AN EVIDENCE-BASED APPROACH TO ASSESSING AND DEVELOPING TEAMWORK SKILLS

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INTRODUCTION

Real-world engineering practice requires a strong set of both technical and professional skills. Although graduating students are proficient in technical aspects of their work, they often lack the interpersonal skills required to succeed in today's modern team-based environments. This gap is likely due to difficulty associated with explicitly training and assessing soft skills such as self-awareness, communication, and teamwork.

This paper describes a collaborative project between Psychology and Engineering that was established to build strong teamwork capabilities in engineering students. This three year partnership has resulted in the development of evidence-based reflective team and individual assessments and participative activities. The aim of this paper is to describe and disseminate resources we developed that improve the professional skills of engineering students. Accordingly, we offer free access to the tools described in this paper at www.itpmetrics.com and we encourage engineering educators to adopt them to assess and develop teamwork skills in their students.

Team-based work is often implemented with the assumption that students will instinctively develop teamwork skills through these experiences. Unfortunately, simply participating in team projects does not necessarily allow students to develop appropriate teamwork capabilities. In reality, students are unaware of which specific behaviors lead to effective teamwork. Teamwork that is not properly supported may leave students feeling ill-equipped for work in today's dynamic work environments. Taken together, the research and tools presented in this paper align with CDIO's vision to better integrate learning of professional skills, such as teamwork, into engineering curriculums.

TEAM DYNAMICS – CARE MODEL

Based on an exhaustive review of the teamwork literature, we developed the Team CARE assessment, which provides students with specific information on the "health" or

effectiveness of their team by aggregating team members' responses to survey items. The CARE model encompasses four key aspects of teamwork and stands for Communicate, Adapt, Relate, and Educate. The CARE feedback report gives students an understanding of aspects related to successful teamwork, and an accompanying debrief activity prompts teams to commit to action steps that will improve their team's functioning. CARE teaches students about important team-level considerations such as goal progression, role clarity, process conflict, strategy and planning, task conflict, information exchange, trust, and cooperation. By introducing students to this model, we offer them a basis for understanding and developing strong teamwork skills. The following section will explain the model, theoretical background, preliminary data, how to access the tool, and will provide an example of a team diagnostic report. We present the CARE model as 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 objectives (Stout, Cannon-Bowers, Salas, & Milanovich, 1999). 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 work (Rizzo, House, & Lirtzman, 1970). Third, cooperative conflict management is a communication style associated with high team performance (Alper, Tjosvold, & Law, 2000). Because of the interdependent nature of teamwork, conflict is unavoidable (Johnson, 2003). 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 gains (Shaw, 1971). Teams with poor coordination end up duplicating each other's work and waste time on logistical issues which can result in frustration and provoke conflict (Behfar, Mannix, Peterson, & Trochim, 2010). 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 objectives (Burke, Stagl, Salas, Pierce, & Kendall, 2006).

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 equality (Jehn, Northcraft, & Neale, 1999). Trust is important because it facilitates cooperation, information sharing, and open communication (Dirks, & Ferrin, 2001). 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 opinions (de Wit, Greer, & Jehn, 2012).

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 behavior 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 their current knowledge-base to search for new information, whereas exploitative learning happens when teams refine, leverage, and capitalize on their existing knowledge (March, 1991). Constructive controversy is another type of learning behavior that entails gaining an in-depth understanding of each member's ideas and integrating the best components into a final solution (Tjosvold, 2008). Taken together, this dimension offers value as it makes explicit three different types of behaviors 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 behavior leads students to develop novel ideas and solutions, exploitative behavior results in well practiced skills leading to enhanced understanding and efficiency, and constructive controversy allows students to gain knowledge directly from their peers.

In the following section we provide information regarding technical aspects of the scales encompassed in the Team CARE model. We then present a complementary addition to the CARE assessment, specifically, individual peer feedback.

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).

Table 1

Example of questions assessing each dimension

Communication
"We develop an overall strategy to guide our team activities."
"There are clear, planned goals and objectives for each of our roles."
"Team members seek solutions that will be good for all of us."

Relate
"How much were personality clashes between members of the group evident?"
"How often is there tension in your team caused by member(s) not performing as well as expected?"
"I can rely on those with whom I work in this group."

Adapt
"Our team will re-establish coordination when things go wrong."
"We regularly monitor how well we are meeting our team goals."
"We seek to understand each other's strengths and weaknesses."

Educate
"We work to improve and refine our existing knowledge and expertise."
"We evaluate diverse options regarding the course of the project."
"We use our opposing views as a learning opportunity to better understand the problem."

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 Alpah scale reliabilities for all variables in the CARE Model sorted by bucket.

PEER FEEDBACK

To complement the CARE model we also developed a peer feedback platform to target individual team members' skill development. Team members anonymously rate each other on five teamwork competencies we adapted from Ohland et al.'s (2012) extensive research. Additionally, the tool is flexible and allows team members to provide each other with written feedback, if the instructor/administrator chooses. Introducing students to the behaviors of effective team members, observing and rating members on these behaviors, and receiving

personalized feedback on the behaviors, allows students to learn how to become a highly effective team member.

Peer Feedback Background

The utility of using peer feedback to improve target behaviors has been well established in past research. The underlying premise of peer feedback postulates that introduction to the interpersonal competencies required to be an effective team member, combined with providing feedback on team member's competencies and receiving feedback on one's one competencies, will help students develop and improve their teamwork skills (Brutus, & Donia, 2010). One benefit of using peer feedback is that students working in a team interact more with one another than with the instructor. This means that teammates are able to provide insight that may not otherwise be accurately captured (Brutus, & Donia, 2010). Additionally, gathering performance feedback from multiple team members, rather than solely from an instructor, reduces the possibility of bias and increases response reliability (Brutus, & Donia, 2010). Exposing students to the required team competencies early in their education will allow them to gain familiarity with these soft skills, providing a rich developmental opportunity. Furthermore, repeated use of a peer feedback assessment has previously been shown to improve students' faith in their ability to accurately provide feedback to their peers (Donia, O'Neill, & Brutus, 2015)**.** Increased confidence in providing feedback could also lead to increased confidence in the accuracy of the feedback one is given. Additionally, using peer feedback tools provides students with support and structure in their skill development process.

In order for peer feedback to be effective the feedback tool must be user-friendly, psychometrically strong, and well received by students, instructors, and researchers alike. These attributes are essential in order to encourage participation and promote accuracy of the feedback provided. Accordingly, our tool asks students to rate one another on a number of attributes, which load onto the following factors: communicating with team members; strong foundation of knowledge, skills and abilities; commitment to the team's work; emphasizing high standards; and keeping the team on track. These dimensions were included in the assessment as they have previously been validated as critical components for effective team performance, and have demonstrated strong validity and reliability in past research (Festinger, 1954). The peer feedback tool, which can be accessed at www.itpmetrics.com, presents dimensions using a different interface than the ones used in other platforms. Our interface is designed to make use of social comparison theory, which proposes that we are able to provide more accurate ratings of both others and ourselves when we are comparing multiple people on the same dimension at the same time. Therefore, participants rate both themselves and others with regards to each dimension in sequence, rather than providing ratings across all dimensions for one person at a time. This approach has been linked to higher reliability and validity, thereby encouraging participation, response accuracy, and superior effectiveness of the tool in educational settings.

As the overarching goal of using peer feedback assessments is to guide students on the path to skill development, it is critical to assess whether or not they intend to change their behaviors based on the feedback with which they have been provided. It has previously been established that if an intention to change is expressed, a corresponding behavioral modification can reasonably be anticipated (Wood et al., 2015). The underlying theory behind this postulates that behavioral intentions are the most proximal construct to behavioral change. Intentions represent one's attitude towards the behavior, capturing the effort individuals are willing to expend in order to engage in a particular behavior. Therefore, our

platform aims to encourage students to set intentions to change. In order to most effectively accomplish this goal, it is critical to assess students' reactions to the tool: perceived usefulness and satisfaction have previously been positively linked to behavioral intentions regarding further use of the system (Liaw, 2008).

We are therefore interested in students' perceptions of the usability of the tool, and the usefulness of providing and receiving peer feedback. Tool usability refers to student perceptions of how easily they could navigate the interface and their understanding of the tool. The usefulness of providing and receiving peer feedback refers to student beliefs about the accuracy of the feedback they received, and how confident they felt in providing feedback to their peers.

We discovered that students responded positively to the use of our tool, indicating strong satisfaction with its usability (M = 4.08, SD = .91) and a high degree of confidence in the feedback accuracy (M = 3.63, SD = 1.03). Students also indicated that they intended to change their behavior based on the feedback received (M = 3.76, SD = .97). Furthermore, the spread of the responses was largely clustered toward the high end of the scales for each dimension, indicating high satisfaction and expressed intentions to change, as seen in Figures 1, 2, & 3 below.
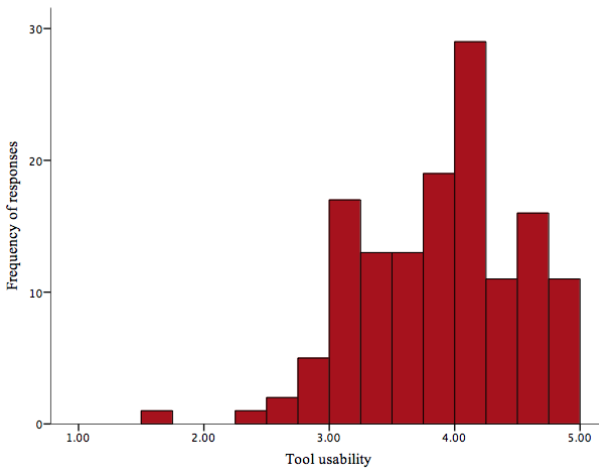

Figure 1. Students' average score on perceptions of the tool's usability, where the y-axis indicates the frequency of that score in the sample.
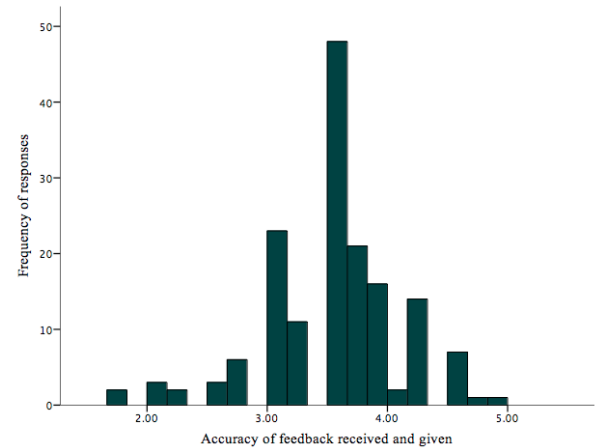
Figure 2. Students' average score on beliefs in the accuracy of the feedback they received and provided, where the y-axis indicates the frequency of that score in the sample.
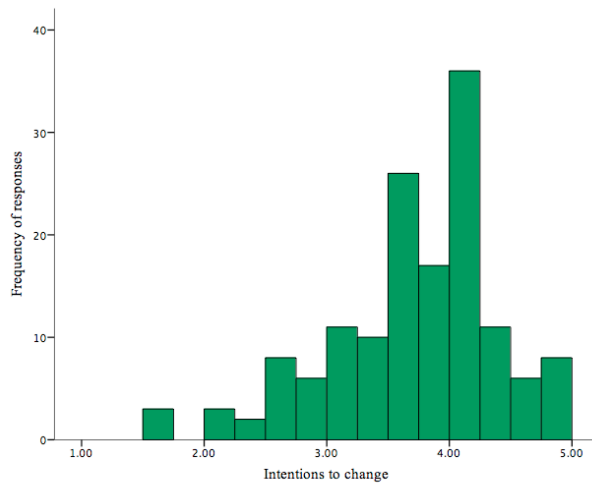
Figure 3. Students' average score on intentions to change based on the feedback they received, where the y-axis indicates the frequency of that score in the sample.

CONCLUSION

We believe that the Team CARE assessment and peer feedback tool have enormous potential to impact the teamwork capabilities of engineering student teams. First, our platform (www.itpmetrics.com) offers instructors a pedagogical framework and practical tool for supporting the development of student teamwork skills. Second, merely exposing students to the assessment provides them with an understanding of the behaviors that contribute to effective teamwork. Where repeated use, allows students to develop superior soft skills. Additionally, instructors may use the assessments to track cohort changes in teamwork skills as students advance through their education. Taken together, the team dynamics and peer feedback assessments provide instructors with an opportunity to diagnose, develop, and monitor teams and individual students in order to guide them towards effective performance and interpersonal development.

REFERENCES

Alper, S., Tjosvold, D., & Law, K. S. (2000). Conflict management, efficacy, and performance in organizational teams. *Personnel Psychology*, *53*, 625-642.

Behfar, K. J., Mannix, E. A., Peterson, R. S., & Trochim, W. M. (2010). Conflict in small groups: The meaning and consequences of process conflict. *Small Group Research,* 1-50.

Brutus, S., & Donia, M. B. (2010). Improving the effectiveness of students in groups with a centralized peer evaluation system. *Academy of Management Learning & Education*, *9*, 652-662.

Burke, C. S., Stagl, K. C., Salas, E., Pierce, L., & Kendall, D. (2006). Understanding team adaptation: a conceptual analysis and model. *Journal of Applied Psychology*, *91*, 1189-1207.

de Wit, F. R., Greer, L. L., & Jehn, K. A. (2012). The paradox of intragroup conflict: a meta-analysis. *Journal of Applied Psychology*, *97*, 360-390.

Dirks, K. T., & Ferrin, D. L. (2001). The role of trust in organizational settings. *Organization science*, *12*, 450-467.

Donia, M., O'Neill, T. A., & Brutus, S. (2015, January). Peer Feedback Increases Team Member Performance, Confidence and Work Outcomes: A Longitudinal Study. In *Academy of Management Proceedings* (Vol. 2015, No. 1, p. 12560). Academy of Management.

Festinger, L. (1954). A theory of social comparison processes. *Human relations*, *7*, 117-140.

Jehn, K. A., Northcraft, G. B., & Neale, M. A. (1999). Why differences make a difference: A field study of diversity, conflict and performance in workgroups. *Administrative science quarterly*, *44*, 741-763.

Johnson, D. W. (2003). Social interdependence: interrelationships among theory, research, and practice. *American Psychologist*, *58*, 934.

Liaw, S. S. (2008). Investigating students' perceived satisfaction, behavioral intention, and effectiveness of e-learning: A case study of the Blackboard system. *Computers & Education*, *51*, 864-873.

March, J. G. (1991). Exploration and exploitation in organizational learning.*Organization science*, *2*, 71-87.

Ohland, M. W., Loughry, M. L., Woehr, D. J., Bullard, L. G., Felder, R. M., Finelli, C. J., ... & Schmucker, D. G. (2012). The comprehensive assessment of team member effectiveness: development of a behaviorally anchored rating scale for self-and peer evaluation. *Academy of Management Learning & Education*, *11*, 609-630.

Rizzo, J. R., House, R. J., & Lirtzman, S. I. (1970). Role conflict and ambiguity in complex organizations. *Administrative science quarterly*, 150-163.

Shaw, M. E. (1971). Group dynamics: The psychology of small group behavior.

Stout, R. J., Cannon-Bowers, J. A., Salas, E., & Milanovich, D. M. (1999). Planning, shared mental models, and coordinated performance: An empirical link is established. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *41*, 61-71.

Tjosvold, D. (2008). Constructive controversy for management education: Developing committed, open-minded researchers. *Academy of Management Learning & Education*, *7*, 73-85.

Wood, C., Conner, M., Miles, E., Sandberg, T., Taylor, N., Godin, G., & Sheeran, P. (2015). The Impact of Asking Intention or Self-Prediction Questions on Subsequent Behavior A Meta-Analysis. *Personality and Social Psychology Review*, 1-24.

BIOGRAPHICAL INFORMATION

Nicole Larson. Nicole is first year of her PhD 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 three 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.

Julia Smith. Julia is a M.Sc. candidate in Industrial-Organizational Psychology at the University of Calgary, supervised by Dr. Thomas O'Neill. Her research interests include the study of factors impacting teamwork and leadership capabilities.

Genevieve Hoffart is a first year master's student at the University of Calgary focusing on at team dynamics, training, and communication. She has been working with the Schulich School of Engineering for the past four years during which time her focus has been on improving team dynamics and maximizing the student experience. In addition to co-developing a communication training framework that has now been applied to over 5000 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 experience and functioning of student teams in institutions across North America.

Tom O'Neill. 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.

Marjan Eggermont. Marjan 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.

William Rosehart appointed dean of the school in early 2014 after serving as Interim Dean for the year prior. Before his appointment, he was the head of the Department of Electrical and Computer Engineering. Dr. Rosehart holds a BASc (Electrical Engineering), Master's of Applied Science and PhD from the University of Waterloo and joined the University of Calgary in 2001. He has won many awards including the SSE Service Excellence Award in 2009, the Department of Electrical and Computer Engineering Professor of the Year Award for 2003-04 and the Students' Union Teaching Excellence Award. He has also received awards from the Institute of Electrical and Electronics Engineers (IEEE) and the Association of Professional Engineers and Geoscientists of Alberta (APEGA). He is registered as a Professional Engineer through APEGA, was a member of the Governing Board of the Institute for Electrical and Computer Engineers' (IEEE), Power Energy Society (PES) and was the PES Vice-President, Meetings and Conferences, from 2010 to 2013. A founding member of the Canadian Engineering Education Association (CEEA), he was on the CEEA's Board (2011-2013) and is currently a member of the Petroleum Technology Alliance Canada (PTAC) board.

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