

# BUILDING EFFECTIVE TEAMS AND TEAMWORK SKILLS

SANDRA L. PETTIT AND CLIFFORD L. HENDERSON  
The University of Alabama • Tuscaloosa, AL 35487

## INTRODUCTION

Whether working in engineering design, production and manufacturing, or research and development, most engineers will spend a significant portion of their career in teams. Teams may consist of other engineers or be multidisciplinary. Teams may include nontechnical members, consumers/clients, manufacturers, government liaisons, and many others. Development of team skills is vital to becoming a successful and productive engineer. In a meta-analysis by Riebe and others, it is noted that employers expect graduates to be able to effectively work in teams as soon as they enter the workforce and that they equally weigh the need for teamwork and related interpersonal skills with graduates' technical skills.<sup>[1]</sup> The importance of teamwork is further evidenced by the ABET Engineering Accreditation Commission. All programs seeking accreditation for engineering programs must document the attainment of specific student outcomes, including the ability to function effectively on a team.<sup>[2]</sup>

It is at this point that perhaps a delineation between and definition of groups versus teams should be made. Often these terms may be used loosely and interchangeably, but practically there are some very important, but perhaps subtly different, functional distinctions between a team and a group. Whether the collection of students placed together makes the transition from being a group to truly functioning as a team itself may often dictate their success or failure in producing a good end product for their course assignment. According to Katzenbach and Smith, for managers and leaders to make better decisions about whether, when, and how to encourage and use teams in a corporate environment, it is important to be precise about what a team is and isn't.<sup>[3,4]</sup> It is equally important in the educational setting for faculty to understand these differences and to also make sure that their students understand these differences as well.

At a fundamental level, Katzenbach and Smith argue that a "group" is a collection of individuals brought together for the purpose of things like sharing knowledge and coordinating efforts but whose goals and performance center around

and are judged upon individual goals, results, and achievements.<sup>[3,4]</sup> In that case, characteristics of groups include individual goals, individual accountability, and individual success or failure. In the academic setting a good example is the classic "study group." Students come together to form such groups to share knowledge and reinforce learning amongst one another, but each individual in such a group maintains their own academic goals, is most commonly accountable individually through their independent completion of learning evaluations such as tests, and ultimately whose success or failure is reflected most directly in an individual grade. In contrast, a "team" is a collection of individuals who share common goals, generally have both individual and team accountability, and who succeed or fail as a team.<sup>[3,4]</sup> In the engineering course setting as it pertains to a lab team or project team, the collection of students working together in such instances should truly be functioning as a team when they ultimately produce a common product such as a lab or project report and as they share a common grade for such a work product.

**Sandra L. Pettit, PhD, PE** is the Assistant Dean for Student Success in the College of Engineering at The University of Alabama. Previously, as a Professor of Instruction in chemical engineering at the University of South Florida, she taught team-based senior engineering courses with integrated professional development for several years. Prior to joining academia, her industrial experience included over 15 years of team management in manufacturing, plant design, and construction.



**Clifford L. Henderson, PhD,** is the Dean of the College of Engineering at The University of Alabama and a Professor of Chemical and Biological Engineering. He received his B.S. in Chemical Engineering from Georgia Tech and M.S. and Ph.D. from The University of Texas at Austin. In his current and prior roles (faculty at Georgia Tech and Department Chair at USF) he has been heavily involved in advancing engineering curricular innovation and engineering pedagogical innovation.

For many students, they learn about team function by being placed in a group and being assigned a project.<sup>[5]</sup> Some students may find themselves in a like-minded group with similar individual academic goals and work styles that can both lead to team success and to the belief on the part of the student that they understand and are proficient at teamwork. Others may find themselves in teams with conflicting individual goals and expectations, work styles, or other issues that result in a variety of negative team experiences and often poor team performance. Those same students also may have little actual experience or skill in constructing and managing teams and teamwork, which may lead them to questions such as why their team is “so bad,” why they personally are bad at teamwork, or even whether teamwork is valuable and something they wish to participate in going forward. In either case, their success or failure and that of their team are heavily influenced by luck.

Studies have shown that professional skills development, like communication skills, benefits from situated learning.<sup>[6,7]</sup> In other words, utilizing a simulated workplace context for the students to practice the skill and receive feedback provides an active learning environment to effectively develop the skill. This teaching strategy can be reasonably applied to other professional skills development. So when assigning team-based projects, the pedagogy of teamwork should be taught (or, if previously taught in another required prerequisite course, be reinforced in the current course), and development and application of teamwork methods and skills should be emphasized and formatively assessed. Tools and techniques to aid in the progression of the developmental stages of teams and teamwork should be formally introduced to the students and teams. To prepare students for successful team-based work, they need a basic understanding of the organizational psychology underpinning teamwork and practice with the tools and techniques to develop and sustain team effectiveness.

**The goal of this paper is to introduce faculty to strategies, techniques, and tools that can be utilized to teach teamwork skills during team-based assignments and projects.** The content is tailored to the needs of chemical engineering faculty in laboratory courses and courses involving team projects, such as process and/or product design courses. To establish a common vocabulary for discussion, team effectiveness will be introduced from the viewpoint of organizational psychology. Our temporal model to evaluate growth of team effectiveness is based on a slightly modified version of Tuckman’s model for small group development.<sup>[8]</sup> Finally, tools and techniques that can be utilized at each stage of team development to enhance team performance and productivity will be shared. This will also include suggested resources and readings for advanced content that should be shared with students as part of their formal education with respect to team formation and operation. The tools provided will not only aid in the execution of

the course, they will prepare students to effectively tackle a variety of future team-based opportunities with a structured way to think about and develop functional teams.

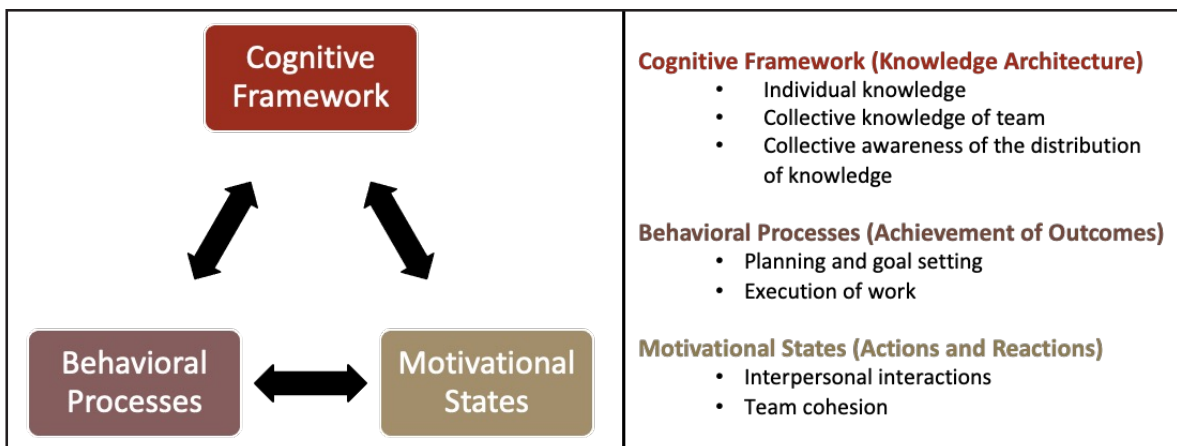
## FUNDAMENTALS OF TEAMWORK

While the benefits of learning teamwork skills are well documented, educators often place students in teams to accomplish homework and projects in a course when they have had little or no training on teaming and teamwork skills in their prior formal college coursework requirements and when no such formal training in teamwork is included in the current course itself. In fact, in a survey of 50 engineering faculty members across five institutions and multiple disciplines, 41 indicated that teamwork was not explicitly taught anywhere in their curriculum, and the top reason for no formal training was that they did not know how to teach it.<sup>[5]</sup> There is not a general and clear consensus on the required elements of teamwork pedagogy, which results in educators and faculty feeling inadequately prepared to address the topic in a formal manner with their students as opposed to the technical content of their courses. Further, they report having little to no time to develop materials or to teach the content and having little experience in the assessment of team processes (in comparison to assessment of work product outcomes).<sup>[1]</sup> While there is still significant work to be done to advance the pedagogy of teamwork and validate the efficacy of team building tools, we can draw upon fundamental research in psychology and generally accepted business practices to guide our teaching of team skills. In the sections to follow, we will describe a framework to explain the fundamental constructs of teams and a developmental model to assess team processes at various stages. This framework and model can be shared with students to explain the background and encourage the use of the team building tools and strategies presented in later sections.

### Psychology of Team Effectiveness

In a meta-analysis by DeChurch and Mesmer-Magnus,<sup>[9]</sup> key variable mediators that impacted team effectiveness were explored. Team effectiveness was further delineated into the team functioning (processes) and team performance (outcomes). Team function was found to have three cornerstones: the cognitive framework, behavioral process, and motivational states. As shown in Figure 1, the cornerstones are interconnected and influence each other as a team develops.

The cognitive framework is the knowledge architecture that describes both the individual team member knowledge and the collective knowledge of the team. This is developed through general education, on-the-job-training, and practice as a team. The development and impact of the cognitive framework can be greatly influenced by the membership



*Figure 1. Three cornerstones for describing and assessing team function and development.*

and distribution of the team. In teams with compositional cognition, members' individual knowledge is similar to the collective team. In teams with compilational cognition (e.g., multidisciplinary teams), team members have unique knowledge, and the team must develop the organization and distribution of knowledge and the collective awareness of who knows what in order to function effectively.<sup>[10]</sup> Compositional cognition has the greatest impact on team performance (outcomes), whereas compilational cognition has the greatest impact on team functioning (processes).<sup>[11]</sup> Further, compilational cognition becomes increasingly important as teams become geographically and/or temporally distributed.<sup>[11]</sup>

Behavioral processes are the interdependent acts of the team members to organize work and achieve outcomes. These activities include planning, goal setting, coordination, and execution of the work. Motivational states relate to the interpersonal actions and reactions of the members and the cohesion and efficacy of the team. While conceptually distinct, cognition, behavioral processes, and motivational states are interdependent drivers for team effectiveness. They develop in tandem over time as team members interact and achieve goals. A gap or an imbalance in one of these three cornerstones will detrimentally impact the others; therefore, assessing developmental stages as teams are formed and progress through their work is an important process in achieving team efficacy and effectiveness.

### Team Development Model

One of the most influential and cited models for team development was developed by Tuckman.<sup>[12]</sup> Tuckman set out to develop a framework to describe temporal change in small teams. The original model published in 1965 identified four stages: forming, storming, norming, and performing.<sup>[8]</sup> In 1977, an update to the model was published that added a fifth stage, adjourning.<sup>[12]</sup> While the original model

was limited in the available data and team types, it became the exemplar to which future studies were benchmarked. Due to its simplicity and general applicability, educators use this model in teamwork pedagogy to describe the likely stages that a team must pass through successfully to become effective. A summary of the stages with supplemental content<sup>[13, 14]</sup> is presented in Table 1.

It should be noted that in Tuckman's original model, conflict was closely tied with the storming stage of development. Numerous studies have shown that conflict is a complex issue within team development and is not a linear process. Conflict should be evaluated based upon the driver and resolution and is generally an iterative sub-cycle within the model.<sup>[12]</sup> Nonetheless, with minor modification (as shown in Table 1) and explanation of the iterative nature of conflict resolution, the linear team development model is useful in helping students understand the various stages and expected outcomes for team development.

## TOOLS FOR DEVELOPING TEAMWORK SKILLS

### Team Formation

The first step in team-based work is the selection of the team. A comparison of common selection methods is presented in Figure 2. Each method has pros and cons that should be considered in light of the student population and course structure in which teams are being formed and the expected team outcomes. As a matter of practice at the authors' institutions, all of the methodologies described have been utilized in courses across the engineering curriculum. Exposure to the various formation conditions provides a breadth of learning experiences to prepare students for future working scenarios. In considering team outcomes, in addition to the obvious outcomes around the work product to be produced by the team, faculty should consider the

TABLE 1 Stages of Team Development			
Forming (Collection)	Storming (Group)	Norming (Developing Team)	Performing (Performing Team)
People are cautious, guarded, curious	Group is developing identity and purpose	Emerging team is developing goals, roles, and relationships	Team is acting on goals with synergy and efficiency
Minimal visible disagreement, polite	Getting to know each other	Learning to appreciate differences	Differences are valued
Curious about norms	May form pairs or cliques	Norms established	Conflict is framed as problem solving
Testing the boundaries of behavior	Conflict arises readily	Conflict is usually about task, not about personal interaction	Cohesive team
Lacks identity, unity, loyalty	Leaders may be challenged	More communication and a sense of belonging	Collaborative environment
	Confusion, irritation, frustration on the rise		

various learning outcomes they expect students to achieve through the team effort in deciding on the best team selection process. For departments in which students operate in teams across a number of different courses in the curricula, the faculty may want to consider varying the team forming process to increase the breadth of the students' educational experience.

In highly constrained systems where a specific balance in skills or diversity is required or where student schedules vary greatly, educator selection may be warranted. A popular tool used by some educators to assist in team selection and formation is CATME.<sup>[15]</sup> This tool allows information input by the students that can be used in conjunction with weighting factors to achieve specific team selection outcomes and provides a framework for peer evaluations of the team as it is composed and functions. Care should be taken when gathering and utilizing student input for team composition, particularly when using automated tools. Students may use specific constraints such as availability for meeting times to bias the formation process to result in a team composition of their preference. Another more recently developed tool is ITP metrics.<sup>[16]</sup> While both tools are based upon behavioral methods of performance appraisal, they differ in emphasis, interface, and scope. A detailed comparison of the tools is presented by Jamieson and Shaw.<sup>[17]</sup>

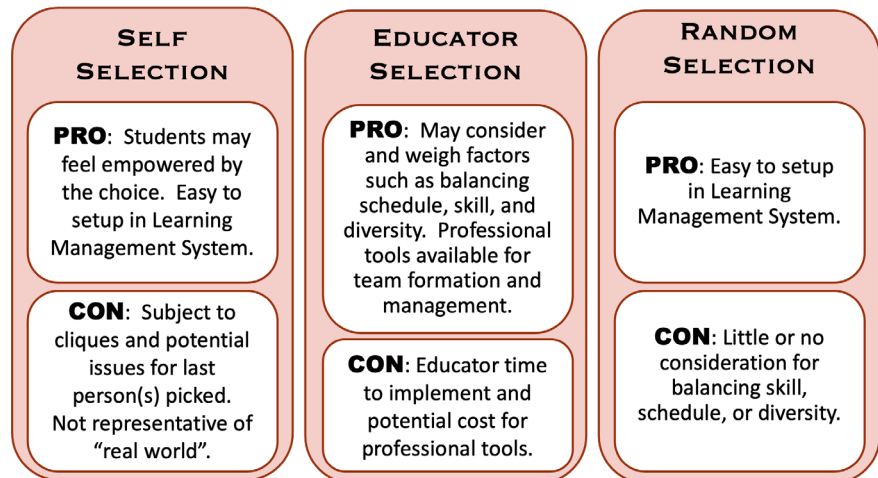


Figure 2. Comparison of team selection methods.

For those with fewer constraints or without the resources to purchase tools such as CATME, one can achieve a similar result using manual student surveys or using a simple hybrid method that combines the benefits of self and random selection. For example, a deck of playing cards can be used as the basis to initially distribute students into teams. The educator creates a class deck by pulling the cards necessary for each student to get placed into the appropriately sized team after selecting a card from the team assignment card deck and finding the other students that have the same matching card type (e.g., three aces, three kings, and four queens can be pulled and used as a team assignment deck that will create two teams of three members and one team of four members). In this manner, all students have a random initial

group assignment. Once students have found their matching student team members, students are given a short time period to discuss their skills and constraints amongst the team. Then, students are given a short period to trade cards with other classmates to reduce potential conflicts, eliminate or minimize schedule conflicts, and diversify skills as necessary. The trades are only complete when students actually agree and exchange cards. This hybrid method more closely matches “real world” scenarios where teams are initially selected based upon availability and proximity, and team leaders or members have to negotiate with other groups to resolve constraints or diversify skills. In some teamwork models, this stage of development would call the students a collection because they have not yet formed a common identity or goal.

A consideration in deciding team formation method is team diversity, equity, and inclusion and the impact of these issues on team dynamics, student experience, student learning, and work product quality. There may be a perception by faculty that self-selected teams will have fewer issues with conflicts and produce higher satisfaction levels with the students in the function of their teams. Likewise, faculty may feel that in cases where self-selected teams do not function well, the students involved can only blame themselves and that the faculty will not be blamed for creating a team assignment that failed and harmed the students’ experience in the course. There may also be similar feelings on the part of students as well. However, it is clear that organizations and companies value diverse teams and the ability of new people joining such organizations to have skills that will allow them to function in such diverse teams.<sup>[1, 18]</sup> If students are never expected to function in diverse teams, then they are missing out on a valuable learning experience as students and one that future employers will expect them to have experience with when they look for a job after graduation. Furthermore, studies have clearly shown that the work product of diverse teams is in general equal to or better than more homogeneous teams. For example, a recent paper by Uzzi and co-authors highlights the increase in the novelty and number of ideas generated by more gender-diverse teams.<sup>[19]</sup>

While random team assignments or instructor-designed teams are not guaranteed to give students a diverse team experience, they are more likely to do so than self-selected teams. In particular, instructor-designed teams can be formed using methods and tools that consider student characteristic inventories or data and that optimize some team diversity objective. One way to encourage students to embrace instructor-designed diverse teams is to point out exactly these kinds of studies and results that show improved team performance and work product and the expectations of employers in this area. In the specific context of assembling diverse teams in a university coursework and project setting, recent research that looked at student evaluations of

their team experience in instructor-designed diverse teams compared to self-selected teams indicated that functioning in instructor-designed more diverse teams did not lead to more general team conflict or less team cohesiveness, but that instead self-selected teams experienced higher levels of conflict in agreeing on meeting times, higher levels of perceived social loafing amongst team members, and lower perceptions of their functioning as a team.<sup>[20]</sup> Again, these types of studies and results are likely worth sharing with students so that again they can understand that diverse teams operate equally well or better than self-selected teams even in the university setting.

Both faculty and students should also be aware that studies have shown that many people’s intuitions about the role of diversity in teams, the way they function, and the quality of the resulting team work product are often incorrect. After participating in a diverse team, even the initial reaction of members about the quality of their work product may be incorrectly influenced by their perceived difficulty in working within such a diverse team. There is a common bias that psychologists refer to as the “fluency heuristic” that basically states people prefer information that is processed more easily and judge such information to be truer or more beautiful.<sup>[21]</sup> In the case of more homogeneous versus diverse teams, there is a common misconception related to this fluency heuristic that because teams composed of individuals who are more homogeneous in some way are often perceived to communicate and process information between team members more easily, the resulting team work product will be better. For example, the study by Neale and coworkers provides a fascinating insight into this issue where introduction of a diverse team member in the middle of a team task was found to produce a more correct team product while also leading to team members having more doubts about the quality of the team product.<sup>[22]</sup>

In the experience of the authors, it is actually rarely the types of more obvious diversity characteristics, e.g., gender, race, student experience level, etc., that lead to poor group dynamics, conflict, and lower quality work product. Instead, two of the largest determining factors in terms of team diversity that affect the function, cohesion, efficiency, and work quality of a student team are: (1) diversity in individual academic goals and standards of individual team members and (2) diversity of behavioral and work styles of individual team members. Ultimately, it is these types of motivational and behavioral diversity that most often drive team conflict and poor team performance if left unaddressed. Therefore, a key part of teaching students how to function in teams is to gain skills in conflict resolution, which is addressed later in this paper. In some sense, having all teams experience some level of conflict is a useful environment in which to allow students to actively learn and practice conflict management techniques.

Another aspect of the team formation process that should be considered is the size of a team. At least three basic questions are worth considering:

1. What size team is best for optimal performance of the team in terms of producing the best work product?
2. What size team is best for students learning from a diverse group environment without experiencing higher than necessary levels of discomfort and stress from coordination and management of interpersonal dynamics of larger group sizes?
3. What size team might be best for students from a learning perspective given other group experiences they will have had in their common required curricular coursework?

There have been numerous studies that have looked at optimal group sizing from different objective function perspectives. For example, work by Laughlin and coauthors looked at the performance of individuals and groups (i.e., groups of two, three, four, and five members) on highly intellectual problems and found that groups sizes of three, four, and five all equally performed better than individuals and two-person groups on such tasks. Given that the complexity of managing interpersonal dynamics and group logistics scales with group size, they concluded that a group size of three was optimal for highly intellectual tasks.<sup>[23]</sup> A similar study by Akinola and Ayinla compared the impact of team size on various measures of team effectiveness and work product quality in collaborative computer programming assignments and concluded that teams of four students produced optimal learning and team work product results.<sup>[24]</sup> In practice, in cases where assignments and projects are extremely large and may naturally have enough sections and tasks to warrant larger group sizes or call for larger numbers of team members with different skills and expertise, there of course may be good reason to consider larger team sizes. However, based on the available literature, it appears that group sizes of three or four are optimal in many respects for students to both learn and practice valuable teamwork skills while also allowing the teams to produce an optimal work product in a minimal amount of team work time that likely contributes to optimal student learning. In the authors' experience, we have also found group sizes of three and four produce what seem to be the best learning experience for students while at the same time allowing the groups to achieve the best results on their assigned tasks.

### Team Storming and Norming

Once teams are selected and as the collection of students starts to work together, one of their first tasks is to find their identity. This stage is called storming because individuals test the waters with their ideas and opinions amongst the team members, and leaders emerge and may be challenged

for dominance and leadership of the team. Conflict may arise due to differing expectations related to behavioral processes and motivations states. Once a common identity is established, the students may be referred to as a group. Once the group agrees upon their goals and objectives, they start to truly become a team. In the norming stage, teams establish norms and expectations for behavioral processes, motivational states, and performance outcomes. As new tasks or challenges arise, the team may lapse back into behavior from the storming stage. This section describes and references some of the available tools used to guide teams through the process of establishing expectations and completing the norming phase.

Expectations for interpersonal interactions and reactions (i.e., motivational states) can be brought to consensus through the development of a Team Code of Conduct. The Team Code of Conduct is a set of ground rules that the team agrees upon as governing team interactions. Behaving in manners that are consistent with the Code aids teams in establishing trust and creating a sense of belonging and unity. Likewise, by explicitly listing and agreeing upon expected behaviors in team interactions amongst the team upfront, it is much more straightforward for teams and individual team members to honestly assess and identify when other members or their own behaviors are not consistent with the expectations of the team and may be leading to problems. Hensley assembled a sample list of interaction expectations upon which teams can expand and adapt to their unique identity.<sup>[13]</sup> The following is a paraphrased excerpt of key elements of a Team Code of Conduct:

- *Speak candidly within the team*
- *Respect others and their jobs*
- *Be honest about fulfilling deadlines*
- *Use positive reinforcement and praise*
- *Provide and accept constructive criticism*
- *Take personal responsibility*
- *In regards to communication, be aware of tone, use tools like text and direct message carefully, and take concerns directly to the involved parties*

A common tool used in development of behavioral process expectations is the Team Contract (or Team Charter). The Team Contract can be utilized to facilitate conversations amongst the team (and potentially with their faculty instructor/advisor as appropriate) about communication protocols, work objectives, quality targets, and workplans. A sample template for the questions to be addressed in the Team Contract is provided in Table 2. Collectively, the Team Contract and Team Code of Conduct help to minimize wasted energy in the storming phase by triggering conversations to identify and resolve divergent expectations before they become a source of team conflict and drama.

**TABLE 2**  
**Team Contract Template Questions**

<b>TEAM PROCEDURES</b>
<ol style="list-style-type: none"> <li>1. Day, time, and place for regular <b>team meetings</b></li> <li>2. Preferred <b>method of communication</b> and contact information (e.g., email, text, Slack®, MS Teams®)</li> <li>3. <b>Decision-making policy</b> – by consensus, majority vote, or team lead?</li> <li>4. Method of <b>record keeping / data storage</b> – Who is responsible? Where is it kept? How &amp; when is it disseminated?</li> <li>5. Procedures for review and <b>submittal of products</b></li> <li>6. Team <b>roles</b> – How will work be assigned? Define roles and responsibilities. How will roles rotate or change?</li> </ol>
<b>TEAM EXPECTATIONS</b>
<p><u>Work Quality</u></p> <ol style="list-style-type: none"> <li>1. <b>Project standards</b> – What is a realistic level of quality for the team work?</li> <li>2. Strategies to fulfill the standard – How will the standard be evaluated (rubric)? Who is responsible for <b>quality assurance</b>?</li> </ol> <p><u>Personal Accountability</u></p> <ol style="list-style-type: none"> <li>1. <b>Diversity &amp; Inclusion</b> – How will you ensure that all voices will be heard and all members have a chance to contribute?</li> <li>2. Expectations for <b>individual participation</b>, attendance, and punctuality – What is an acceptable reason for missed or late participation? How should this be communicated?</li> <li>3. Expectations for fulfilling assignments and <b>meeting timelines / deadlines</b> – What should members do if they cannot complete the assignment or meet the deadline?</li> <li>4. Expected <b>level and frequency of communication</b></li> </ol>
<b>CONFLICTS AND CONSEQUENCES</b>
<ol style="list-style-type: none"> <li>1. List known <b>conflicts</b> and constraints (conferences, major events, work schedule)</li> <li>2. How will you handle <b>infractions</b> of the obligations in this contract?</li> </ol>

Another approach to establishing expectations for interactions is presented by Mackin in “The team building tool kit: Tips and tactics for effective workplace teams.”<sup>[25]</sup> In this resource Mackin suggests the creation of a Help/Hinder List based upon critical team behaviors. This approach breaks down the behaviors to a more granular level that may be beneficial for novice teams working on short time scales. However, the Help/Hinder list includes both interpersonal actions (motivational states) and interdependent acts to achieve outcomes (behavioral processes) and is more difficult to link to the developmental stages model for teams and other tools presented in this paper.

Depending upon the nature of the work product and duration of the team cycle, other project management tools and processes may be beneficial for team efficacy and effectiveness. The educator should consider the introduction and use of tools such as Gantt charts, flow charts, and specialized problem solving tools. Further, teams may benefit from practice in creating agendas, recording meeting minutes, and formally defining roles and responsibilities. In the literature review of teamwork pedagogy by Riebe and others, the subject area and key findings from 57 teamwork-related articles are summarized.<sup>[1]</sup> This summary is a helpful resource to quickly locate relevant literature to specific teamwork pedagogical goals.

### Team Performing

A key difference between a norming and performing team is the degree to which the team behaves as a cohesive and collaborative unit. These characteristics depend upon the motivational state and the behavioral processes of the team members. It may often be the case that students and teams feel that once they get to the “performing” stage that they no longer need to deal with formally continuing to work on team dynamics and function and instead should shift completely to accomplishing whatever tasks the team was built to complete. However, even though the team should have developed norms for their team expectations and behaviors, the degree to which the team and its members maintain those norms during project performance should also be periodically evaluated in a formal manner to both ensure that what was agreed upon during the norming phase is actually fully understood by each team member and that those norms are being maintained to sustain high team performance and avoid team dysfunction and conflict.

The motivational state of a team can be assessed by evaluating how well the team and its members meet the expectations for interpersonal interactions and reactions as described in their Team Code of Conduct. The more consistent

the behaviors are with the expectations, the greater the sense of belonging and unity. Using a Likert-type scale, each team member should reflect on the individual elements of their Team Code of Conduct to assess the level and frequency to which they are individually meeting the expectations. For example, using the sample Code adapted from Hensey, a team member might evaluate their ability to meet the expectation to *Speak candidly within the team* on a scale of: (1) does not meet, (2) infrequently meets, (3) meets, (4) sometimes exceeds, and (5) frequently exceeds. This type of tool can be used as an individual self-assessment and as a team self-assessment. When used as a team self-assessment tool, each member should provide their assessment of the overall team behavior and not other particular individuals. If a particular element has divergent ratings from the individual team members, this is an indicator of a potential source of conflict. Team members should discuss the basis of the divergent rankings to determine if behaviors need to be modified or if even perhaps the original Team Code may need to be refined. Sometimes it is determined that the behavioral element was not discussed in sufficient detail during the earlier development stage and/or that the team had not truly reached consensus on the expectation. This disconnect will likely become a source of conflict if not resolved through further discussion and modification of the Team Code of Conduct.

Just as the motivational state of the team is periodically reviewed, the behavioral processes (the interdependent acts of the team members to organize work and achieve outcomes) should also be assessed. The Team Contract captures the expectations for behavioral processes and is the basis for the Peer Evaluation tool. Using a Likert-type scale similar to

the one used with the Team Code of Conduct, each team member evaluates the behavior of their teammates for areas 1 through 5 in Table 3. The remaining areas (6 through 8) are free response evaluations with the caveat that they should be focused on behaviors that impact process or motivation. Students are instructed that the critique in area 7 should be actionable. In other words, it should focus on an action/behavior displayed by the individual and the impact or effect that action has on team functioning or outcomes.

It should be noted that the creation of the Code of Conduct and Team Contract and their use as tools to assess team and peer performance are teaming skills that must be developed. As such, formative assessment by the instructor is recommended. The creation of the Code and Contract should be assigned shortly after the selection of team members. The rubric to score these assignments should focus on the team's actions to establish norms and expectations and their ability to document these norms and expectations in sufficient detail. In other words, the rubric should not be based on whether the team plans to meet once or twice a week, whether their quality standard is a passing score or an A grade, or whether the team uses a thumb drive or cloud storage for their data. The rubric should be based on whether sufficient detail and information are included to establish clear expectations and guide the team behaviors and actions. Similarly, team and peer evaluation are learned teaming skills. The first team and peer evaluation should be assigned after the completion of the first milestone task/outcome by the team. Again, the rubric should be formative in nature and assess the team's ability to analyze and critique behavior; it should not be based upon the behaviors themselves or the ratings team members give to themselves or one another. However, for

**TABLE 3**  
**Peer Evaluation**

Student Form	Instructor Rubric
<p><i>Using the following scale, rate each team members' ability to meet the expectations as set forth in the Team Contract and Code of Conduct:</i></p> <p><i>(1) does not meet, (2) infrequently meets, (3) meets, (4) sometimes exceeds, (5) frequently exceeds</i></p> <ol style="list-style-type: none"> <li>1. Regularly attend and participate in scheduled meetings</li> <li>2. Communication, both written &amp; verbal (clarity, accuracy, frequency, and tone)</li> <li>3. Performance of individual tasks</li> <li>4. Willingness and ability to meet project deadlines and standards</li> <li>5. Respect for team members and inclusion of diverse viewpoints</li> </ol>	<p>Ratings provided for each category (2 or 4 pt).</p> <p>If rating of 1 or 5, action and effect described below (2 pt, if applicable)</p>
<p><i>The following evaluation should focus on individual team member action/behavior and the effect on team functioning and outcomes.</i></p> <ol style="list-style-type: none"> <li>6. Best individual contribution to project/task</li> <li>7. Describe ONE thing they could do to improve performance of the team</li> <li>8. For ratings of 1 or 5 above, explain the basis for rating or provide a specific example</li> </ol>	<p>For 6 and 7: 1 pt - for response, 1 pt - behavior based, 1 pt - effect described</p>



teams with low Likert-type ratings, instructor-led intervention and mediation may be beneficial and should be offered. Teams should be encouraged to periodically continue the self-assessment process for the duration of the team tasks. At the adjournment of the team, a final set of assessments can be completed as part of the closure process for the teammates and as feedback to the instructor about the development of teaming skills over the duration of the project/task. Some instructors utilize a final evaluation to weigh individual contributions and adjust the project output/task outcome score to an individual team member score. This method should be used with caution as it can be a very subjective and sometimes prejudiced evaluation that results from when there is unresolved conflict in the team. It is the goal that with proper instruction on team building and feedback, there would be no need to weigh individual scores on the output/outcome of the team's work product since it would be the agreed upon result of a productive and effective team effort. To emphasize the importance of developing team building skills, the formative assessments used throughout the project (i.e., the instructor's assessments of the development and use of the tools) can be utilized as a portion of the overall project or course grade.

### Conflict and Conflict Resolution

As previously suggested, even a well performing team will have conflict arise over time. To keep teams from backsliding into the storming stage, formal discussion of

conflict within teams, discussion of approaches to team conflict resolution, and practice with conflict management strategies for students are recommended. Although it may seem obvious to some, root causes of conflict and escalation of conflict within teams to the point of team dysfunction include the inability of team members to recognize the early stages of conflict, lack of knowledge and insight as to the type(s) of conflict and their root cause(s), failure to implement early and simple fixes to mitigate conflict amongst the team, and the need for constant attention for signs of conflict and early and deliberate conflict resolution to prevent further conflict escalation that leads to team dysfunction. The authors have found it valuable to discuss with all students in such team-based courses these three elements of conflict and conflict resolution: (1) levels of conflict and conflict escalation, (2) types of conflicts and their common causes, and (3) methods for conflict management and resolution.

Although there are many ways to view and discuss the degrees or stages of conflict within a team, two frameworks that the authors find particularly useful are the five stages of conflict model developed by Spillman and Spillman and Glasl's nine stages of conflict escalation model.<sup>[26, 27]</sup> An adaptation of the five stages of conflict is shown in Figure 3. Sharing such ways to envision the stages of conflict with students and having a discussion about how these various stages may escalate in the context of a team-based project can aid students in being sensitive to the need to pay attention to team conflict and helping them practice recognizing conflicts early within their group.

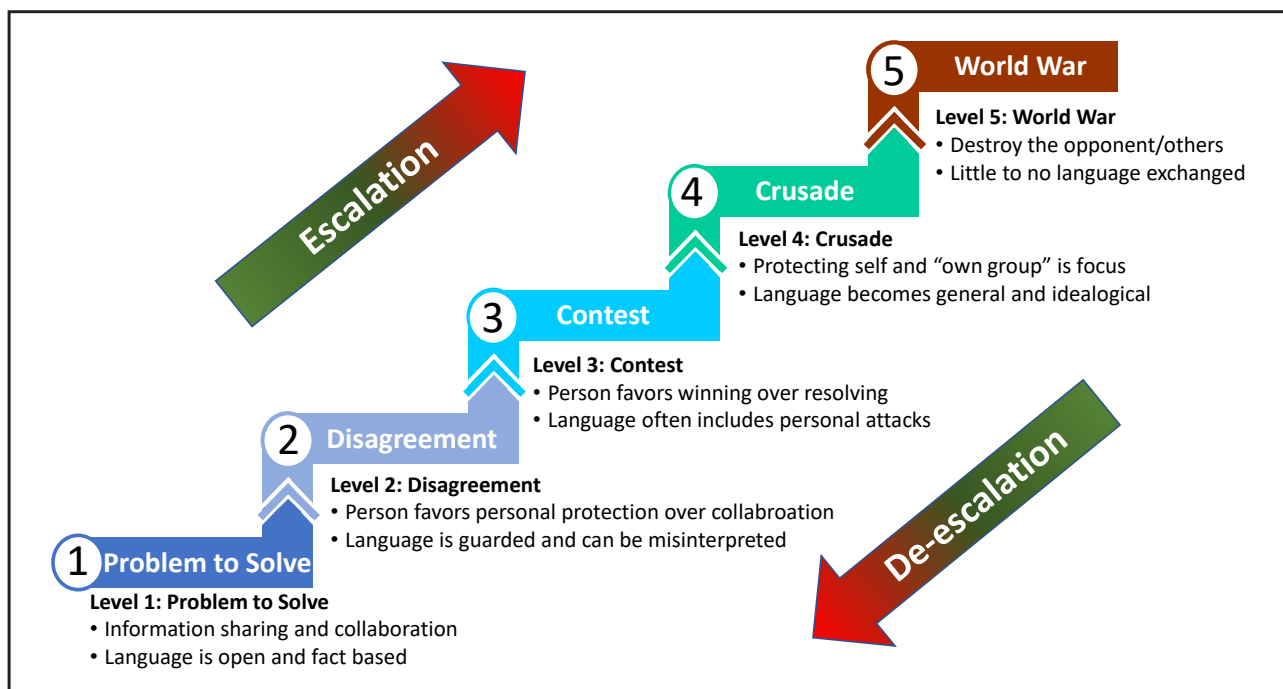


Figure 3. Illustration of the five stages of group and team conflict.

The other area of discussion that can help students to recognize and deal with conflict early is to discuss with them the various common types of conflict. At a basic level, there are essentially two types of common team conflicts: (1) substantive (sometimes called task conflicts) and (2) emotional (or sometimes called relationship conflicts). Substantive conflicts arise over things such as different views on goals, tasks, work processes and methods, and allocation of resources. For example, in a student team project, the choice of approach to modeling a problem may be unspecified, and different students on a team may prefer different software packages or tools for accomplishing such a modeling task. Emotional conflicts arise from things such as jealousy, insecurity, annoyance, envy, and other personality conflicts. Causes of emotional conflicts can vary widely and include things like team members holding opposing viewpoints on non-work-related issues, having conflicting work styles, or having different leadership styles. For example, one student may prefer to work in their group with music playing while another may need peace and quiet to concentrate on the tasks at hand and discussions with their teammates. Another common framework in which to discuss project team conflict types is sometimes referred to as the Four C's of team conflict and dysfunction: (1) task conflicts, (2) work style conflicts, (3) leadership conflicts, and (4) personality conflicts. The authors have often found this level of detail an easy framework in which to discuss types of common conflicts found in engineering student project teams and to discuss approaches to mitigate them early before they cause serious problems for the teams. The key to minimizing the negative impact of conflict on team performance is for team members to recognize the various conflicts that may arise in the team early and address them while all team members are still in a collaborative state of mind (i.e., while they are at Level 1 or Level 2 in the stages of conflict shown in Figure 3). It is at these early stages of conflict where resolution of the conflict within the team and between particular team members involved in the conflict can generally be accomplished without need for outside intervention by parties such as the course instructor. Course instructors should also be prepared to watch for signs of team conflict that are escalating and, when needed, be ready to serve as a mediator to help teams resolve higher levels of conflict when they arise.

Inevitably, students and potentially instructors will need to deal with conflict management and resolution. Numerous resources are available on the topics of managing conflict, conflict responses, and conflict mediation. Several of the cited references in this paper include sections on conflict management.<sup>[10, 13, 25, 28]</sup> “The team building tool kit: Tips and tactics for effective workplace teams” is a good fundamental resource for team behavior and conflict management.<sup>[25]</sup> In Chapter 3 (Team Behavior), Mackin describes both helpful and destructive team member and facilitator behavior and how these behaviors can lead to team conflict.

The chapter continues by describing how to create a conflict resolution protocol and providing an example of a four-step protocol. The author has recently adopted creation of a team conflict protocol as part of developing team building skills. The activity is most relevant after teams have started to work together but before major conflicts arise. Teams are asked to develop the protocol after their first milestone/outcome is completed. Anecdotally, teams have commented that this process has led to deeper team discussions and revealed issues that were growing and could have become conflicts.

## CONCLUDING REMARKS

Engineering students are asked and expected to operate in teams from the first days they step onto a college campus. While it is generally accepted that these students often lack any formal training in soft skills such as the interviewing techniques that will be critical to their ability to obtain internships, cooperative education positions, and full-time jobs, it is often perhaps not appreciated that they generally critically lack any real training, knowledge, or skills in how to effectively create and work in teams. Somehow it is instead generally assumed or expected that they will somehow have developed these skills in their earlier education, perhaps because there, too, they have been asked and expected to function in teams without any real formal education on the subject. Given the critical nature of teamwork, not just in engineering education but also in engineering practice, the pedagogy of teamwork should be included in higher education curricula to provide students with opportunities to build teamwork skills, to improve communication, to construct compilational knowledge frameworks, and to meet student outcome requirements for program accreditation. These skills and knowledge are best developed and delivered when this pedagogical work on teaming and teamwork is coupled directly to coursework or similar hands-on experiences where students will go through the stages of building and functioning as a team to accomplish a defined set of tasks. By giving students a formal structure in which to think about team construction and function, students will be better prepared to not only have a better learning experience through such team-based exercises but to also be prepared to function within or lead teams as they transition to engineering practice.

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