Teaching Teamwork: A Training Video Designed for Engineering Students

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Abstract

The ability to communicate and work effectively on a team has increased in importance in the field of engineering as the demands of business and industry have evolved[1]. Engineers today report that communication is critical to their success and spend a large percentage of time interacting with others[1] and working on teams[2]. Despite the need for interaction in practice, industry reports indicate engineering graduates show skill deficiencies in communication and teamwork[3]. Due to the importance of these skills, many encourage their integration into the engineering classroom, suggesting curriculum should emphasize their value and reinforce their importance in students' future engineering careers[4]. Instructors who teach team skills, or who integrate effective team practices into the design of projects, can set student teams up for success, maximize their learning, and enhance students' ability to work on teams in the future. Teaching these skills can be challenging however, which led us to create a brief research-based video that integrates research and theory relevant to engineering student teams, from the fields of engineering education and Industrial/Organizational (I/O) Psychology, a field that studies behavior at work. The purpose of this paper is to provide a resource to educators who want to learn more about the practices demonstrated in the video and how to integrate this learning tool into their classroom successfully. We discuss the research and theory behind the strategies modeled and taught in the video, focusing specifically on what instructors can do to improve team effectiveness throughout a project.

Introduction

Team projects are frequently used in both engineering education as well as industry, yet teamwork is often fraught with conflict which interferes with a team's effectiveness and their ability to produce desired outcomes. Borrego, Karlin, McNair, and Beddoes (2013)[2], conducted a meta-analysis on the use of student teams in undergraduate and graduate engineering and computer science education. Their meta-analysis, which included 104 articles published between 2007 and 2012, identified five constructs that are particularly relevant to engineering student teams and suggested strategies for educators to address each issue. Borrego et al. (2013) also called for the integration of theory and research from Industrial/Organizational (I/O) Psychology, a field that studies behavior at work, to better understand and improve teams in engineering education. Expanding upon the work of Borrego et al. (2013), we created a video learning tool integrating theory from both engineering education and I/O Psychology, to facilitate the teaching of team skills to engineering students. This educational resource incorporates research on team effectiveness, specifically relevant for engineers, along with best practices utilized at well-known engineering institutions including the Massachusetts Institute of Technology (MIT), Cornell, and University of California (UC) Berkley.

The five core teamwork constructs identified as critical for undergraduate engineering projects by Borrego et al. (2013) are social loafing (i.e., lack of equal team member contribution), interdependence (i.e., task completion is dependent on collaboration), conflict resolution, trust, and shared mental models (i.e., mutual understanding of roles and responsibilities that guide

team behaviors). Each of these constructs are incorporated into the video and strategies to mitigate problems that arise from them are discussed. The video follows a team of four engineering students through their senior design project, focusing on three key points in any project; formation, mid-point, and completion.

The medium of video training was chosen due to its accessibility and ease of implementation in the classroom. Video training has been shown to be equally effective to other training mediums[5], and significantly better than print resources alone[6]. As a relevant example, a study on conflict resolution training, showed that video training had a significant positive impact on conflict resolution, increasing participant solutions, and elevating conflict resolution self-efficacy[7]. Training has been shown to impact learning and behavioral change, with training on interpersonal skills showing the strongest connection to results[8]. Effective training is directly related to performance, adaptation, and skills, and indirectly related to empowerment, communication, planning, and task coordination[9]. Ideally this brief video would be paired with a class discussion or a reflection assignment to crystalize learning, similar to the reflection assignment modeled by the students near the end of the video[10], but the video can also stand alone as an educational tool.

Individuals are more motivated by work if they believe it to be important to them personally[11], and receive the most benefit from training when they are highly motivated to learn[12]. As a result, the teaching of team skills and communication, which may seem out of place in the engineering classroom, must be prefaced with conversation around the importance of these skills for practicing engineers in order for students to see the message as important. Most engineering work today is done in teams[2] and engineers report that much of their time is spent communicating with others[1]. As a result, the development of team and communication skills should be presented to students as a fundamental element of their education, which is critical to their future success in the field. Instructors can reiterate this message by giving examples in their classes of engineering teams or experiences they, or other engineers have had working in teams. Conversations such as these can be integrated throughout the course and can provide an introduction to the video by communicating its relevance to engineering students. The training video uses situations and language specific to engineering, but instructors can emphasize this message, increasing the benefit of viewing the video and the likelihood students will implement the practices.

Team Formation

Tuckman's (1965)[13] model of effective teaming has frequently been integrated into programs designed to address teamwork skills in engineering students and has been used at schools including MIT, Cornell, and UC Berkeley. The model includes four stages: forming, storming, norming, and performing. Research has shown that effective teams are typically not quite this linear, but the model has prevailed due to its simplicity, relevance to team experiences, and because it normalizes interactions that might otherwise be viewed negatively, such as conflict resolution[14]. The forming stage, in which teams come together, is a critical time that can significantly influence the project and students' level of performance. Intentionality in this stage is critical as teams need to set expectations that will guide their work and ensure they are working towards the same goals. During the team formation phase, the training video focuses on

contracting and establishing team norms, to address the constructs of conflict resolution, trust, and shared mental models. Research has shown that efforts to define team processes and norms of behavior, including communication and interpersonal interactions, can help prevent conflict in many situations[14]. Establishing norms can also improve team efficacy, or the team's confidence in their ability to accomplish their goals, as well as their overall performance[15, 16].

An effective strategy to help students establish norms and expectations for their team is to have them create a team contract when they begin working together, which can be given as an assignment. Contracting is beneficial as it encourages them to set goals and provides an opportunity for them to discuss their expectations and hold each other accountable during the project. The act of creating a contract and setting goals as a group can increase the chances team members will share the same mental model, which can reduce conflict throughout the project[17]. Shared team mental models can be described as a mutual understanding of tasks, roles, responsibilities, and experiences that guide team behaviors[18]. An effective way to create shared mental models is to require project teams to think through these aspects together when creating their team contract[14, 15].

Goals

Research on effective goal setting has been a focus of I/O Psychology due to the influence goals can have on both motivation, and performance. It seems intuitive that it would be hard to achieve something if you do not understand what it is you are trying to accomplish, and yet people often skip the step of creating specific goals to focus and define their activities. Goal specificity improves performance by reducing the ambiguity about what is to be attained[19] and will help students clarify what they are trying to achieve. Effective goals encourage team interdependence, or the need for team members to collaborate[20]. Goals should be created as a team when possible, which ensures shared mental models, and in turn increases team efficacy and performance[11]. Student teams should be encouraged to create goals at the outset of their project which will guide their work and help them create a shared sense of direction. Instructors should encourage teams to set goals that are specific and challenging, yet achievable, as goals of this nature are more likely to lead to higher performance[11].

When task complexity leads to high levels of anxiety, as is often the case in student projects, learning goals are recommended over performance goals[11]. A learning goal is focused on development and potential, with an emphasis on mastery through effort and strategy, rather than focusing on achievement[21, 22]. An example of a learning goal is, "by the end of this project, I would like to have significantly increased my knowledge of subject (X), even if our design is not perfect." Learning goals such as this encourage the individual to focus on learning, and places emphasis on effort. An example of a performance goal, in contrast is, "I want to earn an 'A' on this project." The problem with performance goals, which are the type most commonly set, is they prioritize achievement over learning. Thus, students who set these types of goals focus on maximizing performance to earn a grade instead of making sure they learn the concepts and skills.

Specifying the end but not the means energizes team members, orients their attention and action, and engages their talents[23]. Instructors who allow teams the autonomy to determine how they

will accomplish their goals, allow them to draw on their full range of knowledge, skills, and experience, help motivate them to perform at their highest level[23]. Teams should be encouraged to set goals together, as well as to set individual learning goals which align with the team's objectives. This approach can help to reduce conflict and to increase team participation and commitment. Conflict between personal and team values may result in members pretending to embrace team values, when in actuality they are less motivated to work on team goals[24]. Social loafing, or the phenomenon that individuals contribute less while working on a team than they would if working alone,[25, 26] is by no means found only in undergraduate engineering project teams. Social loafing is an issue that has been identified in teams worldwide, and most often manifests when individuals lack motivation or engagement[2]. Research suggests that a team's commitment to a common purpose, and a set of specific and actionable performance goals, can help prevent social loafing[27], which is why contracting and goal setting in the forming stage is crucial. In addition, instructors can reduce the extent of social loafing by communicating that team participation is mandatory and specifying how each individual's contribution will be measured[25, 26, 28]. Examples of how to measure individual performance include peer evaluation, specific task designation and measurement, and instructor observation. In addition, team members are more likely to be motivated to contribute when their contribution is unique[2, 25, 26]. This can be accomplished by assigning specific roles[2] or emphasizing diversity of thought and experience within each team[25, 26].

Defining roles during the formation phase can help the team clarify responsibilities and prevent conflict[29]. In particular, designating a facilitator to organize and moderate can help meetings run efficiently and effectively; while designating a note taker can ensure that important team information is captured and recorded[29]. Different projects will require additional roles that instructors can help students define and assign within their teams, depending on the needs of the project.

Another critical aspect which should be emphasized in the forming stage, and included in team contracts, is the use of an agenda for every meeting. Students often complain that group meetings are unproductive and a waste of time[17]. The efficiency of meetings can be greatly enhanced with the use of an agenda as it gives structure to the meeting and clearly outlines what team members should be prepared to discuss. Student teams should be required to create and distribute an agenda to all team members prior to each meeting[17]. The agenda should list the topics to be covered in the session, as well as the time allocated for each topic. To help students think about their meetings and maximize their time together, instructors can encourage students to consider the "Five W's of Team Communication" when they create each agenda; this tool emphasizes the importance of establishing who, what, when, where, and why a team will communicate[30]. 'Who' focuses on those that should be involved, 'what' looks at the content communicated, 'when' and 'where' help the team organize meeting times and places, and 'why' clarifies the importance of communication. The individual in charge of the agenda should announce it aloud to the team at the beginning of the meeting in order to set the meeting structure and guide their time together.

Conflict Resolution

Cognitive conflict, or conflict between ideas, can be beneficial for teams as it improves decision quality and is related to increased understanding, creativity, and interpersonal relationships within the team[31]. It can also help teams avoid the social phenomenon of groupthink where team members prioritize consensus over independent thinking and critical evaluation of ideas[32]. Interpersonal conflict, however, has been shown to be destructive for decision quality and team efficacy[31]. When conflict occurs, it is more productive and effective to focus on the divergence in opinions relevant to the task, rather than on interpersonal issues[33-35]. Stress and anxiety from conflict can have physical consequences, trigger the fight-or-flight response, and disable rationale conversation[36]. Therefore, it is important for team members to remain calm and tactful during conflict, and to focus on the content of the ideas, which allows for better understanding of the rationale behind differing opinions and resolution[34]. In addition, students should be instructed to revisit their contract and team goals when conflict arises to see if they included any provisions about how they would handle conflict. Team members may also find that certain goals or aspects of their contract need to be redefined in order to overcome the conflict and prevent it from arising again in the future[37].

Mid-Point Check-In

Revisiting the team's contract is a valuable activity both when conflict arises and at the mid-point of the project where an assessment of the team's progress and processes can facilitate project completion[38]. A mid-point check-in is critical to a team's success for several reasons. One is that it causes teams to pause and reflect on what is working and what is not, allowing adjustments to be made, rather than reaching the end of the project and realizing things could have been done more smoothly. At the beginning of a project, it is difficult to know every aspect that will need to be contracted or the actual scope of the work. By the mid-point, teams have a better idea of what the work entails and how they work together, allowing them to make necessary adjustments. When instructors introduce a project, they can inform the class each team will do a mid-point check-in, which will give them a chance to reflect on their progress and processes, and make changes to help them complete the project. Groups should be encouraged to make changes to items in their contract or processes that are not working, and to think about what they are doing well, so they can capitalize on their strengths. Instructors could give students a portion of class time to meet with their teams and perform the mid-point check-in or could require each team to turn in a revised contract or work plan based on their conversation.

End of Project

Reflection is important not only at the mid-point, but also at the end of a project, as it helps students synthesize their learning and make changes moving forward. A key criterion of team effectiveness is individual learning and well-being[23]. One of the most effective ways to capture learning through experience is to intentionally reflect on what is being learned either during or immediately after the experience[10, 39]. An example of a reflection assignment would be to have each team member write about what they learned in relation to the concepts being taught. In addition, students should write about what they would do differently when working within a team in the future, as this will help them solidify their learning and apply it. It is best to have

students do a reflection while the experience is fresh in order to best synthesize and reinforce their learning[10, 20, 38].

Summary

Communication and team skills are critical for success in the field of engineering but can be difficult to teach in the classroom. We created a training video for engineering students to fulfill this need, which focuses on the aspects of teamwork and communication most relevant to this population. This video should provide an effective way for instructors to teach these skills without requiring much preparation or class time. An instructor can be a valuable supplement to the video if they build these practices into their projects and communicate to students that these skills are valuable and critical for their development. Instructors can support effective team practices throughout the process by having students define and establish team norms, goals, and processes, and write these into a contract at the beginning of the project. They can also encourage teams to take time for evaluation at the mid-point to assess their process and make adjustments, and encourage reflection at the end of a project to facilitate application and learning.

Bibliography
1. Darling, A. L., & Dannels, D. P. (2003, January). Practicing engineers talk about the importance of talk: A report on the role of oral communication in the workplace. *Communication Education, 52*, 1-16.
2. Borrego, M., Karlin, J., McNair, L. D., & Beddoes, K. (2013, October). Team effectiveness theory from industrial and organizational psychology applied to engineering student project teams: A research review. *Journal of Engineering Education, 102*(4), 472-512.
3. Prescott, D., El-Sakran, T., Albasha, L., Aloul, F., & Al-Assaf, Y. (2012, Spring). Teambuilding, innovation and the engineering communication interface. *American Journal of Engineering Education, 3*(1), 29-40.
4. Dannels, D. P., Anson, C. M., Bullard, L., & Peretti, S. (2003, January). Challenges in learning communication skills in chemical engineering. *Communication Education, 52*, 50-56.
5. Macurik, K. H. (2008). Video training of support staff in intervention plans for challenging behavior: Comparison with live training. *Behavioral Interventions, 23*(3), 143-163.
6. Donkor, F. (2010). The comparative instructional effectiveness of print-based and video-based instructional materials for teaching practical skills at a distance. *The International Review of Research in Open and Distance Learning, 11,* 96-116. Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/792/1486
7. Guzzo, R. A., & Dickson, M. W. (1996). Teams in organizations: Recent research on performance and effectiveness. *Annual Review of Psychology*, *47,* 307-338. doi:10.1146/annurev.psych.47.1.307
8. Arthur, W., Jr., Bennett, W., Jr., Edens, P. S., & Bell, S. T. (2003). Effectiveness of training in organizations: A meta-analysis of design and evaluation features. *Journal of Applied Psychology, 88*, 234-245. doi:10.103770021-9010.88.2.234
9. Aguinis, H., & Kraiger, K. (2009). Benefits of training and development for individuals and teams, organizations, and society. *Annual Review of Psychology*, *60,* 451-474. doi:10.1146/annurev.psych.60.110707.163505
10. Hill, C. (2013). What, so what, now what? In C. D. McCauley, D. S. DeRue, P. R. Yost, & S. Taylor (Eds.), *Experience-driven leader development: Models, tools, best practices, and advice for on-the-job development* (pp. 229-233). San Francisco, CA: John Wiley & Sons.
11. Locke, E. A., & Latham, G. P. (2002). Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American Psychologist*, *57*, 705-717.
12. Noe, R. A. (1986). Trainees' attributes and attitudes: Neglected influences on training effectiveness. *The Academy of Management Review*, *11*, 736-749. doi:10.2307/258393
13. Tuckman, B.W. (1965). Developmental sequence in small groups. *Psychological Bulletin, 65,* 384–99.
14. Feldman, D.C. (1984). The development and enforcement of group norms. *Academy of Management Review, 9*, 47-53

15. Hunsaker, P., Pavett, C., & Hunsaker, J. (2011). Increasing student-learning team effectiveness with team charters. *Journal of Education for Business, 86,* 127–139.

16. Stogdill, R. M. (1972). Group productivity, drive, and cohesiveness. *Organizational Behavior & Human Performance*, *8*, 26-43. doi:10.1016/0030-5073(72)90035-9

17. Manager Tools, LLC (2010). The effective meetings starter model. Retrieved February 25, 2014 from http://www.manager-tools.com/docs/Effective_Meetings_Starter_Model_Slides.pdf

18. Kozlowski, S. J., & Ilgen, D. R. (2006). Enhancing the effectiveness of work groups and teams. *Psychological Science in the Public Interest*, *7*(3), 77-124. doi:10.1111/j.1529-1006.2006.00030.x

19. Locke, E. A., Chah, D., Harrison, S., & Lustgarten, N. (1989). Separating the effects of goal specificity from goal level. *Organizational Behavior and Human Decision Processes*, *43*(2), 270-287. doi:10.1016/0749-5978(89)90053-8

20. Wageman, R., Hackman, J., & Lehman, E. (2005). Team Diagnostic Survey: Development of an instrument. *Journal of Applied Behavioral Science*, *41*, 373-398. doi:10.1177/0021886305281984

21. Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist, 41*, 1040-1048.

22. Dweck, C. S. (2006). Parents, teachers and coaches: Where do mindsets come from? In *Mindset: The new psychology of success* (pp. 168-206). New York, NY: Random House.

23. Hackman, R. J. (2002). *Leading teams: Setting the stage for great performances*. Boston, MA: Harvard Business School Publishing.

24. Hewlin, P. (2003). And the award for best actor goes to: Facades of conformity in organizational settings. *Academy of Management Review, 28*, 633-642. doi:10.5465/AMR.2003.10899442

25. Karau, S. J., & Williams, K. D. (1993). Social loafing: A meta-analytic review and theoretical integration. *Journal of Personality and Social Psychology, 65*, 681–706.

26. Karau, S. J., & Williams, K. D. (1995). Social loafing: Research findings, implications, and future directions. *Current Directions in Psychological Science, 4*, 134–140.

27. Katzenbach, J. R., & Smith, D. K. (2003). *Wisdom of teams: Creating the high-performance organization.* New York, NY: McKinsey & Company.

28. Price, K. H., Harrison, D. A., & Gavin, J. H. (2006). Withholding inputs in team contexts: Member composition, interaction processes, evaluation structure, and social loafing. *Journal of Applied Psychology, 91*, 1375–1384.

29. Stagl, K. C., Salas, E., & Burke, C. S. (2007). Best practices in team leadership: What team leaders do to facilitate team effectiveness. In J. A. Conger & R. E. Riggio (Eds.), *The practice of leadership: Developing the next generation of leaders*. (pp. 172 – 198). San Francisco, CA: Jossey-Bass.

30. McComb, S., Schroeder, A., Kennedy, D., & Vozdolska, R. (2012, Sept/Oct). The five W's of team communication. *Industrial Management,* 54(5), 10-13.

31. Amason, A.C. (1996). Distinguishing the effects of functional and dysfunctional conflict on strategic decision making: Resolving a paradox for top management teams. *Academy of Management Journal, 39*, 123-148.

32. McCauley, C. (1998). Groupthink dynamics in Janis's theory of groupthink: Backward and forward. *Organizational Behavior and Human Decision Processes*, *73*(2-3), 142-162. doi:10.1006/obhd.1998.2759

33. Behfar, K. (2003). The team exchange contract in autonomous work groups: Behaviors and work strategies for sustainable performance. Doctoral dissertation, Cornell University.

34. Edmondson, A.C. (2012). *Teaming: How organizations learn, innovate, and compete in the knowledge economy.* San Francisco, CA: Jossey-Bass.

35. Jehn, K. A., & Mannix, E. A. (2001). The dynamic nature of conflict: A longitudinal study of intragroup conflict and group performance. *Academy of Management Journal, 44*, 238–251.

36. Gottman, J. (1994). *Why marriages succeed or fail…and how you can make yours last*. New York, NY: Simon & Schuster.

37. Somech, A., Desivilya, H. S., & Lidogoster, H. (2009). Team conflict management and team effectiveness: The effects of task interdependence and team identification. *Journal of Organizational Behavior*, *30*(3), 359-378. doi:10.1002/job.537

38. Gersick, C. J. G. (1988). Time and transition in work teams: Toward a new model of group development. *Academy of Management Journal, 31,* 9–41.

39. Baird, L., Holland, P., & Deacon, S. (1999). Learning from action: Imbedding more learning into the performance fast enough to make a difference. *Organizational Dynamics, 27,* 19–32.