



Team CARE model: Assessing team dynamics in first-year engineering student teams

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Nicole is completing her final year of her Masters in Industrial Organizational psychology at the University of Calgary under the supervision of Dr. Thomas O'Neill. Nicole has been working with the Schulich School of Engineering for the past two years. During this period she has been involved in several initiatives such as assessing student learning and engagement, implementing systems for peer evaluations, and leading teamwork training sessions. She is currently conducting research on team learning processes in engineering student project teams. Additionally, she has co-developed a framework for measuring and interpreting an array of team dynamics. An online assessment tool has been created based on this framework which allows teams to diagnose and improve the "health" of their team. She is passionate about her area of research and plans to continue conducting research on factors that contribute to effective teamwork.

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Genevieve is completing her honours degree under the supervision of Dr. Thomas O'Neill at the University of Calgary looking at the influence processes in teams. She has been working with the Schulich School of Engineering for the past three years during which time her focus has been on improving team dynamics and maximizing the student experience. In addition co-developing the communication training framework that has now been applied to over 2500 students campus wide, Genevieve has personally facilitated many of the training sessions. Her goal is to continue working on developing applicable and universal tools to improve the functioning of both student and industry teams in institutions and organizations across North America.

Dr. Tom O'Neill, University of Calgary

Tom is a Professor of Industrial/Organizational Psychology and leading expert in the areas of team dynamics, virtual teams, conflict management, personality, and assessment. He is director of the Individual and Team Performance Lab and the Virtual Team Performance, Innovation, and Collaboration Lab at the University of Calgary, which was built through a \$500K Canada Foundation for Innovation Infrastructure Grant. He also holds operating grants of over \$300K to conduct leading-edge research on virtual team effectiveness. Over the past 10 years Tom has worked with organizations in numerous industries including oil and gas, healthcare, technology, and venture capitals. He is currently engaged with the Schulich School of Engineering at the University of Calgary to train, develop, and cultivate soft-skill teamwork competencies in order to equip graduates with strong interpersonal and communication capabilities.

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Marjan Eggermont is the current Associate Dean (Student Affairs) and a Senior Instructor and a faculty member at the University of Calgary in the Mechanical and Manufacturing department of the Schulich School of Engineering, University of Calgary, Canada. She teaches graphical, written and oral communication in their first Engineering Design and Communication course taught to all 650 incoming engineering students. With co-editors Tom McKeag (San Francisco) and Norbert Hoeller (Toronto) she co-founded and designs ZQ, an online journal to provide a platform to showcase the nexus of science and design using case studies, news and articles (zqjournal.org). As an instructor, she was one of the recipients of The Allan Blizzard Award, a Canadian national teaching award for collaborative projects that improve student learning in 2004. In 2005, she was one of the recipients of the American Society of Mechanical Engineers Curriculum Innovation Award. She is - as PIC II chair - currently a board member of ASEE.

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Introduction

Educators in engineering disciplines have traditionally focused on creating professionals who are able to solve a variety of technical problems. More recently, there has been a call for the development of process skills or “soft skills” that are used in the application of knowledge¹. One such skill, and the focus of the present paper, is teamwork. Given the increasing complexity of work, nearly all new graduates will end up working as part of a team in some capacity. Accordingly, engineering accreditation boards have recognized teamwork skills and collaborative ability to be a critical competency^{2,3}.

Although many instructors place a high value on teamwork skills, few instructional hours and resources are devoted to developing these skills at the undergraduate level. Cooperative learning approaches, such as team-based project work, is often implemented to address this gap. Unfortunately, simply participating in team-based work does not necessarily allow students to develop appropriate teamwork capabilities. In reality, students are unaware of which specific actions and behaviors lead to effective teamwork. Thus, teamwork that is not properly supported may result in conflict and leave students feeling reluctant about participating in future team-based work.

Most engineering instructors are unaware of fundamental research that provides the foundation for assessing and developing students’ teamwork skills. To address this issue, an inter-departmental partnership between Industrial Organizational Psychology and the Schulich School of Engineering has resulted in an in-depth examination of factors that lead to better teamwork. Based on a review of the literature and preliminary data collected from engineering students, the Individual and Team Performance Lab at the University of Calgary has developed a pedagogical team effectiveness model. Specifically, the Team CARE model is a developmental tool that provides teams with specific information on the “health” or effectiveness of their team. Team CARE represents four key teamwork skills: Communicate, Adapt, Relate, and Educate.

Our model brings together several teamwork theories to provide an inclusive assessment of a team’s current state of functioning. By introducing students to this model we offer them a basis for understanding and developing strong teamwork skills. This paper will explain the model, theoretical background, preliminary data, how to access the tool, and will provide an example of a team diagnostic report. Although not an empirical study, this paper describes a valuable tool and framework for assessing, teaching, and tracking the development of teamwork skills in engineering students.

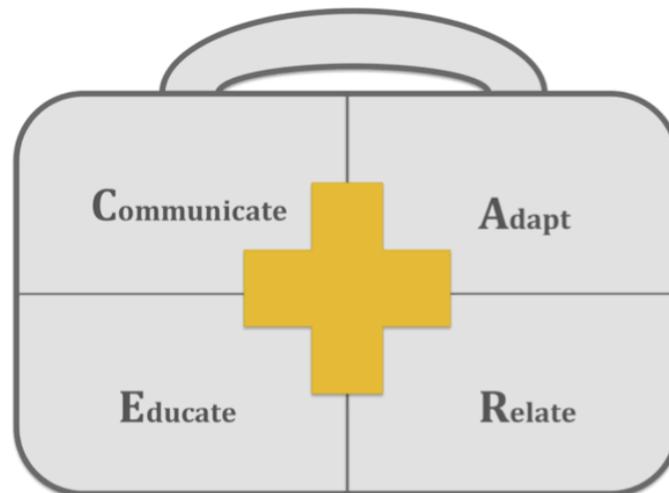
The CARE model

The first dimension of the CARE model represents communication norms. Communication encompasses strategy formation, role clarity, and conflict management. First, strategy formation and planning is important because it involves decision making on how team members will go about meeting their objectives⁴. During strategy formation students should be discussing

situational constraints, time restrictions, team resources, and member expertise. Second, role clarity ensures that team members know exactly what is expected of them. Having a clear understanding of roles provides each team member with a sense of purpose and direction and helps to appropriately distribute work⁵. Third, cooperative conflict management is a communication style associated with high team performance⁶. Because of the interdependent nature of teamwork, conflict is unavoidable⁷. Thus, students should discuss how they intend to approach conflict. Teams that adopt a cooperative conflict management approach view conflict as a mutual problem and seek solutions that will be good for the whole team.

The value of communication in teamwork is intuitive.

Typically, communication is simply thought to represent the transmission of information among members. However, the CARE model extends beyond this simple conception and offers pedagogical value by encouraging teams to discuss their strategy, roles, and approach to dealing with conflict.



The second dimension of the CARE model stands for Adapt. Adaptability is related to a team's ability to coordinate efforts, monitor team progress, and provide each other support through backup behaviors. Coordination is an important skill to develop in student teams as it leads to productivity gains⁸. Teams with poor coordination end up duplicating each other's work and waste time on logistical issues which can result in frustration and provoke conflict⁹. Students should also be encouraged to monitor their team's goal progress, which involves using clearly defined metrics to assess progress. Through monitoring, teams are able to identify problems and take action. Accordingly, backup behavior follows monitoring, and entails providing each other with the appropriate support when needed. Engaging in backup behaviors can include things such as coaching, providing feedback, or offering tangible support to other members of the team.

Adaptability allows a team to maintain awareness of changing factors, and such vigilance moves the team toward its objectives¹⁰. Developing an adaptable team can be challenging for students because each member has different schedules, time constraints, and priorities. Therefore, teams need to integrate their efforts, monitor progress, and assist one another in working toward the team's objectives.

The third dimension of Team CARE is concerned with how team members interact with one another and therefore stands for Relate. Interactions leading to positive team outcomes are driven by several factors such as trust, a lack of personal conflict, healthy fact-driven debate, and contribution equality¹¹. Trust is important because it facilitates cooperation, information sharing, and open communication^{12,13,14}. Relatedly, conflict due to interpersonal tension or inadequate

member contributions should be monitored and addressed as it may detract from the benefits of learning in a team setting. Additionally, healthy fact-driven debate is a critical skill to develop as it allows students to comfortably and intellectually discuss the merits of different perspectives, views, and opinions¹⁵.

Team member interactions are often described as one of the most challenging aspects of student team-based work. Students are typically unaware of how their individual behaviour helps or hinders the overarching climate of their team. Consequently, students need to gain awareness of the interpersonal aspects of teamwork and work to foster positive interactions. To accomplish this, instructors should facilitate positive relations by implementing team charters and contracts, which aligns the team's expectations of one another.

The fourth and final aspect of the CARE model is Educate. This dimension is related to team learning and encompasses exploratory learning, exploitative learning, and constructive controversy. Exploratory learning occurs when a team goes beyond its current knowledge-base to search for new information, whereas exploitative learning happens when teams refine, leverage, and capitalize on their existing knowledge¹⁶. Constructive controversy is another type of learning behaviour that entails gaining an in-depth understanding of each member's ideas and integrating the best components into a final solution¹⁷. Taken together, this dimension offers value as it makes explicit three different types of behaviours that can lead to the acquisition of knowledge and improve team functioning.

The Educate dimension of the CARE model highlights the participative and experiential aspects of cooperative team-based learning that instructors strive to foster. Specifically, exploratory behaviour leads students to develop novel ideas and solutions, exploitative behaviour results in well practiced skills leading to enhanced understanding and efficiency, and constructive controversy allows students to gain knowledge directly from their peers.

Unlike similar tools, such as the Comprehensive Assessment for Team-Member Effectiveness (CATME), this tool offers a unique advantage because rather than assessing how each individual is functioning within the team, it focuses on how the team is functioning together as an entire unit. Offering feedback at the group-level allows teams to reflect on and discuss their current norms, climate, and team processes. In contrast, other tool typically have team members rate each others teamwork skills, and this process may lead to tension, animosity, and increased conflict within a team. Furthermore, research has shown that team-level feedback can improve members attitudes toward the team resulting in greater cohesion.

In the following section we provide information regarding technical aspects of the scales encompassed in the Team CARE model. We then present an example of how instructors are currently using the tool in their classrooms.

Team CARE scales

Our assessment tool utilizes several scales in order to evaluate how teams are functioning in each of the four CARE dimensions (Communicate, Adapt, Relate, Educate). For an example of survey items used for each CARE dimension please see Table 1. All scales used in the current

assessment are derived from well established measures that have demonstrated stable and predictable relationship with several important team outcomes (e.g., team satisfaction, learning, potency, cohesion, and performance). Thus, although we have yet to empirically validate the model in its entirety, the variables under each dimension were extrapolated from an exhaustive review of the teamwork literature. Additionally, we have collected preliminary data that support the reliability of the facet level scales (see Table 2). Further data is reported in another paper¹⁸ demonstrating the positive effect of a team training intervention on team dynamics in first-year engineering student teams.

Table 1

Example of questions assessing each dimension

<u>Communication</u>	<u>Relate</u>
<i>“We develop an overall strategy to guide our team activities.”</i>	<i>“How much were personality clashes between members of the group evident?”</i>
<i>“There are clear, planned goals and objectives for each of our roles.”</i>	<i>“How often is there tension in your team caused by member(s) not performing as well as expected?”</i>
<i>“Team members seek solutions that will be good for all of us.”</i>	<i>“I can rely on those with whom I work in this group.”</i>
<u>Adapt</u>	<u>Educate</u>
<i>“Our team will re-establish coordination when things go wrong.”</i>	<i>“We work to improve and refine our existing knowledge and expertise.”</i>
<i>“We regularly monitor how well we are meeting our team goals.”</i>	<i>“We evaluate diverse options regarding the course of the project.”</i>
<i>“We seek to understand each other’s strengths and weaknesses.”</i>	<i>“We use our opposing views as a learning opportunity to better understand the problem.”</i>

Note. Responses are recorded on 5-point Likert scales (e.g., 1 = Strongly disagree to 5 = Strongly agree).

Table 2

Reliability of Team CARE Model Variables

Variable	Cronbach’s Alpha	Variable	Cronbach’s Alpha
Communication		Relate	
Strategy Formation	.70	Trust	.87
Role Clarity	.80	Relationship Conflict	.85
Cooperative Conflict Management	.89	Task Conflict	.76
		Process Conflict	.75
Adapt		Educate	
Coordination	.87	Exploratory Learning	.84
Monitoring	.80	Exploitative Learning	.68
Backup Behaviours	.73	Constructive Controversy	.88

Note. Reported Cronbach’s Alpha scale reliabilities for all variables in the CARE Model sorted by bucket.

How the Team CARE tool works

We are currently offering the Team CARE model at no charge to instructors interested in using the tool to assess and teach teamwork skills in their classrooms. The team diagnostic tool is available through an online platform that presents students with survey items regarding their team's dynamics. The tool analyzes individual team member responses to generate a feedback report for the team. More specifically, the tool automatically calculates the team-level scores by taking the individual responses and averaging them to represent the team-level constructs. Additionally, instructors interested in using the tool will be provided with slides that will allow them to facilitate a participative teamwork lecture. In the following paragraph we present a step-by-step example of how the tool may be used.

Instructors first input their class list along with each student's email address and team number. Next, during a 10 minute presentation, instructors introduce the tool along with the importance of developing teamwork skills (these PowerPoint slides are provided by the authors). After being introduced to the tool, students are automatically emailed participation invites and are provided with a link to the survey. Each student then completes the online assessment which takes approximately 10-15 minutes. Once all team members have completed the online assessment a diagnostic report is automatically generated by aggregating team member responses and is emailed to the team (see Appendix A). Individual responses are anonymous and confidential as only aggregated data appears in the report. Therefore, the report presents teams with their score for each overarching dimension (Communicate, Adapt, Relate, Educate) and sub-facet described earlier. The feedback report also provides clear definitions of each teamwork skill.

Instructor may choose to facilitate a participative teamwork lecture after their class completes the assessments (again these lecture slides are provided by the authors). The participative teamwork lecture takes approximately 50 minutes and allows students to develop an action plan based on the strengths and weaknesses identified in their team report. During this lecture the instructor briefly covers the importance of each CARE dimension, and students develop their action plan during 4 five-minute breakout sessions that occur during the teamwork lecture. In their teams, students discuss their lowest and highest scores for each dimension and record action steps for making improvements (see Appendix B for an example). Depending on the size of the class, instructors may ask teams to share some of their unique challenges and solutions with the rest of the class after each breakout session. Alternatively, some instructors choose to have teams complete the action plan outside of class time and use it as a graded component in the course. Finally, some instructors offer the Team CARE assessment at more than one time point, and this allows them to examine changes in team dynamics over the span of a project or semester.

Conclusion

We believe that the Team CARE model and diagnostic tool has enormous potential to impact the teamwork capabilities of engineering student teams. First, it offers instructors a pedagogical framework for supporting the development of student teamwork skills. Second, merely exposing students to the assessment provides them with an understanding of the behaviours that contribute to effective teamwork. Additionally, instructors may use the assessment to track cohort changes in teamwork skills as students advance through their education. Another use of the Team CARE

model would be in team-based classes that extend an entire semester or year. Specifically, instructors could have teams complete the assessment near the start of their work together, and then use the diagnostic report to encourage teams to discuss potential areas of improvement. The instructor could then have students complete the assessment a second time, near the end of a project, to gauge improvement in team functioning. Taken together, the CARE model provides instructors with an opportunity to diagnose, develop, and monitor teams in order to guide them towards more effective team performance and individual team experiences.

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Appendix A

Sample of the first two pages of the team diagnostic report

Team Dynamics Report

Diagnostics and Prescriptions for a Healthy Team

Communicate

Create a cooperative environment, ensure role clarity, and develop a clear course of action for teamwork.

Adapt

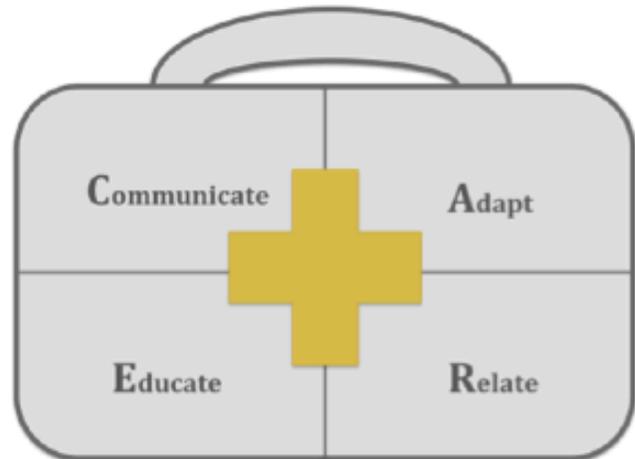
Coordinate team efforts in response to changing task demands, monitor team members' progress, and provide backup when needed.

Relate

Reduce interpersonal conflicts and arguments regarding how to accomplish work. Focus on building trust and a safe place for sharing ideas.

Educate

Learn from other team members, and provide each other with constructive feedback.



Team C.A.R.E. Rx

The team care model was developed by the Individual and Team Performance Lab at the University of Calgary, and is intended to be a prescription for healthy teamwork. The report will allow you to view the health of your team and will provide you with an idea of how you can direct your future actions toward improving teamwork!



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Note: All scores are out of 5.

Communicate

Create a cooperative environment, ensure role clarity, and develop a clear course of action for teamwork.

Overall Score: 3.4

Scale	Score	Description
Cooperative Conflict Management	3.1	Approach to conflict and perceived incompatibilities such that win-win solutions are sought out, conflict is viewed as a chance to learn and make quality improvements, and members work through different viewpoints with mutual respect.
Role Clarity	3.7	The existence of well-defined and understood roles within the team, demonstrated through the establishment and maintenance of clarity regarding responsibilities, goals, expectations and relative authority of each role within the team.
Strategy Formulation & Planning	3.3	The development of overall strategies that guide team efforts, including the sequencing of plan elements, evaluation of progress, and formulation of contingency plans.

Appendix B

Sample of the template to facilitate action steps for improving teamwork skills

COMMUNICATE

Which area under Communicate has the most room for improvement? Identify the barriers that could be preventing this score from being higher.

Brainstorm with your team members to create an action plan that you will commit to as a team in order to improve your Communicate score.

ADAPT

Which area under Adapt has the most room for improvement? Identify the barriers that could be preventing this score from being higher.

Brainstorm with your team members to create an action plan that you will commit to as a team in order to improve your Adapt score.
