AC 2012-4959: A PROPOSED FRAMEWORK FOR TEACHING TEAM-EFFECTIVENESS IN TEAM-BASED PROJECTS

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Abstract

This paper outlines the pedagogical foundations and preliminary design of a proposed on-line tool to support the teaching of team-effectiveness skills through team-based projects. This on-line tool allows students to learn about team-effectiveness and their individual team-effectiveness competencies through the use of self- and peer-assessment in their project teams. The development of our team-effectiveness framework is described with a focus on how it aims to stimulate students to provide mature feedback. Methods used to motivate students to learn about and improve their team-effectiveness competencies are also described. The intended integration of the tool into the curriculum is outlined, highlighting an on-line student portfolio on team-effectiveness that allows students to track their improvement longitudinally across different project teams throughout their undergraduate studies. This work has been developed for team-based design projects in undergraduate engineering but is also applicable in other disciplines.

1. Introduction

Effectiveness in teams is a new attribute desired of graduates from engineering schools [1]. In traditional engineering classrooms, learning of team effectiveness competencies occurs implicitly through involvement in team-based projects [2]; methods to promote team effectiveness which allow the students to work towards their full collaborative potential are often not taught. These projects offer students rich learning opportunities to learn about course material while simultaneously developing important teamwork skills. Students can gain conceptual knowledge relating to team development and function through lectures; however personalized feedback and reflection are also needed for them to learn from their actual teamwork experiences. In addition, issues which inhibit student's abilities to work effectively as team members are less visible to course instructors as class sizes increase and can severely affect a student's performance. In large classes of 100-1000 students (e.g. APS111/112 [3]), most students receive limited or no personalized feedback to guide ongoing learning on their effectiveness as team members, either due to resource constraints, or limited direct interaction time with the teaching team.

Team-effectiveness, unlike most technical material in the engineering curriculum, requires more personalized instruction than is common in technical courses. Targeted learning in team-effectiveness is needed to transform areas of skill deficiencies into competencies [4]; it cannot be learned by simply studying the theory. As these deficiencies differ from student to student based on personality type or past team-experience, a student-centred approach is necessary to create a deep learning experience by which the students can improve. Methods of learning which are personalized, easily accessible, and include exercises that are readily applicable in the students' current situation increase students' motivation to learn [5]. Formative assessments, which help students identify the next steps to improve their performance and create such personalized experiences, are a powerful means of enhancing deep learning and meta-cognitive abilities [6]. Peer feedback within teams can be used to provide such a formative assessment and thereby

increase student learning on team-effectiveness.

A web-based tool is currently being developed at the University of Toronto to facilitate the learning of individual team-effectiveness competencies in engineering team-based projects using self- and peer-assessment within student project-teams. Specifically, this tool will provide students with a team-effectiveness framework to create a common language by which structured feedback can be provided based on visible behaviours. Personalized exercises and actionable strategies that guide targeted learning in the areas thereby identified will be subsequently provided to students based on their received feedback. This tool aims to provide students with a safe, virtual environment in which they can: i) learn about their team effectiveness and team issues, and ii) practice methods to improve on identified areas of weakness before trying them with their teammates. This on-line tool will serve as a one-stop, on-line portal through which students can access self-reflections and feedback from peer-assessments across different project teams and track their improvement across different years of their degree. A description of the proposed tool design is provided herein.

2. Pedagogical Foundations of the Tool

As discussed above, a student-centred and personalized approach is required to teach team-effectiveness due to the range of student proficiencies. Given the focus of engineering curricula on technical competencies, students can undervalue the need for leadership and interpersonal skills, such as effective teamwork, in the profession. This undervaluing may come from ambiguity in defining teamwork as a concrete process in which the variables are explicit and understood. As a result, this tool focuses on defining key team-effectiveness competencies, developing a language to discuss these competencies, and creating clear frameworks within which to model effective teamwork and normalize student interpretations of these competencies. Additionally, through the use of personalized and easily accessible feedback, and exercises selected from multiple sets of team assessments, we aim to increase students' motivation to learn and continue to improve by allowing them to visualize the improvement in, and growth in understanding about, their team-effectiveness.

2.1 Team-effectiveness Framework

The team-effectiveness framework defines the competencies that are seen in effective team members and provides students with a descriptive rubric within which to evaluate their own, and their peers, behaviour during teamwork.

The team-effectiveness framework used in this tool is derived from four existing team-effectiveness models/inventories [7-10], and categorizes individual competencies into three aspects: Relational, Organizational, and Communication. The Relational competencies deals with fostering positive interpersonal relations, the Organizational competencies with managing the workflow of the team, and the Communication competencies with the way in which issues and work are presented and discussed. Bushe and Coetzer [7], and Maxwell [8], proposed inventories that focussed heavily on what we term Relational (conflict management, decision making, cohesion, interdependency) and Organizational (team-member and team performance expectations, direction/goal setting, work processes, etc.) aspects of team-effectiveness. Lingard [9],

incorporated some Communication competencies (share opinions and knowledge, listen to others' opinions, consider others suggestions) in his model. A synthesis of these inventories was developed and redundancy between behaviours was eliminated. The model was then refined and simplified to create the current framework of 27 team-effectiveness competencies, Table 1, based on the most prevalent team-dysfunction issues identified by interviewing faculty at our university who use team projects in their courses.

Table 1. Framework of team-effectiveness competencies.

Organisational Aspects	Relational Aspects	Communication Aspects
Support team rules	Build the trust of teammates	Exchange information in a timely manner
Attend team meetings prepared	Motivate others on the team to do their best	Introduce new ideas
Contribute to making meetings effective	Raise contentious issues in a constructive way	Openly express opinions
Do their fair share of the work	Solicit input before proceeding	Promote constructive brainstorming
Deliver their work on time	Adopt suggestions from other members	Actively listen to teammates
Produce high quality work	Accept feedback about strengths and weaknesses	Provide constructive feedback
Help to plan, set goals, and organize work	Show respect for other teammates	Make sure that teammates understand important information and instructions
Track team progress vs. your timeline	Demonstrate accountability	Help the team build consensus
Encourage progress to meet goals and deadlines	Collaborate effectively	
Display dedication and determination		

2.2 Self- and Peer-assessment

In small-classes, formative assessment can be readily implemented through personalized feedback from instructors. However, in large classes, uses of formative assessments that rely on the teaching staff creating the learning experiences can be both time consuming and costly. As a result, the use of guided peer- and self-assessment to provide this feedback is a more feasible approach. Peer-assessments to measure an individuals' team performance and provide feedback on it are often used in engineering industry and have seen application in universities as a mechanism for evaluating team members' contributions [9,11-13].

Diagnostic tools which allow students to self-assess their team situation along specific team skills/behaviours to identify targeted areas for improvement have proven to be effective in the engineering classroom [9]. These tools allow students to reflect and improve on their own, and their teammates', team-effectiveness as demonstrated both within and outside of class work time. This provides a broader context for the feedback provided as most teamwork in engineering team

projects happens outside of instructor or teaching assistant supervised work time. Existing peer review protocols which provide feedback to students are often paper-based and collated by instructors with summaries distributed to the students [11-12]. This approach is not feasible in large classes. As a result, there has been a shift towards creating web-based tools that allow for the automated collection, collation and analysis of self- and peer-assessment data. The use of web-based tools to create an environment for applying formative assessment has been shown to be successful in both professional development and technical material [14-16].

Through our tool, students use the framework of team-effectiveness competencies as a guide for providing structured assessments on their own and their team members' effectiveness. When providing an assessment, students rank themselves and their teammates according to a 7-point descriptive Likert scale (similar to a rubric) along each competency that explains the behaviours seen at each level. The model we used to develop the descriptions of each competency follows an *uncaring – self focused – team focused* model. The 1-3 range of the Likert scale describes someone who is not engaged in the teamwork, the 4-5 range someone who is focused on themselves and their needs alone, and the 6-7 range someone who is focused on putting the team first, as shown in Table 2. By structuring the assessments, and using descriptions of the different levels of competency, students should: i) all be able to assess according to a common scale, reducing the variation in assessments for a given team member from different teammates, and ii) be able to provide feedback that allows a teammate to easily identify how they need to improve. Additionally, feedback will be anonymised before it is distributed to the students, such that there will be a greater openness to providing honest and accurate feedback.

Table 2. Examples of the descriptive rubric for some of the competencies listed in the framework.

	1	2	3	4	5	6	7
Support team rules	Did not contribute to the development or team rules, nor did they abide by them during the project		Supported only those rules which were convenient or they felt were appropriate		Contributed to the development of the rules and supported most of the rules, most of the time		Contributed to the development of the rules, and not only supported them but assisted other teammates in supporting them
Motivate others on the team to do their best	Did not demonstrate interest in the motivation of anyone on the team, including self		Did not demonstrate interest in the motivation of others on the team		Attempted to motivate others when it was beneficial to self, or was not too time consuming		Motivated others on the team to do their best at all times during the project
Openly express opinions	Did not express opinions		Expressed opinions in a manner which demonstrated hesitation or reservation		Expressed opinions in an open manner		Expressed opinions in an open and unbiased manner that solicited input from others

2.3 Motivation to Engage in Learning

Motivating students to engage in learning about team effectiveness was a focus in the development of this tool, because it can be a challenge to convince engineering students to engage in non-technical material. Methods of learning which are personalized, easily accessible, and include relevant exercises will increase a student's motivation to learn [5]. This on-line tool has approached motivating students in two ways: personalized targeted learning, and student portfolios.

The tool serves as a place for personalized student learning, where each student will only see the information relevant to them. Students will log in to the tool and access their individual space. This section contains the student's received assessments, a section on general team-effectiveness learning related to the framework, and a list of recommended learning activities. These recommended activities will be selected by the tool from a list of activities for all the competencies, so that students are encouraged to engage in the exercises that are most likely to assist them in improving their team-effectiveness. Targeting exercises to the areas of greatest weakness will provide students with the greatest opportunity for improvement. Each student will only be able to access their individual section of the tool, ensuring the received feedback and recommended exercises are only seen by the student they are intended for.

Some peer-assessment software tools have been developed to provide feedback on student performance and promote an equitable grade distribution among students; however these are not intended as tools to promote individualized, actionable learning on team effectiveness. One example of such a tool is the Comprehensive Assessment of Team Member Effectiveness (CATME) [17]. However this tool, like others, is focused on providing a list of feedback to the student and providing the instructor the ability to assess team contribution and identify team issues without observing the teams so as to determine equitable grade distributions. While these tools can identify areas of deficiencies to students, they do not attempt to directly move the students from feedback to practice by providing relevant exercises upon which students can improve on their identified weaknesses. Including opportunities for practice with the feedback should increase the chance that students will respond maturely and investigate the exercises so as to improve their behaviours, rather than immaturely, such as by concluding that the feedback is incorrect.

The student's section within the course tool takes the form of a student portfolio. Each portfolio contains the student's feedback from each team-project which used the on-line tool and allows students to track their growth across different teams over the course of their degree. Being able to track one's improvement across specific competencies, or in specific exercises on team-effectiveness, across the duration of one's degree should encourage greater motivation in the students to improve their effectiveness in teams, as they can visualize the improvement that has already taken place. Additionally, the student portfolio creates a platform upon which students can begin to engage in lifelong learning about their team-effectiveness through learning how to extend the development of their team-effectiveness beyond their current or previous team situations to other teams over the duration of their degree.

3. Integration with the Curriculum - The Student Experience

This tool is designed to be used to teach team-effectiveness alongside any engineering (or non-engineering) course that has a full-term team-based project. In particular, team-based design projects (cornerstone, capstone, or discipline specific) are ideal candidates as they require effective teamwork to facilitate the development of an optimal design solution. The tool comprises four areas where students can engage in learning from their team experience. These areas allow students to:

- self-reflect and provide feedback on their teammates
- review the feedback they have received
- access tools and techniques to improve their understanding of team-effectiveness
- engage in exercises to practice their team-effectiveness competencies

This section outlines our proposed method of integrating this learning tool into a course and its team-based project. Figure 1 demonstrates the progression of a student through the areas of the tool over the duration of a project. The arrows in and out of the student portfolio demonstrate whether it is information a student provides to the tool (arrow towards the portfolio) or whether it is information they receive from others in their team via the tool (arrow from the portfolio). It must be noted that the progression around the circle need not be solely linear, but is shown as such for clarity in this figure. A student may improve their understanding of teams, or engage in exercises at any stage during their team experience by engaging in all the activities available through the tool. However, after a student receives feedback these activities will be more useful, as specific activities (recommended based on the feedback received) will be highlighted. Each use of the tool in one course consists of one pass through the cycle.

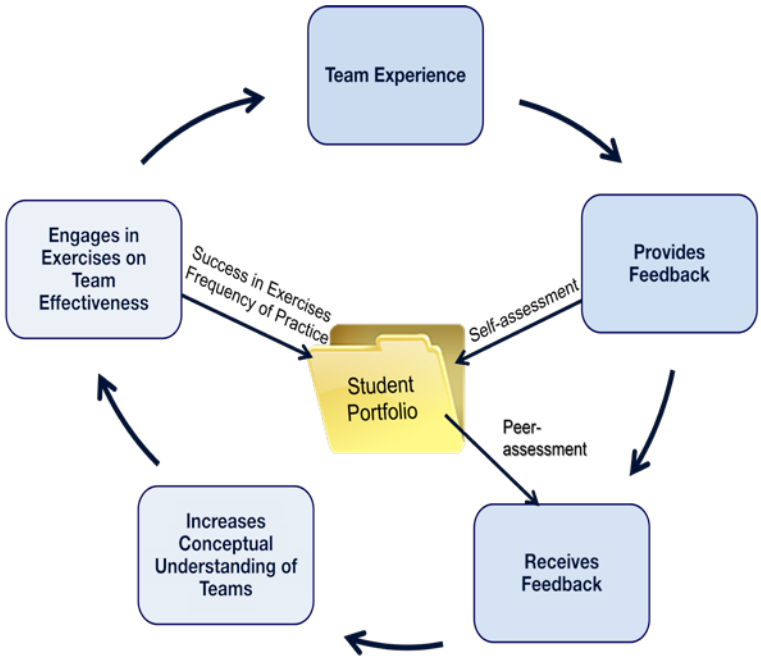

Figure 1. The student's experience with the tool.

3.1 Team Experience

The team experience is where the learning about teams occurs and consists of the physical teaming that occurs in the project. While there is no “team experience” area in the tool it is important to present how the team experience must be framed in order to facilitate the desired learning from the tool. The team experience within the course needs to be approximately one term in length so that students can pass through the forming stage of team development before providing feedback on their teammates, and following receiving their feedback, have time to work on improving their effectiveness within that team. Additionally, the problem in the project needs to be sufficiently complex that an effective team approach is required for it to be adequately addressed.

At the beginning of the course in which the tool will be used, the students must be introduced to both the project in which the learning will occur, as well as the tool. The foundations of team-effectiveness should be incorporated into a lecture within the first week of the course before team-formation occurs. This lecture should introduce the Relational, Organizational, and Communication competencies that comprise the team-effectiveness framework and describe how these competencies are manifested as behaviours in highly-effective, high-performance teams. The use of the framework to provide feedback, as well as how to use the feedback received to improve using the resources in the tool should also be covered.

3.2 Provides Feedback

Within this area of the on-line tool students will be prompted to reflect on their own competencies and provide feedback on those of their teammates. Feedback will be provided according to the framework of team effectiveness presented in Table 1, so as to guide students to provide useful and actionable feedback. Each student will rank themselves and each of their peers according to a descriptive Likert scale along each competency, as demonstrated in Table 2. Feedback provided to teammates will be anonymised before it is made available to them, and will be provided as multiple assessments along each competency. Each course’s feedback is filed in the student portfolio as a separate entry.

The students should be prompted to provide/submit feedback twice over the course of a project: first approximately half way through the project, ideally after a significant deliverable, and second at the end of the project. The first set of feedback is formative, and is meant to highlight for students the weaknesses and strengths that their teammates see in them. Students then have a number of weeks to use the tool to improve their team-effectiveness and demonstrate this improvement to their teammates. At the end of the course the second set of feedback is meant to highlight whether the teammates saw a visible improvement in the effectiveness of the student, or whether more improvement is needed. Allowing for approximately six weeks between the first and second set of feedback gives enough time to the students to practice exercises on-line that are related to their weaknesses and allow their improvements to manifest in their visible working behaviours.

To ensure each student gets a full complement of assessments from their teammates the submission of feedback should become part of a student's project course work. Students can be encouraged to provide these two feedback submissions in a course through the use of "completion marks" worth a few percent per submission, or alternatively by making a component of the project grade allocated to teamwork, and having students reflect on the quality of the feedback and learning experience they provided to, and received from, their teammates. Both methods have been used before for peer feedback in our Faculty, and have generated greater than 90% completion rates.

3.3 Receives Feedback

Within this area students will be able to review the feedback provided to them by their teammates. Students will have their self-assessment noted as from themselves, however the feedback from their teammates will not be labelled so as to ensure the feedback reaching the student is anonymised. Each course's feedback is filed in the student portfolio as a separate entry.

Each student will receive a colour-coded list from each teammate, which highlights in red the three areas of greatest weakness and in green the three areas of greatest strength identified by that assessor. As a result, a student would receive *n* colour-coded lists, where *n* is the number of members of their team. At the bottom, their three greatest areas for improvement and their three greatest strengths identified by the tool based on the feedback of the teammates will be listed. This list of strengths and weaknesses will include a description of the level of their current competency, and links to specific tools, techniques, and exercises available in other areas of the tool that will help them improve their competency.

Students should receive their first set of feedback within as short a time as possible of providing the feedback to ensure that the assessment of their competency is still relevant and they have the greatest amount of time to improve upon it. Their second set of feedback will include the colour coded lists as described above, and will also comment on the relative improvement of the student as seen between the two assessments.

3.4 Increases Conceptual Understanding of Teams

This area of the tool provides students with information on the skills and behaviours associated with each competency, as well as strategies and techniques for how to develop those competencies. While the lessons for all competencies will always be available to the students, none will be highlighted until after the first set of feedback is received. These highlighted lessons will draw the student's attention to those competencies in need of greatest improvement. Unlike the two feedback areas which are integrated with the student portfolio and allow for a longitudinal review of performance, this area will only highlight the areas of improvement provided in their most recent set of feedback. This way, as the students' competencies grow over the course of multiple uses, they can continue to improve their overall development by being directed to those areas which are currently in greatest need of improvement. Students will be able to access this area of the tool at any time during its use.

This strategies and techniques outline in this section focus on identifying to students what the individual competencies of team effectiveness are, as well as how they affect a team. The techniques and strategies within this area include ways of improving one's competency for both the individual working towards team objectives on an independent aspect of the project, as well as when working together as an entire team. The strategies are designed to provide students with methods by which to improve their competency when engaging in collaborative work with their teammates. The techniques are designed as "check lists" of what to do to improve, as a means of individually preparing one's self for the collaborative work required of the team. At the end of each strategy or technique section on a competency, there is a short one or two question quiz to identify to the student whether they have learnt the material, or not.

3.5 Engages in Exercises on Team-Effectiveness

Exercises are provided to allow opportunities for practicing improvement with the feedback. By recommending specific exercises we hope to motivate students to focus on the competencies in greatest need of improvement by targeting their attention on selected exercises, and not all of them. In this area as well, only the areas of improvement recommended from their most recent set of feedback will be highlighted while all exercises will be accessible. Exercises are designed as a method of allowing students to practice techniques or strategies in a safe, non-judgmental manner before trying them out with their teammates, so as to develop confidence in their competency before utilizing it in the team environment, Figure 2. Students will be able to access this area of the tool at any time during its use.

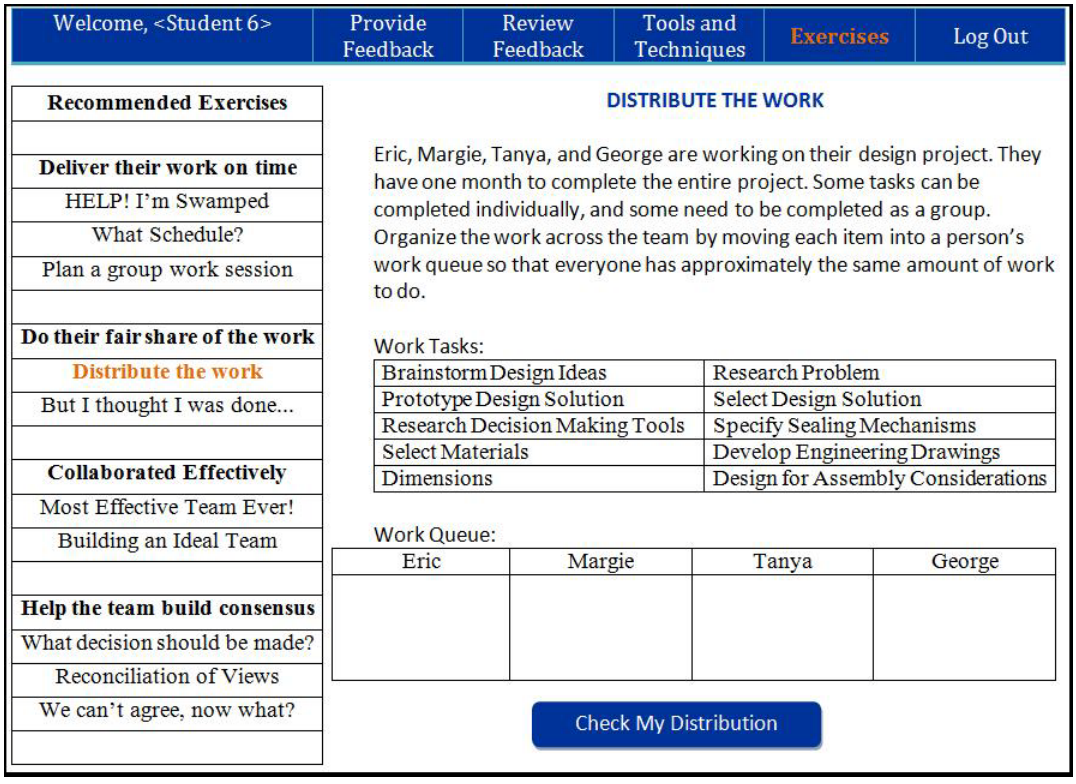

Figure 2. Example of a potential Type 1 exercise for the competency "Do their fair share of the work".

Exercises take three forms:

1. Games, designed to tests student's knowledge and application of the competency
2. Interactive exercises to be engaged in with other anonymous students currently logged in to the tool
3. Exercises to be done in-person with a friend, where the student submits a reflection afterward.

The tool will track a student's progress in the different exercises they engage in so as to demonstrate whether they are improving in their competency. Metrics that capture frequency of practice, which exercises are engaged in, and how often a student successfully completes an exercise will be used to demonstrate this improvement. Providing students with targeted areas of learning in a fun atmosphere (such as a game) should increase student motivation to engage in the exercise, and as a result the learning.

4. Conclusions and Future Work

This paper presents a framework of team-effectiveness and the proposed design of an on-line tool to teach team-effectiveness in large classrooms. The tool is designed to be integrated in courses with full-term, team-based projects. These courses provide team experiences of sufficient duration for a student to receive feedback on their competency as a team member, reflect, practice, and improve their competency based on that feedback. This tool aims to provide students with a safe, virtual environment in which they can: i) learn about their team-effectiveness and team issues, and ii) practice methods to improve on identified areas of weakness before trying them with their team-members. The use of a student portfolio to track assessments over multiple uses of the tool in different teams allows for students to develop a complete picture of their competencies and how they have improved, as well as increase their self-efficacy in the area.

In early 2012, a pilot version of the tool will be tested in a first year cornerstone engineering design course of approximately 250 students to assess the ability of student feedback to be guided via the framework to be accurate and actionable. In the 2012-2013 school year the full tool will be rolled out to multiple large courses in engineering with team-based projects where the entire tool as described will be evaluated. We expect intentional teaching of team effectiveness through self- and peer-assessment to improve student efficacy in team-effectiveness competencies and to improve student performance in team-based projects due to a greater understanding of themselves and of team dynamics.

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