifically designed for and validated in medical school TBL activities (Supplemental Figure 1) (44). The team features that survey encompasses—high levels of engagement by all members; discussions at deep, conceptual levels; and a strong sense of team identity—are all highly relevant to the CBCL setting, as well. However, given the structural differences between TBL and CBCL, we examined its application for classes at HMS and explored its utility as a diagnostic tool to identify dysfunctional groups. We then investigated the impact of a pilot intervention intended to improve the learning environment and determine the feasibility of a more extensive intervention in the future.

METHODS

Study Design

In designing this mixed methods educational quality improvement project, we adopted a constructivist approach under which the research questions evolved over the course of the study in light of our preliminary findings (45). As such, the specific methods and analyses were adapted real-time rather than dictated by a pre-specified framework. All data were collected from first-year medical and dental students taking the required course *Homeostasis I*, which encompasses the physiology and pathophysiology of the respiratory, cardiovascular and hematologic systems. This course runs from February to March and consists of two group rotations of four weeks each. The HMS Institutional Review Board deemed this study exempt.

Data Collection

Our data collection began in 2017. At three different time points in the course (week 2, week 4, week 6), all students in the class were invited to complete a Qualtrics survey asking them about the group with which they had most recently worked. The survey included two components. The first component was a minimally adapted version of the TPS. The original TPS included a 7-option scale (0 = none of the time, 6 = always), but we adapted it to 5 options (never, rarely, sometimes, often, always) for simplicity, and removed question 14, which was deemed less relevant to our circumstances. During the week 2 administration, we also collected open-ended responses to the following the two questions:

1. What is one thing that your team has done well?
2. What is one thing that your team could improve on?

The majority of this paper only includes data points from week 2 because that administration encompasses both quantitative and qualitative data. In this paper, we use the label “2017w2” to describe that one administration.

The following year, we administered the full TPS and those same two open-ended questions to all students twice during *Homeostasis I*—once at the end of each group rotation. In this paper, the label “2018w4” describes the survey administration assessing groups from the first rotation, and “2018w8” describes groups from the second rotation.

In all situations, participation was voluntarily. In 2017, students completed the survey on their own time, and TPS and free responses were anonymous besides the level of the class section. In 2018, students were provided class time to complete the survey, and we collected individual student identifiers to allow for the linkage of responses to individual outcomes and comparison of responses among students in a given CBCL group.

Pilot Intervention

For the first group rotation of 2018, the course was run as it had been for students in 2017 cohort. However, the second group rotation in 2018 involved a pilot intervention intended to impact students’ CBCL group dynamics. At the start of the second rotation, groups engaged in a 20-minute norming activity. Students were given class time to share their personal goals and norms with their group members, as well as discuss group norms and a group leadership structure upon which they as a team could agree (Supplemental Figure 2). Both individual and group norms were collected via Canvas, HMS’s online course management platform (Instructure, Inc., Salt Lake City, UT). Two weeks later, at the mid-point in the rotation, students were given 15 minutes of class time to check in on how their groups were doing, revisit their norms, and consider revising them (Supplemental Figure 3). For both of these check-ins,

faculty were present but generally did not interact with the groups. This intervention was designed by former HMS student Alexander Kazberouk, MD/MBA class of 2018, based on his experiences working for a management consulting firm. The organizational theory underpinning the two-part structure of these activities will be more fully addressed in the Discussion section.

Data Analysis

Given the differences between the original TPS and our adaptations, all scores were normalized as a percent out of maximum score to allow for direct comparison between our results and those presented in the original paper. Supplemental Table 1 compares our findings with those in the original Thompson et al (2009) paper, demonstrating that the scale is valid in our context. ANOVA was used to compare score distributions across the three survey administrations in 2017 and across the four class sections within a given cohort. Independent samples t-tests were used to compare score distributions between the 2017w2 and 2018w4 cohorts before aggregating them into a single “pre-intervention” dataset to allow for increased sample size. These analyses were performed using an online statistical calculator (www.SocSciStatistics.com).

Free responses were analyzed for overarching themes via an inductive coding approach. First, two independent raters (H.B. and M.K.) reviewed all free responses and developed a preliminary codebook involving descriptions of each theme and inclusion and exclusion criteria. Next, M.K. and D.K. independently coded the 2017 free responses according to this scheme before meeting to discuss discrepancies, assign consensus codes, and further refine the codebook. They finally used this revised codebook to independently code the 2018w4 and 2018w8 free responses before meeting to discuss discrepancies and assign consensus codes. Quotations serving to illustrate each theme were selected by M.K. and evaluated by D.K. to

ensure adequate representativeness. Group norms were thematically coded according to the finalized codebook by M.K. Throughout all coding, responses that encompassed multiple themes were coded accordingly. Cohen's kappa was calculated based on the 2018w4 and 2018w8 student free responses using Stata 14.

Once coding was completed, we verified that the frequency of themes among the free responses for the two questions did not vary greatly between the 2017w2 and 2018w4 cohorts before aggregating them to allow for increased sample size and consistency with the aggregated TPS score dataset. For reference, theme frequencies of the two cohorts separately are available as Supplemental Figure 4.

Following the aggregated thematic analysis, we then sought to stratify the theme frequencies across teams of various performance levels, as determined by TPS score. These demarcations between Low-, Middle-, and High-TPS categories were empirically, iteratively developed based on the data distribution and the number of data points in a category. The association between individual TPS scores and student grades was assessed with linear regression using the Data Analysis Package for Microsoft Excel for Mac 2016.

In 2018, the collection of identifying information allowed us to link free responses and TPS scores with individual students, and then compare the results among members of the same CBCL group to determine how each student's experience in the group compared with their peers'. CBCL group profiles were developed by M.K. and H.B. based on their analysis of the free responses and personal experiences working in and facilitating CBCL groups. M.K. selected representative quotations to illustrate particularly compelling group stories. Group norms were coded using the previously specified theme book by M.K. The association between

the thematic richness of a group's norms and its mean TPS score was assessed with linear regression using the Data Analysis Package for Microsoft Excel for Mac 2016.

RESULTS

Individual Student-Level Analysis

What are students' experiences at baseline?

Across the three survey administrations in the 2017 cohort, response rates decreased from 90 of 170 students (53.0%) in week 2 to 68 students (40.0%) in week 6. There was no statistically significant difference in mean TPS score across the three administrations ($p = 0.727$), indicating that students had roughly consistent assessments of their groups' performance throughout the duration of the course. Only week 2 data will be included in the rest of the analysis because that set alone also contained free response comments.

For the 2018w4 cohort, which in contrast to the previous year now received class time to complete the survey, the response rate was 165 out of 169 students (97.6%). There was no statistically significant difference in mean TPS score across the four class sections in both the 2017w2 ($p = 0.199$) and 2018w4 cohorts ($p = 0.205$). There was also no statistically significant difference in mean TPS score between the 2017w2 and 2018w4 cohorts ($p = 0.510$), so those data points were aggregated into one pre-intervention, baseline dataset.

The mean TPS score of this combined "2017 and 2018 Baseline" dataset was 85.4 out of 100 (SD 11.7), indicating that overall students perceived their CBCL groups to be performing fairly well. Nonetheless, the histogram displayed in Figure 1A demonstrates a more nuanced picture. There was an apparent discrepancy: Nearly a fifth of students rated their groups with nearly perfect TPS scores, while an approximately equal number of students comprised a left-sided tail of notably lower scores. The overall distribution presented here is separated into the performance categories of Low-, Middle-, and High-TPS scores. The cutoffs for each category were developed empirically based on our subsequent analysis of free response themes.

It was unclear to what degree this range of scores represents students documenting truly variable levels of team performance or rather making different subjective assessments of objectively similar situations. To examine this, we turned to the free responses that prompted students to describe what was going well in their team (“Done well”) and what they could improve on (“Improve”).

Our analysis of free responses revealed six key themes that encapsulate students’ experience working in CBCL groups (Table 2). The responses were thematically rich, with very few concepts discussed not being captured in the coding scheme (Supplemental Table 2). Cohen’s Kappa averaged across all codes was 0.765, indicating excellent inter-rater reliability (Supplemental Table 3) (46). Responses in the Done well and Improve prompts of a given theme often addressed the same underlying behaviors and issues, implying the themes have strong construct validity. Furthermore, these themes map very closely to the questions in the TPS (Supplemental Figure 1).

A theme’s appearance in the free responses represents students’ perceptions or awareness of these dynamics in their group activities. By demonstrating the frequency of the various themes across the Done well and Improve questions, Figure 2 represents the extent to which students identify them as areas of success or improvement. The ratio of a theme’s frequency between the two domains can serve as a proxy for whether students view it as a relative strength or weakness of their groups. To be clear, the theme frequencies do not represent objective performance assessments, as many factors can influence the particular elements of their group work that students decide to share. In order of frequency, the three most common themes were promoting balanced participation, ensuring universal understanding, and safe environment. All three were more commonly cited in Done well than Improve. Comments about individual

preparation and focus and larger group learning were least common overall but far more likely to occur in the context of needing improvement.

To determine whether students of various teams were having different experiences, we stratified their free responses' themes across the three performance categories (Figure 3A–C). Students from Middle- and High-TPS groups had approximately similar experiences: In both of these categories, Done well comments outnumbered Improve comments in promoting balanced participation, ensuring universal understanding, and safe environment. For grappling and synthesis, Done well and Improve comments were about equal. Larger group learning was commonly mentioned as an area for improvement. In contrast, students in Low-TPS groups seemed to have a different experience, with the Improve comments equaling or outnumbering the Done well comments for almost all domains. For promoting balanced participation and especially safe environment, the ratios of comments between Done well and Improve were markedly less favorable than they were for the Middle- and High-TPS categories. Furthermore, the specific content within those Improve comments showed more evidence of dysfunction, as we will elaborate in the next section. Low-TPS students less commonly mentioned their large group interactions.

In all, this qualitative analysis provided two key insights. For one, it served as evidence that individual students were aware of challenges their groups were facing as potential areas for improvement. Furthermore, the analysis demonstrated that those challenges differed across groups. Among groups that surpassed a performance threshold, as signified by a score of 75 on the TPS, students' experiences seem fairly similar. While even students in Middle- and High-TPS groups could identify various ways to improve their interactions, issues with promoting

balanced participation and safe environment may be particularly salient for those in low-performing groups.

In light of these insights, our goal for an intervention was to first provide students an opportunity to translate individual-level awareness to group-level awareness, and to then help them actually improve their group dynamics. We also wanted to give groups the freedom to determine what areas they wanted to focus on.

How did those experiences change after the intervention?

The response rate to our survey in the 2018w8 “Post-intervention” cohort was 161 out of 169 students (95.3%). The distribution of TPS scores in this cohort is shown in Figure 1B, with the colors indicating the same performance thresholds as established in the prior cohort. The mean TPS score of this 2018w8 cohort was 89.9, which was statistically significantly higher than the mean TPS score of the 2018w4 students prior to the intervention ($p < 0.001$). Because TPS scores did not increase over time in the prior year, we take this change as evidence that the intervention improved team performance. Specifically, a smaller proportion of students (8.7% in 2018w8 vs. 20.0% in 2018w4) rated their groups in the Low-TPS category that we previously identified to be potentially problematic.

Additionally, qualitative analysis revealed that students perceived their groups to be overall safer. Figure 3D–F shows that groups in all three categories had more comments about safe environment as something they did well than as an area for improvement. Promoting balanced participation remained a common topic for improvement for all group categories.

Students’ experiences and exam scores

We assessed whether students’ TPS scores were associated with their academic performance. For the 2018w4 cohort, there was no association between individual students’ TPS

scores and their grades on the quiz they took at the end of that period ($p = 0.313$). There was similarly no relationship between 2018w8 TPS scores and students' grades on the quiz at the end of that period ($p = 0.636$).

Group-Level Analysis

Characterizing group profiles

Although the prior analyses indicate that students had a range of experiences in their CBCL groups, we do not know how consistent these experiences were among students in the same group. To answer that question, we assessed the non-anonymized 2018 dataset and compared individuals' TPS scores and free responses to those of their fellow group members. We calculated the mean TPS score of individuals in each group and the standard deviation (SD) of those scores to indicate heterogeneity among members. Figure 4 demonstrates a scatter plot of the mean and SD of each 2018 pre-intervention CBCL group's individual TPS scores.

To help us characterize this scatter plot distribution as a whole (and eventually compare it with the post-intervention data), we divided it into regions corresponding to different group profiles. The demarcations between profiles, though somewhat arbitrary, were derived from our interpretations of the previous data. Across the x-axis, the previously identified TPS score cutoff of 75 separates red-colored Low-TPS groups from blue-colored Middle-TPS groups, and 95 again demarcates the green-colored High-TPS groups. We call the Low-TPS region "Toxic" since the stratified qualitative analysis suggested that individuals in those groups were more likely to experience an unsafe environment. Since the analysis previously demonstrated that students in Middle- and High-TPS groups had roughly equivalent experiences, those blue and green points were grouped together into one "Well-Performing" profile. In addition to those two group profiles, we wanted to capture the idea that some groups may be characterized by greater

heterogeneity of experience than others. We created an “Asymmetric” profile to denote groups with a very high group TPS SD. Based on the normal distribution of the data, we decided to set the y-axis cutoff at 14.0, which is one SD above the mean value of all groups’ SD.

These profiles primarily serve a predictive function in relating a group’s TPS mean and SD to the interpersonal dynamics likely to be seen in it; just because a group falls in a particular profile region does not mean it necessarily demonstrates those features. However, these conjectures are often supported by the descriptions of the groups apparent from the free responses. All subsequent quotations are taken from the Improve question. Consider, for example, students’ experiences in the team denoted with the orange highlight (TPS mean 74.4, SD 6.5), at the right side of the “Toxic” region in Figure 4:

“There was one dominant personality in my group who often came across as condescending and not valuing the opinions of women. And the other guy at a table just co-signed it. I often felt like I and the other woman in the group were third wheels because the guys would often have conversations among themselves and only work with each other. I never brought it up because the guy who was the main issue had been doing this from the beginning and had gotten feedback from peers and faculty, and nothing changed, so I felt it wasn’t worth my time” (Individual TPS 67.8).

Similarly, in Team Red (TPS mean 66.7, SD 11.0), it was fairly well recognized by all group members that the group lacked a supportive environment and cohesion:

“Better communication and giving people the space to speak their mind” (Individual TPS 58.9).

“Facilitating a real group discussion; often we just moved the discussion between just two people in the group and weren’t talking with the group overall” (Individual TPS 74.4).

A final example of a Toxic group is Team Yellow (TPS mean 73.3, SD 16.2):

“I think it was very hard for me at the table at first because often one member would jump into answering the question immediately and respond with the answer as opposed to the process. This was frustrating, as we often skipped the thought process and thus important misconceptions. I often felt like there was an argument between two group members and I felt awkward interjecting. I also felt hesitant to speak up because the pattern had been to jump directly to the answer, which is not how I am able to think. It was exhausting trying to counteract this every day, especially at the end of the day. I felt like there was no effort to try and reign their responses in. Sometimes, it felt like there was no room for wrong answers as well, because some group members discounted someone else’s response. I noticed that the other female member of the group became quieter over time as well. It did not feel like a collaborative effort” (Individual TPS 65.6).

“Less mansplaining would be nice; not jumping on discussions” (Individual TPS 54.4).

Such blatantly negative dynamics were never discussed by students from groups outside the Toxic region.

The bottom right of Figure 4, where groups fall if all members assigned middle or high TPS scores, is where we would expect to find Well-Performing groups. In general, these teams’ TPS scores were also reflected in their free response comments. Take, for example, the two students who completed the survey for Team Green (TPS mean 98.9, SD 0) trying to find a topic for improvement:

“Honestly can’t think of anything. We had a really great group. Didn’t always get the right answer, but the process was always sound” (Individual TPS 98.9).

“Hard to come up with” (Individual TPS 98.9).

To be sure, this does not mean that students in all Well-Performing groups were entirely satisfied with their performance. In Team Teal (TPS mean 91.1, SD 4.8), even a student who assigned a maximum TPS score could still find opportunities for growth:

“For questions we understood well, we could discuss more ‘what if’ questions and explain what would happen with slight variations” (Individual TPS 100.0).

Finally, Asymmetric teams are ones in which there is notable discrepancy in TPS score among students, resulting in relatively high SDs and usually mid-range means. This may result from fragmented groups, in which the four students essentially functioned as two separate pairs. Take Team Gray (TPS mean 79.6, SD 14.5) as an example:

“We often split up into two duos depending not the side of the table we were on, and could have collaborated more as a group of four” (Individual TPS 86.7).

Asymmetry may also result from different subjective interpretations of the same activities. Team Purple (TPS mean 86.7, SD 15.4) has a compelling story: Two students had the same recognition that their group may be plagued by groupthink, but their TPS scores were vastly different:

“We could explore ideas other than those we all think are right from the get-go” (Individual TPS 95.6).

“My team could improve on listening to opposing viewpoints and also elaborating more. I think that we would often talk about things on a more surface level, and we would come to agreement without delving into more depth about the mechanism or topic” (Individual TPS 68.8).

The fact the second student related the superficiality of their discussions to their difficulties in listening to opposing viewpoints may suggest a relationship between low psychological safety and predisposition to groupthink. Also note that it was the student whose comments suggested an unsafe environment who rated the TPS much lower. The topics were not addressed further in the other two group members' comments.

Mapping the means and SDs of the post-intervention 2018w8 groups onto the scatter plot regions defined by the 2018w4 data showed a decrease in the number of groups labeled as Toxic and Asymmetric (Table 3). Separately from this framework, analysis of the free responses indicated that although the lower-performing teams still had noteworthy areas for improvement, they did not demonstrate any signs of outright interpersonal conflict as seen in the prior cohort.

What did groups discuss in their norming activity?

The intervention during the second group rotation of 2018 asked groups to develop norms to guide their CBCL activities. We were able to qualitatively code the norms for forty-two groups (Table 4 for a sample). The most commonly mentioned themes were promoting balanced participation (in 80% of groups), individual preparation and focus, ensuring universal understanding, and safe environment (each in about 55% of groups) (Figure 5). Group norms addressed an average of 3.0 unique themes, and we found no association between the number of themes and the group's average TPS score ($p = 0.784$). However, we note that all of these groups' TPS scores were above 75, meaning they were all in the Middle- and High-TPS range that we previously established to have little variation in student experience. Thus, it makes sense that thematic richness of norms was not associated with higher TPS scores since the TPS loses its utility within this score range.

Upon assessing the content of the norms beyond themes, we note that there are important differences in the specifics of students' decisions. Some groups elected to have a specific group leader for each discussion question and rotate that group leader for each question. They also said they would look up at one another to let each other know that they are ready to discuss their thoughts. Another group in the same section decided not to appoint a table leader for each question, but they stated that they will reconsider it if they find that things are not going as well as they would like. Similarly, they would flip up name tents to signal that they are ready. In all, these two groups highlight that there is no one "right" way to go about their CBCL group work. Rather, the purpose of the norming activity was to make them aware of what they were doing, and to empower them to shape their group dynamics to what worked best for them.

DISCUSSION

A Conceptual Model of CBCL

Our initial qualitative analysis identified six thematic categories regarding the key components of students' daily work in CBCL groups. Further analysis of those free responses and then the group norms allowed us to link the themes to one another relationally and chronologically and develop a model of the interactions and processes that arise (Figure 6). The first theme, preparation and focus, encompasses the prerequisite conditions for CBCL groups to engage in their in-class activities: students' preparedness (i.e., having done the assigned readings as homework, as well as past experiences and expertise), timely attendance, and attention and motivation during class. When students begin to lose interest or "go down a rabbit hole" exploring a question besides a key learning point, it is important that the students can recognize this and keep their peers on track. While some of these components are more "individual" tasks than the later themes, there are certainly opportunities for group members to hold each other accountable and help one another.

The next set of themes address the heart of CBCL work, which occurs once a case has been presented to the group. The first-level discussion that groups have is characterized by two related themes: promoting balanced participation and ensuring universal understanding. Promoting balanced participation encompasses the behaviors that groups undertake to actively solicit the different points of view of all of their members. In addition to going around in a circle to ensure everyone has a chance to speak, for example, it can also include reserving some time at the start of their discussion to ensure that everyone has had a chance to formulate their thoughts and develop their own hypotheses before they hear others'. Closely related to these behaviors is a commitment to ensuring that all group members understand the topics of discussion and are on

the same page regarding what other members are thinking. This manifests as individuals explaining their proposed solutions to those who might not understand. These two themes are linked into a mutually reinforcing cycle, as students will very likely need to further explain their thoughts once they initially share them, and one person taking time to explain their thoughts may help others develop their own alternative interpretations or ideas.

Once all group members have presented their thoughts and everyone is on the same page, groups engage in a second-level discussion in which they refine and synthesize those initial responses into a coherent solution. This often involves students reconciling discrepant interpretations and grappling with views that differed from ones they initially held. Finally, once the group has settled on a solution, they then have the opportunity to report it out to the other groups in their section so that other groups may benefit from their discussion.

Keeping this model in mind, we will address the four guiding questions posed in the introduction.

Do CBCL groups really function as interdependent teams?

Our model of CBCL group dynamics undoubtedly portrays the work of an interdependent team—far more than a co-acting group (32). The themes of promoting balanced participation, ensuring universal understanding, and grappling and synthesis necessarily require students to engage with one another's contributions. These show that the group of individuals transforms into a team that is greater than the sum of its parts (33).

Critically, the free responses also address how these group processes happen best under certain conditions: a social environment in which students feel like their contributions are valued and they are not afraid to speak up and respectfully voice disagreement. Although the themes

overall arose de novo, we note that this particular theme almost perfectly maps onto psychological safety.

Edmondson explains that “for psychological safety to be a group-level construct, it must characterize the team rather than individual members, and team members must hold similar perceptions of it” (35). The free responses coded under this theme did indeed refer to attitudes of the group rather than individuals, and our model accordingly places it in the middle-tier “group” realm rather than as a first-tier “individual” factor with preparation and focus. However, we recognized a safe environment seemed qualitatively different from the other themes discussed so far. Comments coded under preparation and focus, promoting balanced participation, ensuring universal understanding, grappling and synthesis, and large group learning would best be described by Valentine et al (2015) as “behavioral processes,” or observable actions. Psychological safety, on the other hand, is an “emergent state,” and particularly one in the affective domain (47).

We note that the behaviors associated with promoting balanced participation and ensuring universal understanding can promote a safe environment by creating a space in which risk-taking is normalized as part of daily practice. The safe environment then feeds back in and further promotes those two steps: Students will be more inclined to share a thought that they worry might be wrong or seek clarification regarding a potential error. Psychological safety is also a critical prerequisite for the more challenging conversations that occur under the group-level’s second-stage behavioral process of grappling and synthesis. This “emergence” of psychological safety will be discussed further in the subsequent section.

Before moving on, we note that the most complete model of CBCL may actually be nested. The output from our single-group model—the group’s collective answer—would

essentially be the input (akin to the “preparation” theme) for the learning processes that occur within the larger class environment. That larger group has its own processes, including promoting balanced participation among different CBCL groups (rather than individuals) and ensuring universal understanding across groups. The faculty facilitators may then have to consider the next-level states that can emerge from this dynamic. However, documenting such larger-group processes are beyond the scope of this project.

Although students’ experience in the CBCL groups suggests that they are engaging in true teamwork rather than mere cooperative learning, we note that this may in fact be despite rather than due to the structural arrangements of their groups. Table 1 indicates that students in both cooperative and team learning arrangements can benefit from efforts to teach and analyze group process skills, but such attention can be especially helpful for smaller, shorter-term groups like those used in CBCL. The lack of explicit attention to issues of group process in CBCL to date was a major motivation for our pilot intervention and subsequent curriculum design.

Utility of a Norming Intervention

How might medical educators help student groups recognize their dynamics, reflect on how well they are serving the group’s purposes, and ultimately change them if needed?

The free responses indicated that students already had a keen awareness about what features were helpful or detrimental to their experience in CBCL teams. Our pilot intervention was an attempt to translate this individual insight to group-level awareness about how group dynamics may impact members’ day-to-day experiences. The intervention involved 20-minute activity at the start of the rotation during which students shared their personal goals with their group members and discussed their group norms (Supplemental Figure 2) followed by a 15-

minute check-in midway through the rotation to see how their teams are doing and revisit and potentially revise their norms (Supplemental Figure 3).

Having groups write down norms served as a way of helping them identify their theories-in-use (34) and ensure that those approaches were suiting the highest aspirations of CBCL. Single-loop learning, in which groups work better without revisiting their underlying strategies, may very well occur automatically over the course of a group's time together as they gain familiarity with cumulative course content and each other. However, the check-in, in which they revisited their norms halfway through their time together, was intended to provide an opportunity for the groups to engage in more powerful double-loop learning (34): Norms should be reconsidered as the group goes forward and can change if need be.

Educators can take a number of steps to promote team learning (35). Edmondson explains that team learning arises at the confluence of two factors: accountability for meeting demands and psychological safety. In the best scenarios, absence of one or both of these would prevent CBCL from reaching its potential; in the worst, a lack of accountability or psychological safety can even result in downright problematic situations. She provides a 2x2 matrix characterizing the different possibilities (48). The high-accountability but low-safety "Anxiety zone" is reflected in the Toxic teams identified in our analysis. Given this view, it is critical that CBCL groups have sufficient accountability and psychological safety.

To address individual accountability, instructors assign RATs to assess mastery of the homework and make attendance mandatory. However, such measures do not address what happens within the classroom environment. It is critical to note that accountability should involve an expectation that students will actually contribute to their team (49). During the intervention, groups would explicitly discuss team goals and norms as a way of making sure

everyone is committed to work toward shared objectives (50,51). The notion of utilizing norming activities to bring about specific outcomes will reappear as an answer to our fourth question, as well.

Fostering Safety and Critical Thinking

Is it true that peer learning is safe?

Edmondson asserts that psychological safety is a necessary condition for teams to learn (48). Implicit in the arrangement of PAL is the notion that students' peers are "safer" learning partners than faculty because they are at the same status level (13). Our qualitative data from Toxic teams would strongly challenge that notion: Peers can in fact make teams unsafe.

As part of her instruction at the Harvard Graduate School of Education, Professor Monica Higgins discusses three factors that contribute to psychological safety: leader coaching and support (+), level of familiarity/prior interaction (+), and member status differences (-) (52). Regarding the first, there is no clear leader in CBCL groups. Although there are facilitators, they are not so closely involved with group work that they would serve that function. In the absence of such a force shaping the group's culture, the next two factors are all the more important. Next is familiarity and prior interactions, which in this situation we consider to include firsthand experience as well as those communicated indirectly via reputation. We have anecdotal experience that many students had developed reputations within their CBCL sections, both good and bad. While it is true that prior positive interactions can be helpful, some students' comments suggest that negative reputations can be damaging for psychological safety, even in the absence of actual harmful behaviors. Third, member status differences impair team psychological safety. Although students may be in the same academic program, dissimilarities in personality types or prior experiences and expertise, unconscious bias, and diverging goals for the class may all result

in different status assessments among peers (53,54). In all, Higgins' factors underscoring psychological safety are not well supported in the CBCL context. This highlights the necessity for interventions to promote safety and facilitate successful learning teams.

How can medical educators foster close relationships among medical student learning groups while also promoting dissent and critical thinking?

As an emerging state (47), no one specific action automatically produces a safe environment, but tangible actions can certainly contribute. Some behaviors mentioned in the free responses, like expressing appreciation and support for one another or not interrupting when others are speaking, function exclusively to promote a safe environment. As mentioned previously, we are encouraged to see evidence that some actions under the themes of promoting balanced participation and ensuring universal can also serve to promote a safe environment. Furthermore, incentivizing effort rather than performance may engender in students a growth mindset, under which they recognize mistakes and setbacks as critical stimuli for their longer-term development (55).

Related to this notion of a growth mindset, proactively establishing in students the expectation that they should not settle on the first or most straightforward answers proposed may help make groups environments that push rather than stifle individual thinking. A phenomenon exclusively appearing in students' Improve comments involved them realizing that their groups tended to settle on the first answer that came up and did not push themselves to consider alternatives. These were all coded within the grappling and synthesis theme and represent a failure of what that process should ideally achieve. We use these comments as evidence that groups do occasionally fall prey to groupthink. By inhibiting deep thinking, this tendency would drastically reduce the desired yield of CBCL. Returning to Edmondson's 2x2 matrix, we suspect

that groupthink is most likely to arise in situations with high safety but low accountability—what she calls the “Comfort zone” (48). Consequently, students may benefit from interventions that promote critical thinking as a core group value.

One specific practice that can be incorporated for these purposes is mechanistic concept mapping, which involves creating diagrams that synthesize clinical signs and symptoms with pathophysiologic mechanisms for the sake of formulating and assessing hypotheses or differential diagnoses for a chief complaint. When studied in CBCL specifically, concept mapping was found to help students balance discussion between one another and avoid System 1 thinking that can lead to cognitive biases (56). Within the present study, concept mapping (or similar processes involving documenting their thoughts or explaining their reasoning on white boards) appeared in the ensuring universal understanding theme. In all, the fact that a single activity can relate to three themes (promoting balanced participation, ensuring universal understanding, grappling and synthesis) further reinforces the interrelatedness of the conceptual model and underpins the importance of sharing “best practices” among different student cohorts.

Given the positive reception and objective success of our initial norming activity, we saw an opportunity to expand it for the purpose of specifically promoting a growth mindset and critical thinking among student groups. In 2019, the curricular iteration after the intervention analyzed in this study, we augmented the 2018 norming activity by providing students a set of five “HMS Community Norms” intended to guide the development of their smaller group norms. These were all abstract ideals off of which they should develop more granular codes of conduct involving specific behaviors in which they would engage to bring those community norms about (Supplemental Figure 5). Included among the five community values was “Growth” for the purpose of a growth mindset. We also added “Curiosity” to stimulate students to push deeper

than what they may have initially settled upon. We note that this intervention is a feature of the *InterCom* curriculum, which is discussed in the subsequent Future Work section.

Limitations

We acknowledge limitations to this project. For one, because our assessments and interventions occurred within the context of a fully operational curriculum with minimal opportunity for manipulation, it was not possible to create a control group from which the intervention was withheld. The consistency in TPS scores across the three time points in the 2017 cohort, as well as with the pre-intervention group in 2018, would strongly suggest that the increase in TPS score seen in the second rotation of 2018 can be attributed to the intervention itself rather than spontaneous improvement over the span of the course.

Our primary outcomes related to voluntary TPS scores and free responses. Given limited demographic data, we cannot ensure a lack of systematic differences between students who did participate and those who did not. For example, some students, such as those in particularly problematic groups, may not have been engaged enough with the activities to share their full experiences. Although our data show that different students' subjective assessments of a given situation may vary from one another, we note the utility of norming interventions—particularly when they are guided, as ours was in 2019—in setting shared expectations about what features should characterize that experience. While students' perceptions should be considered important in and of themselves, we recognize that medical educators may be curious to see the impact on established performance metrics such as grades. We would not have expected a clear association, as students had numerous opportunities outside their CBCL groups to consolidate in-class material and prepare for the exams.

Lastly, as a case-study, the qualitative component of this project and subsequent curriculum development especially may not be fully generalizable to institutions beyond HMS. The pilot intervention has not been externally validated, and the construct and content validity of the intervention is unknown. Our hope is that readers will have enough context of the HMS curriculum and learning environment to assess the utility of conducting similar assessment or intervention programs at their own institutions.

Conclusions

The student free responses painted a clear picture of CBCL groups functioning as true teams featuring interdependent processes that can only occur on the level of the collective (promoting balanced participation, ensuring universal understanding, grappling and synthesis, and psychological safety). We found that the pilot intervention providing students dedicated time at the beginning of their rotation for a norming activity and then mid-rotation for a check-in was an effective way to help them manage their group learning dynamics. The free responses indicated that CBCL groups are not necessarily safe learning environments, but we note that certain patterns of interaction help contribute to an atmosphere of psychological safety. Specifically promoting these behaviors via norms may be an effective way to foster a healthy learning environment. Similarly advocating for deep critical thinking as a group norm may be an effective way to stimulate rigorous engagement with the course material. For these reasons, we would advocate that setting aside a minimum amount of time for structured norming and check-in activities should be considered a necessary supplement to CBCL.

FUTURE WORK

The intervention was successful because students already demonstrated a high degree of awareness about the processes that do or do not work for their CBCL teams. We can thus infer that for the most part, students already possess some of the communication skills needed to improve negative dynamics in the context of a classroom. However, managing a clinical team is inherently more complex and in itself is increasingly recognized as a core competency of physicians and a necessity for safe, high-quality patient care (5–7). In our hope to best prepare students for the leadership demands that they will face through their careers, we wanted to go further and find ways to actually enhance students' interpersonal and communication skills. We developed the *InterCom* curriculum as a means of incorporating didactic lessons on foundational principles in teamwork and leadership as well as opportunities for experiential learning into the existing CBCL infrastructure. The rest of this section details the theory and specific content of this curriculum, following the steps of curriculum design developed by David Kern:

1. Problem Identification and General Needs Assessment
2. Targeted Needs Assessment
3. Goals and Objectives
4. Educational Strategies
5. Implementation
6. Evaluation and Feedback

Of note, Kern's list describes a "dynamic, interactive process" that does not always proceed in sequence (57). In our situation, implementation (step 5) overlapped with the targeted needs assessment (step 2): The pilot intervention helped us understand the feasibility and best

practices for the full curriculum. Although *InterCom* is currently being implemented, a full explanation of steps 5 and 6 are beyond the scope of this work.

1. Problem Identification and General Needs Assessment

Kern explains that the purpose of a “general needs assessment” is to identify the gap between the current approach to addressing a problem and the ideal approach (57). Although group-based instructional formats provide opportunities for students to develop teamwork skills, such gains are not fully actualized unless those processes are given explicit attention (58). Despite a widely recognized need for developing teamwork skills in medical education, there is no consensus on the optimal way to teach them (59). Rather than adapt an external framework, we sought to create a new curriculum that would be optimal for our environment.

2. Targeted Needs Assessment

Assessing the needs of one’s targeted group of learners and their particular learning environment is critical for integration of a specific curriculum into an overall curriculum (57). The first year of medical school is a developmentally challenging time as students begin to establish their professional identities (60). For many students coming to Harvard, and especially the quarter of the class from backgrounds traditionally underrepresented in medicine, the first year may feature insecurities that they do not belong at such an esteemed institution (61,62). Only approximately one-third of HMS students begin medical school directly after their undergraduate studies, which means that the majority accrued some sort of research or work experience before embarking on their medical studies. That said, all are working to reacclimate to a new educational environment, as they generally have no prior experience with CBCL, and while they find the small group work stimulating, they express a range of opinions about speaking publicly in large group formats. The first months of medical school are frequently

more challenging for the quarter of students who studied non-science majors in undergrad than for students with significant experience with subjects like biochemistry and genetics. In all, while students are very excited to engage with their classmates and finally start working on the skills needed for their careers in medicine, they are also quite eager for guidance about how to navigate this path and gain acceptance from their peers.

Given this context, a defining feature of this curriculum is that it seeks to capitalize on the diversity of student characteristics and experiences. Its overarching goal is to help students identify and further develop leadership styles that feel authentic to them; we do not have some standard view of leadership or teamwork to which we expect all students subscribe. Having students engage with these activities in a classroom setting, surrounded by peers with different leadership styles, may allow them to gain more self-awareness than if they undertook the same activities alone. The lessons are designed to be beneficial—and hopefully enjoyable—for all students, and not just some with certain traits. While some activities may be more uncomfortable for some students than others, we take particular measures to ensure an atmosphere of support and safety, that students may learn all the more from working together.

3. Goals and Objectives

InterCom consists of six lessons spaced over the course of the first year (Figure 7A). The topics of these lessons and their specific objectives were chosen based on our preliminary analyses of the data, personal experiences in teaching and learning in the *Pathways* curriculum, formal studies of teamwork and leadership at various Harvard graduate schools, and consultation with a professional executive coach (Figure 7B). Many of these skills are highly translatable to the clinical setting (2,3,63).

The sequencing of the lessons was highly intentional. First, they are progressive, with later ones building on earlier ones. As much as possible, the didactic portions of the lessons reference previous ones as a means of spaced repetition. Second, the topics are aligned with the social-emotional tenor of the primary classes in which they will be embedded.

- An “Introduction to CBCL” session will occur during orientation week, just after students complete a Leadership and Team Simulation activity but before they have participated in any CBCL sessions. This will be an interactive full-class lecture in which faculty explain the rationale and practice of CBCL and this curriculum specifically.
- Lesson 1, “Building Community: Mission and Norms,” emphasizes community building. It occurs during *Foundations*, students’ first course that interleaves seven basic science units (e.g., biochemistry, pharmacology, microbiology, etc.) and is unique from the other courses in that it involves students working in a different group for each sub-unit (so students will be in three different teams per day, and perhaps five teams in a week). Because they are just getting to know the other students in their section, they are all very much in Bruce Tuckman’s “forming” stage, testing the waters about what behavior is appropriate and what they must do to gain acceptance (64). As such, classroom-wide (in addition to small group) discussions about expectations will help reduce anxieties.
- Lesson 2, “Awareness of Process,” occurs during the second half of *Foundations* and takes the first steps in encouraging students to monitor group dynamics as they are happening. This ability to reflect on the processes happening during their classes (and not just review the content that they are learning) is a cognitively demanding feat and will be essential for all subsequent activities.

- Lesson 3, “Leadership and Group Roles,” explores the different roles that individuals can perform in groups and occurs during *Immunity in Defense and Disease*. By this point, students will likely have settled into their preferred patterns of behavior—those who speak up a lot, those who sit back, etc. The lesson might challenge students to think about contribution differently and encourage them try on different roles before they become too entrenched in their habits.
- Lesson 4, “Conflict Management,” will occur during *Essentials of the Profession*. This course includes a unit on Medical Ethics and Professionalism, which often deals with contentious topics. Although Lesson 4 is somewhat challenging, getting to it sooner rather than later will allow students to use the skills they learn for the rest of their classes. Furthermore, because it is so large, it is broken into three separate components that will be spread over the course of the month. This Lesson’s Part 3 also relates to *Essentials’* Social Medicine unit, which addresses issues of power and privilege.
- Lesson 5 is titled, “Emotional Intelligence.” Although this is a foundational skill that could appear earlier (such as before the conflict lesson), we think it would do well to occur during *Homeostasis I*, students’ first physiology course. Many students find it the most challenging course of medical school and feel overwhelmed and discouraged. As such, this is a prime opportunity to recognize their own emotions and support one another.
- Lesson 6, “Giving and Receiving Feedback,” is in many ways the most challenging. It requires a level of trust that students have each other’s best interests in mind and references skills in conflict management and Emotional Intelligence. It is important that

students have some experience in this domain because feedback will be a major aspect of their clinical training (65).

4. Educational Strategies

This section is an overview of the specific strategies that were selected to best achieve the desired educational objectives (57). Because a description of the approach for each of the six lessons would be too exhaustive, we focus on the curriculum design overall. To structure this discussion, we map each *InterCom* lesson's activities into the framework of Kolb's experiential learning cycle (Abstract Conceptualization, Active Experimentation, Concrete Experience, and Reflective Observation) (66), which fits remarkably well within *Pathways*' existing flipped-classroom structure: All *InterCom* lessons involve preparatory work and then an in-class activity of approximately 40 minutes in which students apply those concepts firsthand. Each step of Kolb's cycle illustrates a key educational principle or theory we applied to this curriculum specifically.

Abstract Conceptualization: Conceptual Change

Just like regular CBCL activities, each lesson of *InterCom* begins with a preparatory assignment. One purpose for these assignments is to provide some instruction on key topics in leadership and teamwork. Each assignment includes background readings on the topic and a description of the in-class activities. We intend for the readings to be as accessible as possible, so we usually included reviews rather than primary sources. While these readings are an essential prerequisite for learning, by no means are they sufficient.

On this topic, we invoke the conceptual change model, which rests on the belief that "students' ability to learn and what students learn depend on the conceptions which they can bring to the experience" (67). Students are likely entering these lessons with a number of

preexisting perceptions about what teamwork and leadership is about, and these biases and perceptions may limit their ability to engage with the readings and subsequent activities of *InterCom* (68). As such, we anticipate that students will occasionally have to recast their previous notions about what teamwork may be. The first step in this process is to recognize their current belief and possible limitations.

Thus, an even greater motive for the preparatory assignments is to stimulate students to reflect on their current understandings and abilities. Throughout these assignments, we provide students significant responsibility in “self-authoring” their own participation: determining their own learning needs and creating their own plans (69). Thus, while the preparatory readings present a certain perspective about various aspects and actions of group work, we are clear that many are only frameworks and best practices, and that students can and indeed should develop their own understandings. We try to create a context in which students can see the arguments and evidence about other frameworks so that they may determine how their own model compares. Even if students do not ultimately change their attitudes or behaviors, the goal is that they critically assess their previous habits in light of other possibilities.

Active Experimentation and Concrete Experience: Metacognition

The in-class activities are designed to provide students a space to start applying and practicing the skills first discussed in the preparatory material. As mentally demanding as it is for students to keep up with the medical content itself, it is all the more burdensome for them to also think about the ways in which they are working with their groups as they go about engaging with that material. Given that the underlying issue here is one of cognitive load, we employ several metacognitive strategies to make this practice more effective.

First off, setting aside time from their regular classwork for these sorts of group process-related activities is essential. By providing students a chance to shift their attention away from their regular class activities and onto the team dynamics that are normally occurring during them, we engage in what David Perkins et al (1990) call “timesharing” (70). Even if the students are sitting in their same seats at the same time of day and have the same facilitator present as their usual class, having time set aside from the course content will help them think about the behaviors and dynamics that they might otherwise have been too busy to recognize.

Next, because it is mentally burdensome for students to manage the logistics of classroom activities and also participate in them, we follow Robert Swartz and Sandra Parks’ (1994) recommendations to “download the mnemonic load” onto physical artifacts and provide students handouts or worksheets to help them document their work and progress through the activities (71). Additionally, all of the in-class activities will have the core course faculty present to oversee—for example, distributing materials, ensuring groups are following the directions, timing activities, and moderating discussions.

Reflective Observation: Transfer

Critical self-reflection is necessary for developing what Patricia Cranton calls emancipatory knowledge, or increased self-awareness and transformation of perspectives (72). Although opportunities for this sort of transformative learning already exist in the context of *Pathways*’ CBCL activities, they have to date not been capitalized upon. Many *InterCom* lessons involve follow-up assignments asking students to keep practicing that skill they initially tried in class or to reflect on the experience. Students will write those reflections in a running Reflection Portfolio so they can see in one consolidated document how they progressed over the course of the year. The journal prompts often ask them to record their affective reactions to the

activities and how their actual experiences compared to their expectations of the activities, highlighting contrast and potential changes.

Our hope is that the knowledge, skills, and attitudes that students develop in their small groups will be transferable to other groups with which they will work in the future. In order to ease the transition between that initial in-class application and later practice, the preparatory readings purposefully take on an “expansive framing” (73) to show how the skills will be relevant for not just the in-class activity, but also students’ CBCL experience more broadly, and even beyond. It helps that the social context of the in-class activities where students can initially try out the teamwork skills is quite similar to that of later CBCL activities (70,74). Once students complete their “first run” during the in-class activity, they are at a minimum encouraged to keep trying the skill throughout their regular class sessions and sometimes even assigned a second in-class activity or follow-up practice that asks them to apply the principles on their own time. Asking students to reflect on their experience to glean principles that can relate to dissimilar situations in the future is a means of promoting more distant application (74). For skills as cognitively challenging as these, repeated practice is necessary for students to become familiar enough with the skills that they become almost automatic (70). The hope is that as students gain mastery of the skills through the semi-guided practice exercises and better awareness of potential transfer scenarios through the reflections, they will be more sensitive and motivated to apply them on their own.

5. Implementation

Implementation involves obtaining faculty and leadership buy-in, identifying and procuring resources, identifying and addressing barriers to implementation, introducing the curriculum, administering the curriculum, and refining the curriculum over successive cycles

(57). Briefly, after this curriculum was developed in the spring of 2019, it was presented to the Preclinical Curriculum Committee, which is comprised of the directors of all *Pathways* first-year courses. We are grateful that many of them were supportive and donated time out of their courses for us to implement our lessons. Each lesson has its own Canvas page, and periodic announcements will ensure that students read the proper lesson and completed the prep assignments before the in-class activities. The majority of the work of administering the curriculum is carried out by Dr. Henrike Besche, Associate Director for Curriculum Integration at the HMS Office of Educational Quality Improvement.

6. Evaluation and Feedback

Kern's final step is assessing the performance of both individuals (individual assessment) and the curriculum (called "program evaluation") (57). For individual assessment, there is little precedent with regards to measuring the performance of medical students' interpersonal skills in a classroom environment. Previous work at the University of Virginia School of Medicine studying the impact of teamwork activities embedded in a team-based learning curriculum used a "Team Debriefing Tool" to assess students' development on eight foundational teamwork knowledge, skill, and attitude competencies (75). While either the TPS or that instrument would be a good start, future work will explore ways to more fully capture the range of skills that students will be practicing, including how they may impact team performance.

Regarding program evaluation, HMS possesses a number of mechanisms by which instructors gather feedback about curricular content. The *Pathways* curriculum is very much an evolving entity, and faculty are constantly adapting their materials from year to year. One of the most distinctive processes to facilitate this is the Ed Reps program, in which student representatives from each section serve as ambassadors that regularly meet with course faculty

and communicate their peers' perceptions and concerns (76). Although many of the design decisions in this curriculum are formed by our impressions of student experience, we realize our views are not representative of all students, and we anticipate the Ed Reps would provide valuable information about what works and what can be improved. It is our hope that the evaluation and further development of the *InterCom* curriculum may be carried forth by subsequent HMS students with an interest in medical education.

SUMMARY

These data indicate that CBCL teams can be interdependent learning teams, but students may benefit from support. The TPS showed that while students rated their groups fairly well on average, there was marked variation, with a portion of scores near the maximum and another portion comprising a left-sided tail of much lower scores. The qualitative analysis revealed six key themes characterizing students' experience in CBCL groups. Stratifying the theme frequencies across different TPS score categories showed that students from groups above a score of 75 had roughly similar experiences, while students who rated their groups below that more frequently identified safe environment as an issue that needed improvement. These data suggest that the TPS can be employed as a screening tool to identify groups likely to benefit from support.

The norming intervention was designed to help individual students share their perceptions with their group members, and to then act on them to improve their dynamics. Following the intervention, we saw a significant increase in individual TPS scores across the whole class, fewer students identifying a safe environment as an area needing improvement, and less asymmetry of experience among students within groups. In all, these data suggest that a brief intervention on group dynamics can be well-accepted by students and may aid in the rapid and reliable formation of learning teams. We recommend that educators ensure time for students to address elements of group process for the sake of optimizing their learning environment.

Providing guidelines about the specific norms by which students should abide may be a way of promoting optimal learning conditions. Future work will investigate how a supplemental curriculum can leverage CBCL activities to more fully develop students' interpersonal and communication skills.

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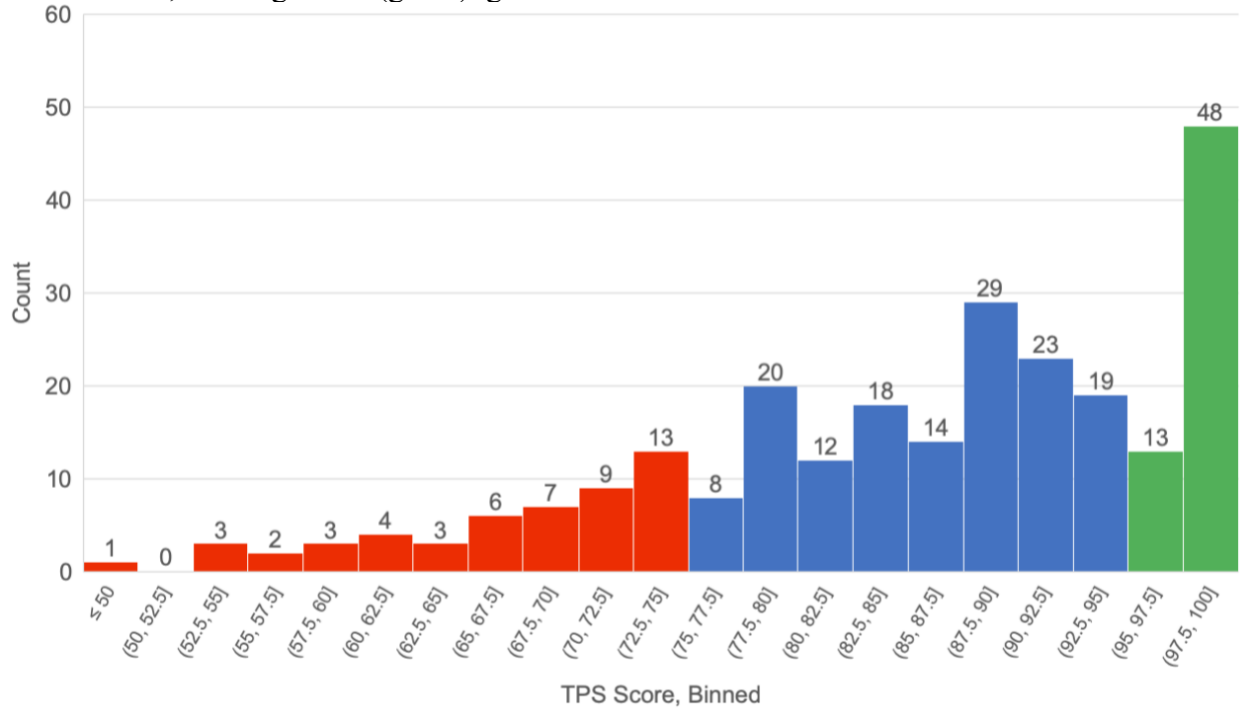
TABLES AND FIGURES

Table 1. CBCL elements in relation to recommendations for other group learning formats.

	Cooperative Learning Recommendations	CBCL Elements in Practice	Team Learning Recommendations
Groups: work in-class or out-of-class?	In-class	In-class	In-class
Duration of groups?	Half-term (or so)	4 weeks	Whole term
Size of groups?	4 or fewer students	Usually 4 students, sometimes 3	5-7 students
Use assigned roles?	Yes	<i>No</i>	No; counterproductive
Grade the group work?	Maybe; maybe not	<i>No</i>	Yes; critical
Spend class time teaching and analyzing group process skills?	Critically important	<i>No</i>	Nice but not critical
Ensure <i>prompt</i> feedback on individual and group performance?	Nice but not critical	<i>No</i>	Critically important
Use peer assessment?	Maybe	<i>No</i>	Yes; critical
<i>Adapted from Table 1.2 "Recommendations for Using Small Groups" (33)</i>			

Figure 1. Histograms of individual TPS scores.

A. 2017 and 2018 Baseline (n=255). We derived three TPS score performance categories based on the free response data: Low-TPS (red): less than or equal to 75; Middle-TPS (blue), greater than 75 to 95; and High-TPS (green): greater than 95.



B. 2018 Post-intervention (n=161). Colors indicate the same TPS score categories as in the baseline cohort. Fewer students rated their group in the Low-TPS range than before the intervention.

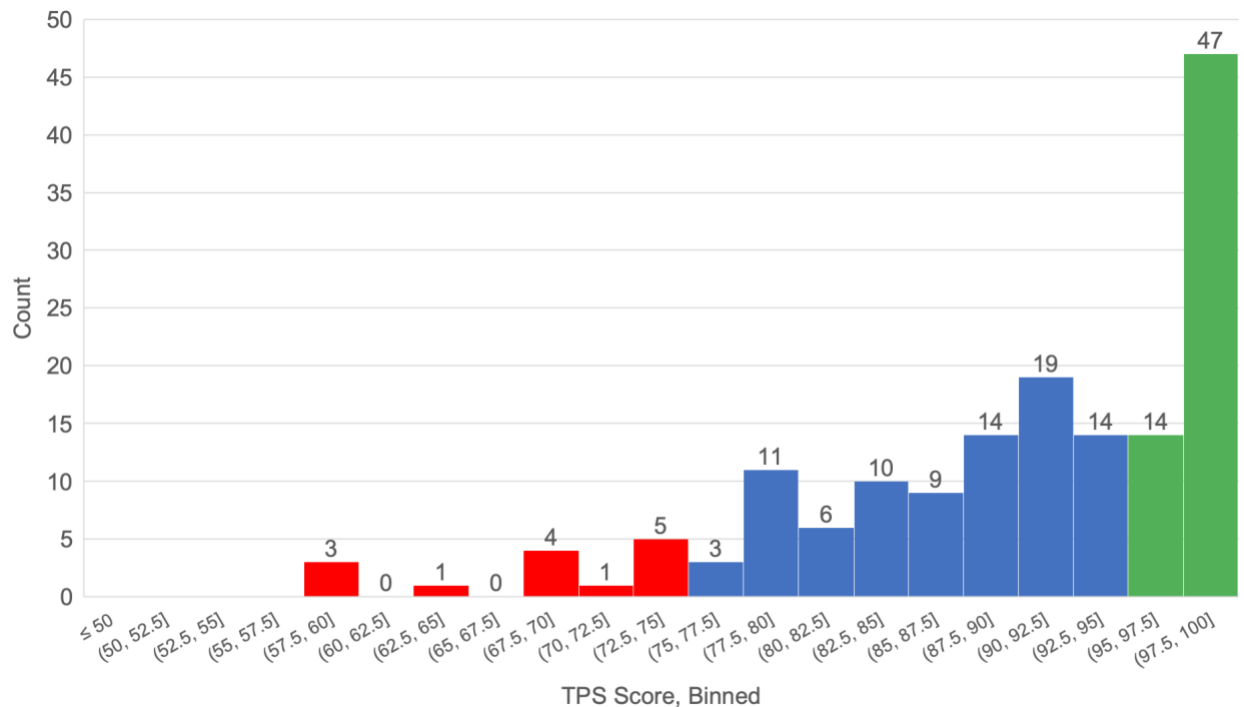


Table 2. Thematic analysis of student free responses.

Theme	Representative Quotations
Preparation and focus	<p>What is one thing that your team has done well?</p> <ul style="list-style-type: none"> • “We are able to apply concepts from the reading to the cases effectively because we are well prepared.” • “We are an engaged group. We are all interested in the material, pay attention, and seek to answer the questions.”
	<p>What is one thing that your team could improve on?</p> <ul style="list-style-type: none"> • “Maybe some teammates be more on time as we only have about thirty minutes per morning.” • “We need to work on sticking to answering the questions posed and staying on track. We get sidetracked on details frequently, which then leads to members being focused on different things instead of trying to answer the same questions.”
Promoting balanced participation	<p>What is one thing that your team has done well?</p> <ul style="list-style-type: none"> • “We use a systematic approach to idea-sharing to ensure that everyone has a chance to take the lead and voice their opinion. We all take time to develop our own answers before sharing them with the group. When it comes time to share with the group, we rotate leadership around the four of us, with each subsequent person taking the lead each time we tackle a new question.”
	<p>What is one thing that your team could improve on?</p> <ul style="list-style-type: none"> • “We could distribute contributions more evenly among team members. There are two of us (myself included) that probably talk a little bit too much... On the other side, the other two members could contribute more.”
Ensuring universal understanding	<p>What is one thing that your team has done well?</p> <ul style="list-style-type: none"> • “We always take extra time to explain to a team member who doesn’t understand the concept to ensure that we cover gaps in each other’s learning.”
	<p>What is one thing that your team could improve on?</p> <ul style="list-style-type: none"> • “Maybe we can try to explain concepts more fully just as an exercise in testing our own knowledge, even if it seems like everyone understands. That way we can make sure that everyone is learning and reveal misunderstandings, instead of just stating the answer and assuming everyone understands.”
Safe environment	<p>What is one thing that your team has done well?</p> <ul style="list-style-type: none"> • “I think members in the team are willing to listen to different ideas without interrupting or without being rude and giving consideration to each idea.” • “We were really positive and fostered a ‘low stakes’ learning environment where members could feel comfortable throwing around ideas without the pressure of feeling like they had to get the ‘right’ answer.”
	<p>What is one thing that your team could improve on?</p> <ul style="list-style-type: none"> • “making sure everyone can voice disagreement” • “My group sometimes talks over the class speaker or will break off into a smaller group to discuss a secondary question of the case, which can be a little off-putting, like you are a second-class citizen at the table. There is also a lot of usage of the word ‘gunner’ which can feel intimidating and not like a good learning environment.”
<i>Continued on next page.</i>	

Table 2 continued. Thematic analysis of student free responses.

Theme	Representative Quotations
Grappling and synthesis	What is one thing that your team has done well? <ul style="list-style-type: none"> • “Discussing lots of ideas before deciding what the correct answer is” • “Take each person’s points of view to help further our overall team consensus.”
	What is one thing that your team could improve on? <ul style="list-style-type: none"> • “I think sometimes if we do happen to agree on an answer, we may not push ourselves to continue further discussion, and end up missing an important secondary point that gets elucidated in the general classroom discussion. We should work on not becoming complacent if we all agree.”
Larger group learning	What is one thing that your team has done well? <ul style="list-style-type: none"> • “Speak up when no one else in the class was speaking. Volunteered our discussion.” • “We encourage each other to share our answers with the larger group.”
	What is one thing that your team could improve on? <ul style="list-style-type: none"> • “We can probably participate more as a table during [section]-wide discussions—we often feel comfortable with our understanding and prefer to listen to our classmates, but we could do more to share our explanations with the class too.”

Figure 2. Free response theme frequency, 2017 and 2018 Baseline (n=255). Left-sided (dark gray) bars represent a theme’s frequency in the responses for the Improve question; right-sided (light gray) bars represent the theme’s frequency in the responses for the Done well question. Comparing the magnitude of the left and right bars for a given theme suggests whether students view it as a relative weakness or strength.

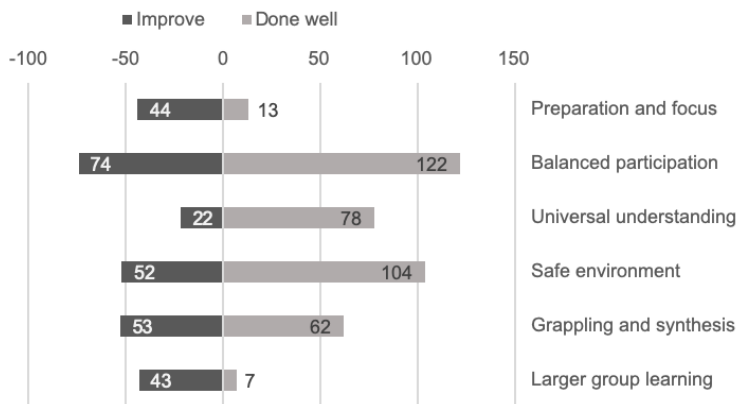


Figure 3. Theme frequencies stratified by TPS score categories. In the 2017 and 2018 Baseline data set, the theme profiles were largely similar for students in Middle-TPS groups (A) and High-TPS groups (B), while students in Low-TPS groups (C) more frequently identified balanced participation and safe environment as areas needing improvement. In the 2018 Post-intervention cohort, a similar distribution of themes was seen within the Middle- (D) and High-TPS groups (E). Although the size of the Low-TPS group (F) is smaller in this cohort, it had Done well comments outnumbering Improve comments for Safe environment.

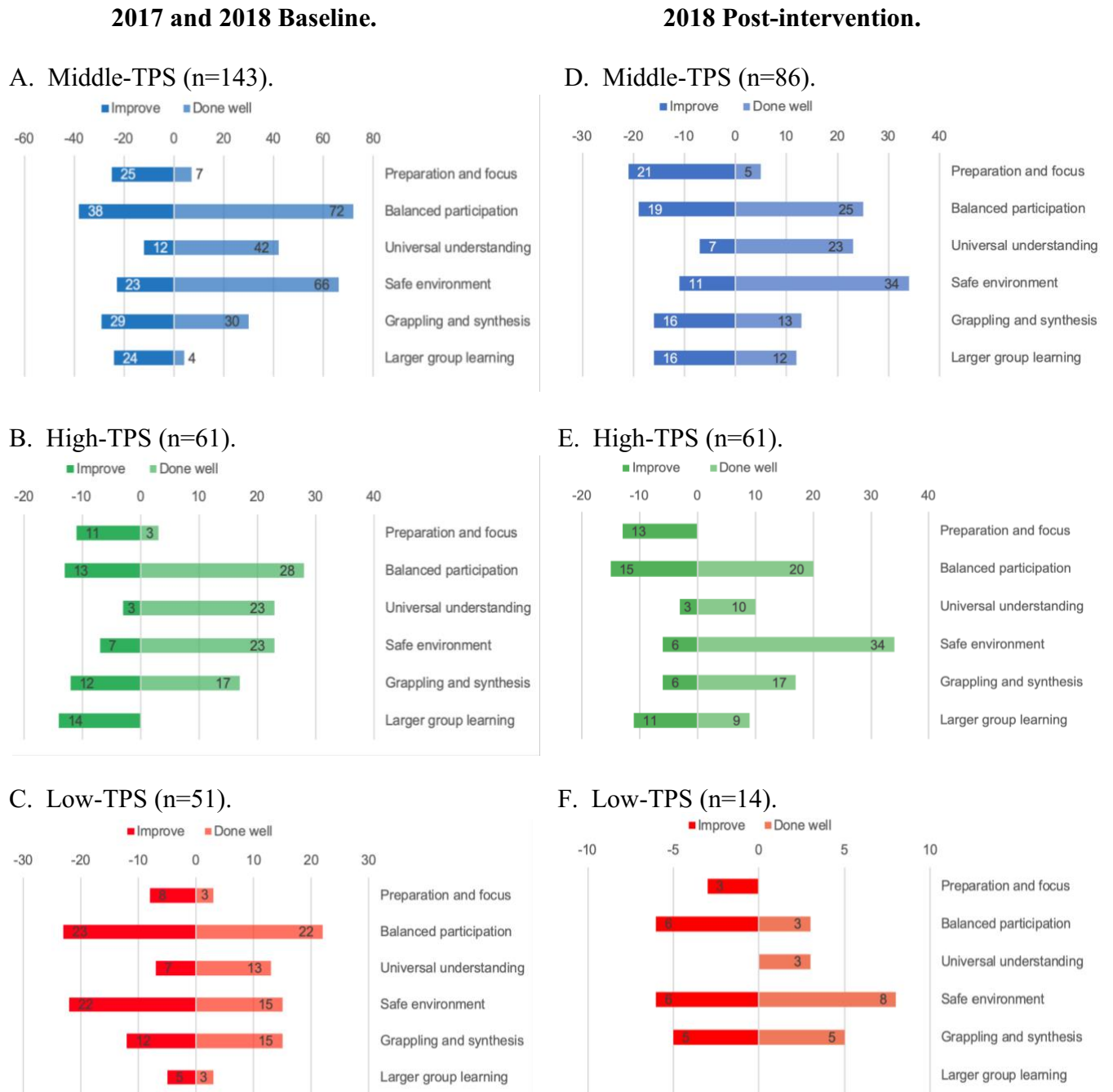


Figure 4. Scatterplot of group TPS means and SDs, 2018 Pre-intervention. The vertical bar at 75 separates “Toxic” red-colored Low-TPS groups from blue-colored Middle- and green-colored High-TPS groups, which are grouped together into a “Well-Performing” region. The “Asymmetric” region contains groups whose TPS SD is over 14.0. Highlighted dots represent groups that are specifically referenced in the text.

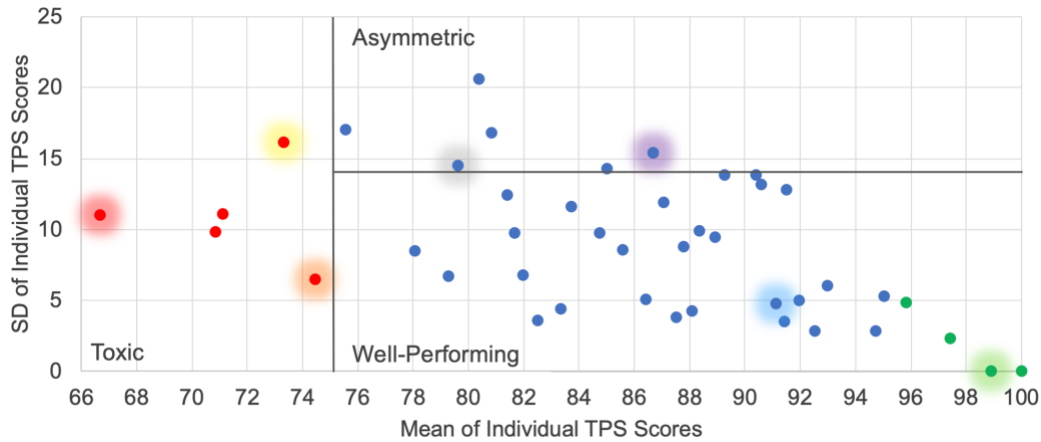


Table 3. Regional distribution of 2018 Pre- and Post-intervention groups by TPS mean/SD.

	Pre-intervention	Post-intervention
Toxic	5	0
Asymmetric	7	5
Well-Performing	32	39

Table 4. Example thematic analysis of group norms.

Group Norms	Themes
<ul style="list-style-type: none"> • Encourage dissenting opinions • Do not interrupt other people • Ensure that everyone is ready before discussion (using name cards to indicate readiness) • Explain thought processes behind answers 	<ul style="list-style-type: none"> • Grappling/Synthesis • Safe environment • Participation • Understanding
<ul style="list-style-type: none"> • Doing the prep – prepared for class • Taking turns answering questions • Ask other questions after finishing discussion on the question at-hand • No belittling any train of thought • No leaving • Don't dismiss anyone if they seem as though they haven't fully grasped the material 	<ul style="list-style-type: none"> • Preparation • Participation • Preparation • Safe environment • Preparation • Understanding
<ul style="list-style-type: none"> • Ensure members arrive on time and alert • Ensure members are given a minute to review the question at hand and formulate thoughts before the group discusses collaboratively • Ensure the question at hand is answered, before other relevant ideas are explored • Ensure that correct and incorrect answers are explored, defining the pathophysiological reasons that make them correct and incorrect • Ensure that all opinions are respected and welcome • All in all, ensure that all members are having an enjoyable time at the table. 	<ul style="list-style-type: none"> • Preparation • Participation and Understanding • Preparation • Grappling/Synthesis • Safe environment
<ul style="list-style-type: none"> • Be as punctual as possible. Things happen and it's okay to be late sometimes, but not all the time. • Reach group consensus on an answer and make sure each person understands why a particular answer was reached (recap of conclusions and summarize what remains confusing towards end of discussion) • Be sure to elicit differing opinions and bring it up (have person explain their POV or thoughts) to ensure that everyone is on the same page • No team leader but everyone should feel comfortable initiating table discussions; if this becomes problem (awkward silences during table discussions), we will re-assess. • Person who has best grasp of an answer can share it with the larger group/class if they are comfortable doing so; if it's the same person every time, we can re-evaluate and discuss how to ensure more participation in large group discussions. • Let table know if there's anything confusing from lecture or larger group discussions; if time allows we can discuss and go over concepts as a group. 	<ul style="list-style-type: none"> • Preparation • Grappling/Synthesis and Understanding • Participation and Understanding • Participation • Large group • Understanding

Figure 5. Theme frequency of group norms, 2018 Post-intervention (n=42 groups).

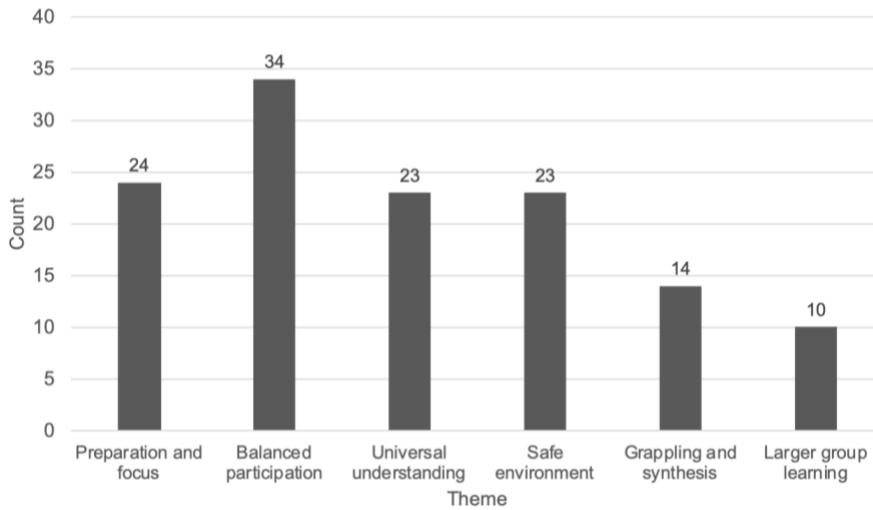


Figure 6. Conceptual model of CBCL. A prerequisite for a productive CBCL session is individual students being prepared and focused. Students’ efforts to promote balanced participation and ensure universal understanding go hand-in-hand to fuel the initial group discussion. Engaging in those actions may give rise to a safe environment, which feeds back and helps students better participate and understand one another. It also facilitates the secondary discussion in which groups grapple with discrepant ideas and ultimately settle on an answer that they can report out to the larger group.

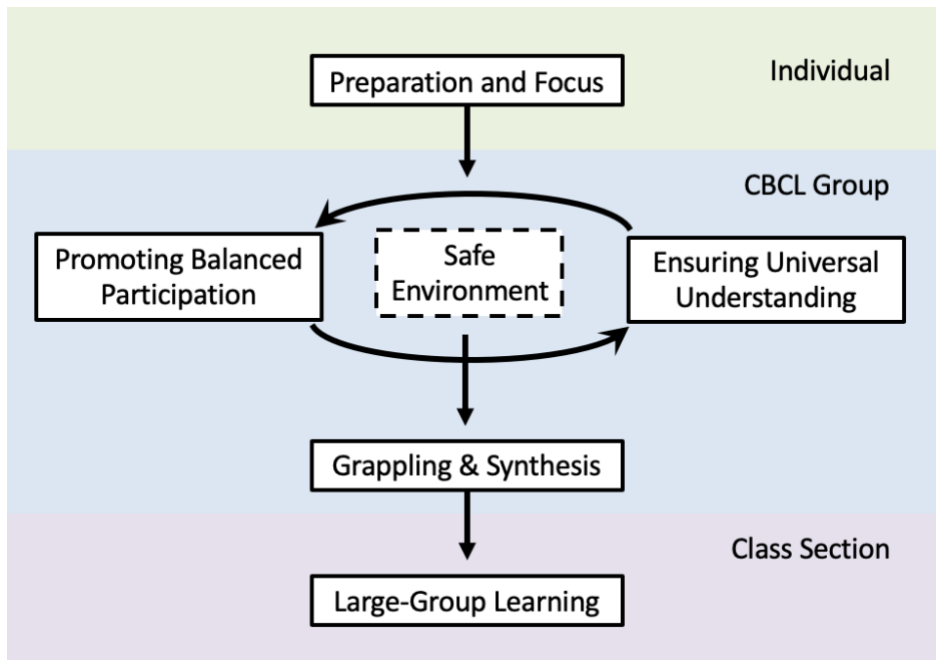
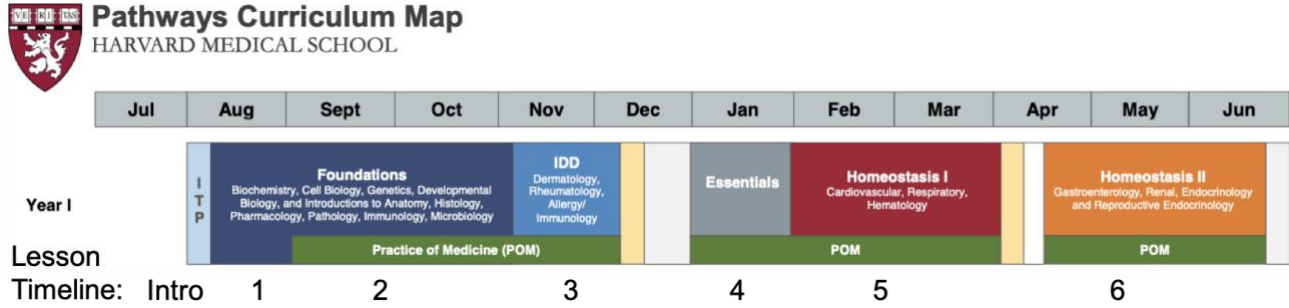


Figure 7. InterCom Curriculum.

A. Lesson Timeline.



1. Building Community: Mission and Norms
2. Awareness of Process
3. Leadership and Group Roles
4. Conflict Management
5. Emotional Intelligence
6. Giving and Receiving Feedback

B. Understanding Goals

Lesson	Understanding Goals
1. Building Community: Mission and Norms	<ul style="list-style-type: none"> • Understand that mission statements and norms help groups establish a shared vision of why and how they want to want to operate. • Understand that upholding norms can promote accountability. <ul style="list-style-type: none"> ○ Proactively prevent undesired behaviors from occurring. ○ Establish notion that undesired behaviors should be addressed. • Understand that norms are an ongoing, fluid framework meant to be revisited beyond the initial formation stage.
2. Awareness of Process	<ul style="list-style-type: none"> • Understand that process refers to the interactions and dynamics that occur as a group is going about its routine tasks. • Understand that the ability to identify and manage processes will help groups achieve optimal performance.
3. Leadership and Group Roles	<ul style="list-style-type: none"> • Understand that engagement can take many forms in a group, including both task functions (e.g., presenting new ideas, refining existing ones) and maintenance functions (e.g., recognizing feelings). • Understand that the ability to engage other group members can enhance group performance.

<p>4. Conflict Management</p>	<ul style="list-style-type: none"> • Understand that too little conflict can be just as problematic as too much conflict, so being able to maintain a healthy amount is necessary for group growth and development. • Understand that most individuals have a natural aversion to conflict and can subconsciously employ a variety of approaches to avoid discomfort. <ul style="list-style-type: none"> ○ “Unproductive rules” of engagement (77). • Understand that deliberate practice can help individuals learn to engage with conflict in a way that addresses disagreements productively. <ul style="list-style-type: none"> ○ “Productive rules” of engagement (77). ○ Interest-based negotiation (78). ○ Conflict management styles (79). • Understand that one’s approach to task conflict and relationship conflict should depend on the specific scenario (80).
<p>5. Emotional Intelligence</p>	<ul style="list-style-type: none"> • Understand that Emotional Intelligence encompasses five domains of developable skills: self-awareness, self-regulation, motivation, empathy, and social skill. • Understand that Emotional Intelligence is a strong predictor of team success (81).
<p>6. Giving and Receiving Feedback</p>	<ul style="list-style-type: none"> • Understand that feedback is a two-sided process, the ultimate effectiveness of which depends on provider, recipient, and contextual factors. • Understand that recipients can prompt providers to give feedback in certain ways.
<p><i>Specific Performance Goals were also developed to articulate how the Understanding Goals will be achieved and demonstrated over the course of each lesson’s activities. They are not included here for the sake of brevity.</i></p>	

Supplements

Supplemental Figure 1. TPS items from original Thompson et al (2009) (44).

Team Performance Survey (TPS) Items

Item	Me
1. All team members made an effort to participate in discussions.	
2. When team members had different opinions, each member explained his or her point of view.	
3. Team members encouraged one another to express their opinions and thoughts.	
4. Team members shared and received criticism without making it personal.	
5. Different points of view were respected by team members.	
6. Often members helped a fellow team member to be understood by paraphrasing what he or she was saying.	
7. My team used several techniques for problem solving (such as brainstorming) with each team member presenting his or her best ideas.	
8. Team members worked to come up with solutions that satisfied all members.	
9. All team members consistently paid attention during group discussions.	
10. My team actively elicited multiple points of view before deciding on a final answer.	
11. Team members listened to each other when someone expressed a concern about individual or team performance.	
12. Team members willingly participated in all relevant aspects of the team.	
13. Team members resolved differences of opinion by openly speaking their mind.	
14. Team members used feedback about individual or team performance to help the team be more effective.	
15. Team members seemed attentive to what other team members were saying when they spoke.	
16. My team resolved many conflicts by compromising between team members, with each one giving in a little.	
17. Members who had different opinions explained their point of view to the team.	
18. Team members were recognized when something they said helped the team reach a good decision.	

* The response scale for each item ranged from "none of the time" (score = 0) to "all of the time" (score = 6).

Supplemental Figure 2. Canvas Page Screenshot: Norming Activity – 2018w4.

Team Performance Survey 2/23

Please note: during this session you will sit in your [week 5-9 table assignments](#) .

Session timeline (8:00 am – 8:30 am)

1. [Complete this survey](#) on team performance survey on experience with your **previous team** over the last 4 weeks. The survey needs to be completed by 8:50 am (5-10 min).
2. Team kick off - using your **weeks 5-9 table assignments** (20 min).

Personal norms (1 minute per person)

1. Discuss personal goals - what are you hoping to get out of this course and what are you focused on.
2. Discuss personal norms - what works really well for you on a CBCL team, what bothers or annoys you, etc.

Team norms (15-20 minutes)

1. Discuss what are norms that the team agrees on (punctuality, cell phone/computer use during session, speaking up for table, time to process questions, etc.)
2. Discuss team organization - is there an assigned leader or do you self-organize every day. If you go with a leader, will she or he rotate by day, what is the role of the leader in the group? How do you plan to resolve problems if they may arise?
3. Briefly (in a couple of sentences and bullet points) summarize key norms that make this group different or distinct and [submit here on Canvas](#) before 8:50 am (please only upload one submission for your whole group - you can decide who submits).

Supplemental Figure 3. Canvas Page: Check-in – 2018w6.

Team Performance Survey 3/9

Session timeline (8:00 am – 8:20 am)

Please sit in your CBCL ([Weeks 5-9 Learning Studio Table Assignments](#)) for this session.

1. Team feedback (20 min)
 - o Compared to other teams you have been on, how is this team working for you?
 - o What are some things this team is doing well?
 - o What are some things this team could improve on?
 - o Briefly (in a couple of sentences and bullet points) go over previously agreed on norms and describe what you will stop/start/continue doing as a team and [submit on Canvas here](#). Please note: only one member from your team needs to submit on behalf of the whole team.

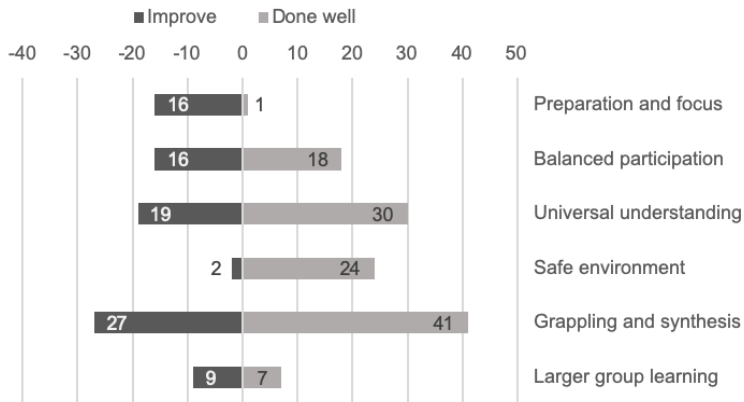
Supplemental Table 1. TPS score comparison with original Thompson et al (2009) (44).

Level of Analysis	Original	2017w2	2018w4	2018w8
Item				
Number of items	18	17	18	18
Maximum score per item	6	5	5	5
Maximum sum of item scores	108	85	90	90
Lowest mean score per item	4.9 (82)	3.8 (76)	3.7 (74)	4.2 (84)
Highest mean score per item	5.5 (92)	4.7 (94)	4.6 (92)	4.7 (94)
Individual Student				
Mean TPS score	96 (89)	72 (85)	77 (86)	81 (90)
SD	14 (13)	11 (12)	10 (11)	9 (10)
Team				
Mean TPS score	96 (89)	n/a	77 (86)	81 (90)
SD	9 (8)	n/a	7 (8)	5 (6)

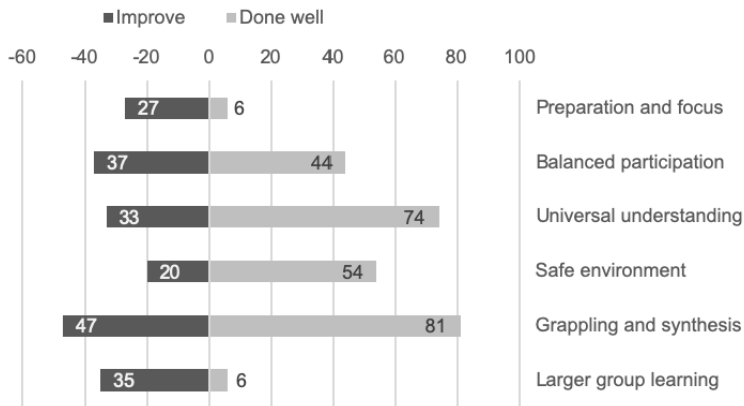
Parentheses indicate raw scores as a percentage of the maximum.

Supplemental Figure 4. Free response theme frequency by class cohort.

A. 2017w2 (n=90).



B. 2018w4 (n=165).



Supplemental Table 2. Free response thematic richness by cohort.

	2017w2	2018w4	2018w8
Free responses (n)	90	165	161
“Done well” codes assigned	121 (1.3)	265 (1.6)	221 (1.4)
“Improve” codes assigned	89 (1.0)	199 (1.2)	164 (1.0)
<i>Parentheses indicate ratios of codes assigned to the number of free responses per cohort.</i>			

Supplemental Table 3. Inter-rater reliability.

Theme	Cohen’s Kappa
Individual preparation and focus	0.760
Promoting balanced participation	0.740
Ensuring universal understanding	0.769
Safe environment	0.830
Grappling and synthesis	0.676
Larger group learning	0.815
Overall Average	0.765

Supplemental Figure 5. HMS Community Mission Statement and Norms, 2019.

HMS Community Mission Statement

The Pathways curriculum is designed to foster the critical thinking and interpersonal skills fundamental to successful members of a 21st century healthcare team. CBCL sessions serve as an opportunity for students to learn about not only content, but also the processes by which they engage with it and the dynamics that arise from them. We use community norms as a means to promote our accountability as individuals and as teams, foster respectful discourse, and connect deeply with our diverse HMS community.

Community Norms:

- **Preparation.** By maximizing your own ability to contribute with class content, you can enhance your group’s efforts as well. Be responsible to your peers.
- **Engagement.** Be engaged yourself, and seek to engage others. Leadership is a shared process grounded in respect: make space and take space.
- **Growth.** It’s not always comfortable: Mistakes and conflict are opportunities to learn from our differences; embrace patience with yourself and others, self-reflection and feedback.
- **Curiosity.** Actively listen to what people are saying and examine your own beliefs, biases and emotions as you respond. How many ways are there to see things differently?
- **Trust.** Trust in your own competence as well as your peers’, and the process too. Assume everyone is doing their best—we are all united in our goal of becoming exemplary physicians.