Student Development of Team-effectiveness Behaviours in Engineering Teams

by

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A dissertation submitted in conformity with the requirements for the Degree of Doctor of Philosophy

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Abstract

The Canadian Engineering Accreditation Board requires all graduating engineering students to demonstrate the ability to work effectively in teams. This thesis provides a response to this requirement through the development and testing of an on-line team-effectiveness learning system (TELS) for use in large 250-900 student classes. Based on Kolb’s Experiential Learning Theory and Hewson and Little’s feedback model, TELS provides students an opportunity to develop their team-member effectiveness through: i) guiding intra-team self and peer assessments of teamwork using an inventory of behaviours customised for engineering students; ii) providing students self and peer feedback to identify opportunities for improvement, and iii) providing online, integrated lessons and exercises on how to improve each behaviour within the system.

The Team-Effectiveness Learning System (TELS) was developed and tested in a multi-year study of two first-year engineering design courses. A mixed-methods approach was taken to assess the efficacy of the system, combining an analysis of students’ self and peer assessments, their use of the online learning system and students’ self-reported assessments of the system’s utility. Findings from three-years of testing and revision indicate that TELS guided students to
provide feedback for improvement that was reliable and that the behavioural inventory used to provide feedback expanded student discussion of relational and communication behaviours. A statistically significant improvement in students’ self and peer assessed weaknesses was seen between mid-term and end-of-term feedback. Student improvement was predominantly motivated by the feedback a student received; students who received feedback that had a greater focus on strengths and weaknesses reported being more motivated to improve their behaviour and did improve their behaviour more than those whose feedback discussed few strengths and weaknesses. Student improvement methods focused on reviewing their feedback and reflecting on how to improve their weaknesses – only 13% of students used the online lessons as scaffolding to support development.

Integration of the Team-Effectiveness Learning System (TELS) into team projects in engineering education affords instructors in large classes a way to provide personalised feedback to individual students. In first-year engineering design classes it has been found to improve students’ team behaviour and expand students’ understanding of effective teamwork.
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1. Introduction

This thesis explores a way of supporting engineering students to enhance their capability to engage in teamwork through the use of an online Team-effectiveness Learning System (TELS).

Since researchers’ definitions of, and approaches to, developing team-effectiveness differ drastically depending on the type of team and the length of time the team works together (Bradley, White, & Mennecke, 2003), instruction on team-effectiveness can occur at either the team or individual level through developing group processes or individual behaviours (Pina, Martinez, & Martinez, 2008). Team-member effectiveness is the approach to developing teamwork capacity taken up in this work. It is defined herein as the level of competency of an individual to contribute to team performance (product outcomes) in a manner that: i) focuses on putting the performance needs of the team before theirs, ii) takes a cooperative approach to the work, and iii) values and leverages the abilities and contributions of all team members. This definition is informed by the group process component of team-effectiveness defined by Wageman (2001), the five aspects of teamwork by Salas et. al (2005), and Le Pine et. al.’s framework linking team behaviour and processes (2011).

The approach taken in this work is not to develop a new model of team-member effectiveness based on the theories of team effectiveness – several models that have been rigorously developed already exist. Instead, it is to contextualise and make actionable for first-year engineering students a model which is understandable, relevant, and useful for providing individualised feedback to team members. Thus, this work provides a means for students to enhance their capability to engage in teamwork through defining a model of team-member effectiveness, leveraging it as assessment criteria for self and peer feedback, and connecting that feedback to online lessons to scaffold student development and learning.

1.1. Motivation

Over the past 15-20 years, there has been a push to outcomes-based accreditation of engineering programs in the United States (ABET, 2012) and Canada (Canadian Engineering Accreditation Board, 2010). Of the twelve desired attributes of graduating engineering students in Canada, seven focus on developing non-technical skills (such as individual and teamwork
skills, professionalism, and life-long learning). To create curricula in which students can learn, and be assessed in alignment with these outcomes, there has been a push towards creating alternate learning environments that model real-world practice. This includes a shift from a lecture-problem-set-based approach to teaching to one that incorporates Cooperative Learning (CL) situations in which students work together on structured activities in groups, and Team Based Learning (TBL) situations in which students work as a team to solve a problem in a manner that models industry practice.

Johnson, Johnson and Smith (1998) describe five criteria of successful CL environments: positive interdependence, face-to-face interaction, personal responsibility to achieve group objectives, interpersonal skill, and group self-assessment. Within the first-year engineering design courses at the University of Toronto the pedagogy of the courses achieves the first four criteria. Design teams have intensive interdependence (Borrego, Karlin, McNair, & Beddoes, 2013), the student teams are given time in class to meet face-to-face to work on their projects, they have a personal responsibility to complete the team’s deliverables as demarcated in attribution tables, and work on projects that require interpersonal skill to navigate their complexity (Hyman, 2003) However, while these projects require interpersonal skills, and because students do not self-assess their skill level, they may not know whether they are working together well or not. Collaborative learning has shown to improve information acquisition (Johnson, Johnson, & Smith, 1998), but this learning will not have the space to occur if students are distracted by team dysfunction. Instruction on how to work effectively as a team is needed to ensure that students can leverage the full benefits of CL and TBL in their learning environments and ensure they do not develop negative perceptions of team-based work (Lingard, 2010).

This work focuses intentionally on one of the twelve desired attributes of graduating engineering students in Canada:

**Individual and teamwork:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

To facilitate developing this attribute, this work approaches developing students’ capability to work in teams at an individual level by developing the behavioural competencies necessary to work effectively as a member of a team. Developing these competencies in the individual instead of the team as a whole is necessary as students change project teams across courses and need to
be able to use these skills in their work after graduation; the behaviours developed by these students need to be transferable across different project teams. These behaviours can be seen as the individual building blocks of team-effectiveness; the more competent a student is, the stronger their building blocks, and the more students with greater team-member effectiveness, the stronger the structure their entire team can build.

However, despite the push from accreditation boards to include developing the capability to work in teams, industry continues to express that there is a gap in student capability. The ability to work effectively in teams is one of the most highly sought-after capabilities, however companies report that it is one of the areas in which their newly hired graduates are least competent.

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 (Larson & LaFasto, 1989); it cannot be learned by simply studying the theory. As these deficiencies differ from student to student based on quantity and quality of past team-experiences, an individualised approach is necessary to create a deep learning experience by which the students can improve their effectiveness from whatever level they start from. However, issues which inhibit students’ abilities to work effectively as team members are less visible to course instructors as class sizes increase. In large classes of up to 1000 students (e.g. APS111/112 Engineering Strategies and Practice (McCahan, et al., 2007)), most students received limited or no personalized feedback to guide ongoing learning about their effectiveness as team members due to resource constraints and limited direct interaction time with the teaching team.

Self and peer assessments within teams on team-member effectiveness can be used to provide personalised feedback to students on their performance thereby increasing student learning about team-effectiveness. On-line self and peer assessments have been used in other disciplines of undergraduate education as a means of providing timely formative feedback to students without overburdening the course instructors, e.g. (Paré, Joordens, & Pruesse, 2009; Hatziapostolou & Paraskakis, 2010). Formative assessments and feedback, 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 (Popham, 2008).
In relation to teaching team-effectiveness, while students may spend 2-3 hours a week working in a classroom with their instructors on their team-based project, students spend significantly more time working together outside of the classroom. As a result, the students are often in a better position to assess and provide personalized feedback on their team members’ effectiveness than instructional staff. 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 (Williams & Williams, 2011).

Thus, this thesis explores a way of supporting engineering students to enhance their learning of team-member effectiveness through defining a model of team-member effectiveness, leveraging it as assessment criteria for self and peer feedback, and connecting that feedback to online lessons to scaffold student development and learning. This integrated tool has been designed to be available to students online as the Team-effectiveness Learning System.

1.2. Literature Review

Given that the online self and peer assessment learning system is designed specifically for students in team-based projects in engineering, this literature review explores both the context of engineering and the process of providing learning in these team environments.

1.2.1. Teamwork in Engineering

Team-based projects have become a common teaching practice in engineering courses as a means to simulate real-world environments and meet accreditation requirements for the development of teamwork skills. In particular, within design courses, team-based projects allow students to engage in problems that are technically more complex and larger than one student would be able to tackle, but that may be solved by a team of students working effectively together.

Students are first introduced to teamwork in their undergraduate engineering program, usually in a design course, either in their first or second year of study. Design-team-based projects are both production environments and learning environments. They encourage each participant to develop a greater understanding of the concepts and processes of design work and of the subject of their design work (learning) while producing a design to meet the needs of their
stakeholders and clients (production). As a result of this, the approaches to collaborative learning that have been traditionally applied to study groups, team tests, and team problem-set answering pedagogies which focus solely on teamwork as a learning environment are not applicable to design teamwork in engineering.

Teamwork in the undergraduate engineering experience primarily occurs in self-managed teams. This type of team self-determines how to achieve their goals, how to manage their workflow, and how to make decisions (Wageman, 1997). As a pedagogical approach, self-managed teams have been used in situations where “interpersonal interaction, communication and creativity are encouraged” (McNair, Newswander, Boden, & Borrego, 2011) which is appropriate for engineering design work. However, allowing students to define how their teams operate is not without concern, as the development of well-designed team norms – to define how the team members will behave – is necessary for success (Wageman, 1997).

Students in design teams need to be able to engage with each other to debate and discuss their respective understandings of the design project and different design concepts, and be able to co-construct a shared meaning that will create a coherent product. Students in these types of projects cannot simply subdivide the projects into smaller individual, independent tasks that can be reassembled into a coherent whole as that is not the way in which design happens (Hyman, 2003). Design engineers working on product development have been observed to spend approximately 40% of their time in ‘socially collaborative work’ such as meeting with their team or clients, and discussion or developing ideas (Robinson, 2012). Team communication in this context holds two purposes: 1) to build shared mental models of the task and 2) to build the interpersonal relationships within the team (Fransen, Kirschner, & Erkens, 2011). Because of this, intensive interdependence is what is desired in these team environments but often not what is created in student teams (Borrego, Karlin, McNair, & Beddoes, 2013). Intensive interdependence occurs when students are able to facilitate and develop spaces in which to have the conversations that leverage the individual perspectives and understandings of the team members to develop, as a team, a collective understanding of and relationship between the interdependent components of their work.

This complexity of facilitating intensive-interdependence team environments has resulted in challenges for both students and faculty given the time-intensive nature of this type of work. In a
review of the team-effectiveness literature by Borrego et. al. (2013), one of the key findings was that “faculty members wanted student projects to proceed smoothly and efficiently, with students managing their time and working together well, and each contributing their fair share of the effort.” To ensure these projects run ‘smoothly and efficiently’, much work has focused on identifying and working to eliminate the negative behaviours of engineering students when working in teams. Minimizing hitch-hiking or “social-loafing” was the top concern identified by Borrego et. al (2013). While evaluation of team-members’ contributions have been a successful approach to minimizing social-loafing (Price, Harrison, & Gavin, 2006), it does not detract from student concerns over grading in team-based projects. Students who are concerned over allowing other students to have any influence over the team’s work and, as a result their grade, demonstrate negative behaviours in the opposite direction from social-loafing, becoming the highjacker or workhorse team member who takes over the work of the entire project or works around the other team members (McAnear, Seat, & Weber, 2000). The percentage of students in a class who commonly exhibit these behaviours has not been reported on, but from my own experience it has not been substantial; however the issues that occur as a result of such students in terms of instructors’ time supporting these dysfunctional teams is substantial. This focuses instructor time on only a select group of students, leaving those who appear to be in non-dysfunctional teams less supported in their development as team members.

Having instructors who support students to learn how to work effectively as a team has been shown to increase student satisfaction of working in teams (Oakley, Hanna, Kuzmyn, & Felder, 2007). It also is presented as an approach to minimize the number of ‘lone wolves’ who do not engage with the team on the team’s work (Barr, Dixon, & Gassenheimer, 2005). Team-based projects offer students rich learning opportunities to absorb course material while simultaneously developing important teamwork skills - provided student learning in both areas is addressed. A survey of engineering faculty at the University of Toronto indicated that instructors had diverse reasons for incorporating team-based work into their courses. The primary motivators for including team-based projects included reduced grading time (given large classes and few teaching assistants), student learning about teamwork, and being able to provide problems that resembled those in industry or the “real-world” (Evans, Moozeh, Oliva-Fisher, Reeve, & Sheridan, 2015). As a result of these varied motivations, students can be required to work in teams in their courses but might not be instructed on effective teamwork. Lingard has found that
students in engineering and computer science are often instructed on the technical aspects of the project material in detail by the course instructor, however they receive little or no instruction on how to function effectively as a team (2010a). Explicitly teaching team skills has been shown to positively enhance the student experience (Riebe, Roepen, Santarelli, & Marchioro, 2010), and can be a way to prevent team dysfunction which has been shown to negatively affect students perceptions of teamwork (Lingard, 2010).

An alternate approach to effective teamwork used by instructors is to eliminate team grading of team projects. A concern commonly voiced among students in team projects (often as a result of the two types of poor team members discussed previously) is that grading is ‘unfair’. Thus, some instructors have focused their efforts on determining a grade-altering co-efficient for each student to give them an individual grade based off of a team grade. This has been instituted by some instructors to force individuals to contribute to teamwork (Salustri & Neumann, 2016) and to increase accountability within the team. Peer assessment systems have become one way of gathering the data to create these co-efficients, and have been shown to reduce the number of complaints instructors experience (Kaufman, Felder, & Fuller, 2000).

Missing from the literature is an understanding of how engineering students (as distinct from other types of undergraduate students) are oriented towards teamwork. While team dysfunction can instill a negative perception of teamwork in these students (Lingard, 2010), it is not documented whether engineering students are predisposed to approach teamwork as a negative experience. Engineering students are described as preferring to work alone and preferring to avoid social activities (Dabby, 2017). They are most comfortable when they can predictably apply pre-existing frameworks to solve the problems in front of them, and when they cannot or there is disagreement they may withdraw from others rather than attempting to figure out how to work with them (Seat, Parsons, & Poppen, 2001). In teamwork, this can manifest in engineering students privileging the deliverable production aspect of teamwork (that can be partially completed in isolation) as compared to the development of an effective team (that requires conversation and social interaction be developed). Instructors have found that having team members get to know each other as ‘friends,’ rather than students, helps teams work more cooperatively (Barr, Dixon, & Gassenheimer, 2005). Ultimately finding a way to have students
value ‘who’ their team members are as opposed to ‘what’ they produce may enhance engineering students’ ability to work effectively as a team.

1.2.2. Development of teamwork capacity

Experiential Learning Theory (ELT), the process by which “knowledge is created through transformation of experience” (Kolb, 1984, p. 41), provides “a framework for understanding and managing the way teams learn from their experience” (Kayes, Kayes, & Kolb, 2005). In teamwork, the experiences that are transformed are the conversations that occur in cooperative learning environments which allow opportunities for ideas to be formalized, structured and discussed as well as for behaviours to be modelled (Johnson, Johnson, & Smith, 1998). Baker, Jensen, and Kolb posit that conversation is both an exchange of concepts as well as a perceptual process that requires conversational spaces to occur (2005). Conversation is not a purely verbal process; non-verbal components provide significant learning opportunities for those engaged in the discussion. In particular, when looking at learning behaviour-based concepts (like teamwork) students must be given the opportunity to appreciate the full context and process of conversation through being made aware of it as a site for learning and reflecting on what happens within those interactions.

ELT approaches learning on two dimensions: the acquisition of understanding through the experience, and the transformation of this understanding into knowledge. To engage learners in the process of experiential learning, Kolb presents a cycle in which students move through four stages: i) a learner gains knowledge about a concept externally from their concrete experience, ii) they develop an understanding of the concept from their reflective observations about it, iii) they subsequently develop a model of the concept through abstract conceptualization, iv) which they then test to develop further understanding through active experimentation. While this description presents the process linearly, ELT requires iterations of the cycle to develop and refine knowledge. Additionally, while this description begins at concrete experience, learning does not have to begin there. Learners can begin the cycle at any stage, and usually have an intuitive preference to begin at a certain stage based on their preferred learning style (Mainemelis, Boyatzis, & Kolb, 2002).
Given the practical experience-centric nature of the knowledge being developed, to be able to develop team-effectiveness behaviours students must both engage in teamwork to gain experience as well as develop an understanding of the underlying theories and practices. As a result, ELT (which focuses on praxis) is an intuitive process to inform the development of team-effectiveness. Collaborative environments can create the “conversational spaces for the praxis between reflection and action to be recognized and continually renewed” (Baker, Jensen, & Kolb, 1997) that is essential to an experiential learning approach.

ELT approaches to the development of team-effectiveness competency in students have typically taken one of three forms.

1. **Standalone courses** on leadership and teamwork have been developed at several universities (e.g. ILead at University of Toronto, and MIT Gordon Engineering Leadership Program). However, they only reach a small fraction of the undergraduate student body (Goodwin, Hundley, Fox, & Wolter, 1999) and as such are not counted towards development of the teamwork graduate attribute at the program level.

2. **Integrated implicit learning** of team-effectiveness through participating in a team experience. In this approach students explicitly engage in the experience but are not guided through the reflection on the experience. Students have found the team approach to learning beneficial (Bronzino, Ahlgren, Chung, Mertens, & Palladino, 1994). However, without explicit instruction on how to work effectively together, teams often fail, resulting in no learning about team-effectiveness on the part of the students and negative perceptions of team-based work developing (Lingard, 2010).

3. **Integrated explicit instruction** about teamwork has been incorporated into some courses. In these courses, students are instructed on teamwork processes (McCloskey, 2004) or are explicitly formed into teams to facilitate a specific type of learning about teamwork (Varvel, Adams, Pridie, & Ruiz Ulloa, 2004). This approach builds on the literature that suggests that teamwork behaviours and skills need to be both taught and assessed to facilitate student learning (Riebe, Roepen, Santarelli, & Marchioro, 2010).
At the individual level the development of behavioural competencies through a critique and improvement process has become common (Morell de Ramirez, Velez-Arocho, Zayas-Castro, & Torres, 1998; Lingard, 2010; Barkel, 2004; Bushe & Coetzer, 1995; Moore, Diefes-Dux, & Imbrie, 2006; Maxwell, 2011; McGourty, 2000). The critique process usually takes the form of a self and peer assessment with the assessments being returned to students as feedback. As a result, the feedback is individualised to the student, providing them at a minimum feedback on their weaknesses, and more ideally feedback on their strengths and weaknesses. This type of assessment and feedback – assessment for learning — provides students an understanding of where to focus their efforts to improve their behaviour (Tillema, Leenknecht, & Segers, 2011).

However, for students to gain the most benefit out of these experiences, they need an accurate assessment of their behaviours and information to guide their efforts to improve. Methods of learning which are personalized, easily accessible, and include exercises that are readily applicable in the student’s current situation increase the student’s motivation to learn (Williams & Williams, 2011).

Focusing in on the context of this work, engineering design classrooms, providing instructor-developed individualised feedback to each student on their team-effectiveness is an intractable problem. Given the size of typical undergraduate engineering classes in large public universities, the only instructors who would have enough involvement with the students and teams to assess their teamwork skills/behaviours would be their teaching assistants (TAs). The TAs who support these design courses are predominantly hired to assess student competence in, and support the development of, the technical or design components of their students’ work. They are not necessarily adept at, or comfortable with, assessing students’ abilities to work effectively in a team environment.

The prospect of engineering design TAs assessing teamwork in tutorial situations is severely constrained compared to the observational approach used in many behavioural assessments. In medical and pharmaceutical education non-technical skills (like teamwork) are assessed during clinical simulations. In these situations, the instructors are able to focus their entire attention on a single team’s simulation without the need to support or respond to it during its execution (Lanning, Brickhouse, Gunsolley, Ranson, & Willett, 2011). In some models of design education, TAs are interacting with and observing several teams at once (upwards of six to
eight), responding to student needs, and observing students’ abilities to work effectively in teams. This cognitive demand is significantly greater for TAs than for medical instructors who are focused solely on assessment; this may result in differences between the behaviours a dedicated observer is able to assess, as compared to a TA. However, while students may work on their projects during class time when they are observed, much of the work happens outside of the classroom. This occurs due to the nature of the projects – they are too large to be contained to a tutorial or to be completed wholly within tutorial time. As a result, much of the student interaction that would inform accurate assessments happens outside of class time.

One approach researchers have undertaken to avoid in-classroom assessment challenges, is to video-record select intervals of team functioning and evaluate them outside of the classroom (Besterfield-Sacre, Shuman, Wolfe, Clark, & Yildirim, 2007). Team-effectiveness within these environments can often be difficult and time consuming to measure, requiring training of the observers as well as a significant time investment in coding and analysis post-observation. As a result, observations of teams in engineering and computer science education have typically looked at which tasks are performed and/or which behaviours are exhibited over a specific observation period (Adams, Zafft, Molano, & Rao, 2008; Kern, Moore, & Akillioglu, 2007; Moore, Dieffe-Dux, & Imbrie, 2006). While these types of assessments allow a student or instructor to get a sense of what the teams are doing it does not provide students with effective feedback on how to improve their interactions with their team members as it does not assess how effective their behaviours or actions were.

The assessment of technical and non-technical skills (such as teamwork) has been shown to be assessed differently by medical students as compared to their instructors. Greater convergence exists between instructor and student assessments in technical skills than in non-technical skills (Arora, et al., 2011), with some instructors rating non-technical skills higher than student peers (Van Rosendaal & Jennett, 1994). Similarly, a study of faculty and students at business schools has shown that faculty perceive there to be more team dysfunction in team-based projects than students do (Chapman, Meuter, Toy, & Wright, 2010), indicating that students and instructors may be observing different markers of team functioning. Whether this stems from less observation time with the students being assessed or from students being more relaxed in their
behaviour around peers than instructors, medical faculty have argued that self and peer assessment is better suited for non-technical skills (Dannefer, et al., 2005).

1.2.3. Self and Peer Assessment

A benefit of cooperative learning approaches is the peer-to-peer learning and development that occurs. This not only fosters more healthy psychological relationships in the students as well as a sense of belonging, but also provides a frame of reference to develop an understanding of their individual competencies (Johnson, Johnson, & Smith, 1998).

The use of self and peer assessment as a formative approach to developing individual behaviours has become common practice as a means to address growing class sizes and increasing resource constraints on instructors (Freeman & McKenzie, 2002). Self-assessment, as defined by Boud and Falchikov (1989), is a two-fold process in which an individual is involved in “the identification of criteria or standards to be applied to one’s work, and the making of judgements about the extent to which work meets these criteria”. Self-assessment provides the means for students to identify their strengths and weaknesses so that they can then engage in self-directed learning and determine how to address their weaknesses and increase their competence (Gordon, 1992). Foundational to the premise of assessment is clear and descriptive assessment criteria that allow students to have a common understanding of what they are assessing and what constitutes good performance. The criteria used in assessments and reflection form a framework (or vocabulary) with which students can begin to understand what teamwork is as well as where their areas of strength and weakness are. Riebe et. al. (2010) argue that “The student experience of working in teams can be enhanced by providing a clear, conceptual framework for developing team skills” that needs to be both explicitly taught and assessed. ‘Assessment for learning’ as discussed by Tillema, Leenknect and Segers (2011), is one way of providing feedback to individuals about the accuracy and coverage of their self-assessments to help them calibrate their perceptions of themselves to reality. In the context of large classes, it is usually the students’ peers that provide this feedback to help students calibrate their self-assessment or develop an awareness of their behaviour.

Engaging students in self and peer assessment encourages students to engage in a relative assessment by reflecting on their learning or performance as compared to their peers (Dochy,
Segers, & Sluijsmans, 1999, p. 340). Debate exists as to whether students use their peers as the benchmark with which to calibrate themselves known as ‘norm referencing’ (Topping, 1998), or whether they use their performance as the benchmark with which to calibrate their peers (van Hattum-Janssen & Lourenco, 2008). When looking at why students self and peer assess differently, Pronin, Berger, and Molouki (2007, p. 586), posit that “people focus on internal information at the expense of behavioural information in making self assessments but not other assessments”. As a result, students engaging in self assessment will rely on “thoughts, motives and intentions” (Pronin, Berger, & Molouki, 2007, p. 586) for assessing their own behaviour, but will rely on specific actions or behaviours to assess their peers.

Engaging in peer assessment can inform self assessment by providing students “an opportunity to observe their peers throughout the learning process” (Dochy, Segers, & Sluijsmans, 1999, p. 338). In studies on peer assessment, students have commented that they have identified mistakes they were making simply from observing and assessing their peers (Rush, Firth, Burke, & Marks-Marlan, 2012). These behavioural observations provide “students with skills to form judgements about what constitutes high-quality work” (Van Zundert, Sluijsmans, & Van Merrinboer, 2010), enabling them to better understand their own level of performance.

From the perspective of the student, providing a self or peer assessment is a similar process provided clear criteria for assessment are provided. However, there is an additional component that becomes important when providing all assessments simultaneously, which is the ability to compare self and peer performance relatively against the criteria. In Ward et. al’s (2002) study of self-assessment accuracy, such relative assessments across a group of individuals were shown to be more accurate than absolute assessments because relative assessment forces a normalised assessment focused on ranking team members. While, providing peer assessments has been shown to increase student self-assessment skills (Dochy, Segers, & Sluijsmans, 1999) there is little agreement as to the mechanism by which this happens. No studies to date differentiate the effect on a student’s self-assessment ability that results from providing self and peer assessments simultaneously.

When looking at this from the perspective of convergence validity, several studies have documented that peer assessments more closely approximate instructor assessments than self-
assessments (Harris & Schaubroeck, 1988). This should mean that peers are capable of seeing students in a similar manner to that of their instructors. Many papers have focused their effort on determining if peer assessments are valid and can approximate an instructor’s assessment. In these studies, in evaluating a work-product or behaviour, typically 4 to 6 assessors are necessary to approach an averaged assessment that is sufficiently similar to that of an expert (Cho, Shunn, & Wilson, 2006; Bouzidi & Jaillet, 2009; Dannefer, et al., 2005). Topping (1998, p. 255) argues that peer-feedback might be of lower quality than that provided by an instructor, however its “immediacy, frequency, and volume” make it useful.

In a study by Ozogul, Oline and Sullivan (2008) peer-feedback was compared to that of instructors and solely a self assessment. While it was found that students who received instructor feedback performed better on their assignment revisions, it was found that the improvement based on both peer-feedback and self assessment was significant. Students who received peer-feedback received more feedback on average than those that simply performed self assessments, and received feedback that was informative, identified strengths and opportunities for improvement. Falchikov (1995) found that when peers were asked to provide feedback on strengths and weaknesses from a set of categories that a group of peers had an overall agreement of approximately 50% on strengths and 60% on weaknesses, indicating a fair level of convergence and resonance amongst the feedback a student received. As well, they found that students perceived the peer feedback to be more informative while the traditional instructor assessment was seen to be more accurate. Similarly, a study by Asch et al. (1998) concluded that peer feedback was seen as more meaningful than instructor feedback.

Further to the concept of analytic feedback (i.e. criterion-referenced assessment) is the premise of holistic feedback as a way to capture the gestalt of a student’s work or behaviour and provide specific guidance to that student on how to improve. In a study by Miller (2003) on assessment instrument design, two instruments of varying form were compared. In the first instrument, feedback was requested on each criterion, whereas in the second instrument feedback was requested holistically at the end of the all the assessment criteria. It was found that the first instrument had more respondents who provided feedback, but that assessors who used the second instrument provided more critical feedback. Similarly, a study by Lin, Liu and Yuan (2001) looked at the effect of holistic versus multiple items of specific feedback on computer science
students in a peer-feedback situation. Some students in previous versions of their assessment instrument complained that “holistic peer feedback was often too vague or useless for self-improvement” (Lin, Liu, & Yuan, 2001, p. 421) and thus they wanted to investigate the effect of specific feedback on student learning. They found that for students with high executive-function it did not matter what type of feedback was provided to them. However, students with low executive-function performed more poorly when given holistic rather than specific feedback.

Within engineering design teams, McGourty (2000) argues that a student’s team members (or peers) are in a better position to provide assessments of a student’s team-member effectiveness. Students can leverage a broader context for the feedback because most teamwork in engineering team projects happens outside of instructor or teaching assistant supervised work time. In a study by Erez, LePine and Elms (2002), self-managed teams that utilised peer assessment had higher levels of performance, workload sharing, and cooperation than teams that were assessed by people outside of their teams. In a study by Donia et. al. (2018) it was found that self and peer assessment systems are an easy way of integrating team instruction into a course as they are an “inexpensive and practical” intervention that only require a time investment by instructors to learn and implement the tool. Additionally, incorporating peer assessments is a predictor of positive attitudes towards teamwork in student teams (Pfaff & Huddleston, 2003). Based on this body of literature, incorporating self and peer assessment systems in team-based courses should enhance student teamwork capability.

1.2.4. Self and Peer Assessment Systems to Measure Teamwork

Despite differing beliefs about the reliability of self and peer assessment outside of the engineering context, many universities that utilise large class teaching have followed McGourty’s argument and moved to self and peer assessment as a way of providing individualised feedback to students on their teamwork skills and behaviours. These systems are typically hosted online and take a variety of forms: i) as tools to support instructors in understanding how their teams are working, ii) to facilitate accountability within the team and generate evidence for grade alterations if there are differences in team-member contribution, and iii) to support student learning of teamwork skills. Tools which fall into each of the three categories will be discussed below. Online tools falling into the third category are summarised in Table 1-1.
There are multiple tools that facilitate accountability and provide instructors with information on how their teams are functioning. Typically these have been developed as in-house products at universities. These tools focus primarily on evaluating teamwork contributions and assessing the agreeability of the team members rather than facilitating behavioural development (e.g., iPeer at University of British Columbia (Ostafichuk, Naylor, & Fengler, 2014), and the use of Fluid Surveys at the University of Saskatchewan (S. Maw, personal communication, 2017)). Because the focus in the development of these tools has been the quantification of student contribution to team dynamics and deliverables these assessments have often been used as a means of modifying individual student project grades to reflect their team contribution (Balascio & Kinney, 2012). This conflation between teamwork capability and project contributions may deter students from social loafing, but may have the unfortunate side-effect of suggesting to students that teamwork is the individual contributions to deliverables and not in the interaction between team members. This detracts from the relational nature of teamwork, where the conversations and interactions between the team members are what drive the production of high-quality collaboratively developed deliverables.

Tools which emphasise working to improve student capability at teamwork look beyond assessing individual student contributions. These types of tools have been used at multiple institutions (see Table 1-1). Two of these tools, while providing feedback to students on their teamwork capabilities, focus primarily on using these assessments for grade alteration (Delson, 2012; Loughborough University, 2009). In both examples, the professors of the course determine the assessment criteria used which may not be descriptive of effective teamwork. Three of the tools focus on providing students feedback primarily as a way of enhancing student capabilities (McGourty & DeMeuse, 2001; CATME SMARTER Teamwork, 2018; ITP Metrics, 2016). Each of these tools has been tested in an undergraduate engineering context, and two (CATME and ITP Metrics) have also been tested in business school programmes.
Table 1-1: Summary of past and existing online self and peer assessment tools for teamwork used in engineering programmes.

<table>
<thead>
<tr>
<th>Online Tool</th>
<th>Description and Purpose</th>
<th>Assessment Criteria</th>
<th>Learning Scaffolding</th>
<th>Analyses Undertaken</th>
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</table>
| RateMyTeammate.org (Delson, 2012) | • Assist professor in making team projects more equitable and inform the instructor of dynamics within the team  
• Alter team grades based on contribution with a guideline provided to students sharing what peer evaluation scores correspond to prospective grades                                                                                                                                             | • team member contribution on a “fixed-pie scheme” in which there are a set number of marks to distribute across all team members  
• team members’ attendance, listening skills, communication skills, responsibility, leadership and “team-building” competency using a 5-point frequency scale                                                                                                                                                                                                 | Feedback provided:  
• Average peer ratings  
• Comments from peers on what they did positively and what they need to improve on  
Instructional Pieces:  
• None                                                                                                                     | None                                                                                                                                                                                                                                                                                                                                                   |
| WebPA (Loughborough University, 2009; Loddington, Pond, Wilkinson, & Willmot, 2009; Kavanagh, Neil, & Cokley, 2011) | • automatically calculate adjusted marks for individual team members based on the team deliverable’s grade and peer feedback                                                                                                                                                                                                                           | • defined by each instructor specific to their course                                                                                                                                                                                                                                                                                                                                                       | Feedback provided:  
• Summary of assessments provided by peers  
Instructional Pieces:  
• Resources for instructors to design and support teams  
• Training package for students on the team-process aspects of teamwork                                                                                                             | • Satisfaction of students and instructors with team projects and grading                                                                                                            |
| Team Developer (McGourty, Using Multisource Feedback in the Classroom: A Computer-Based Approach, 2000) licensed through John Wiley & Sons | • Support student learning of teamwork through feedback on their behaviours in teams                                                                                                                                                                                                                                                                  | • Four aspects of teamwork each with specific items to measure them: collaboration, communication, decision making, and self-management  
• Uses a 5-point frequency scale for each item                                                                                                                                                                                                                                                                                                                | Feedback Provided:  
• Self and average team rating on each item  
Instructional Pieces:  
• Course text written to accompany the software (McGourty & DeMeuse, 2001)  
• Recommended behaviours to develop based on feedback  
• Students expected to determine how to develop these behaviours through action plan generation                                                                                                           | • Student rating change between a mid-course and end-of-course (showed significant increase)  
• Correlation of ratings to student team grades                                                                                                                                       |
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<td>Comprehensive Assessment of Team-Member Effectiveness (CATME) (CATME SMARTER Teamwork, 2018; CATME SMARTER Teamwork, 2018a)</td>
<td>• Tool for evaluation and development of “team members’ contributions to the team” (Loughry, Ohland, &amp; Woehr, 2014) • Capturing accreditation data for reporting to ABET</td>
<td>• Five dimensions which can be assessed: o Using a 5-item behaviourally anchored rating scale (BARS) o 33-item short inventory o 87-item long inventory • Dimensions: contributing to the team’s work, interacting with team-mates, expecting quality, keeping the team on track, having the relevant knowledge skills and abilities • Textual comments provided to instructors and their designates only</td>
<td>Feedback Provided: • Self, peer-average and team-average ratings for each item • Intra-team textual feedback listed as a feature to be introduced in 12-18 months (CATME SMARTER Teamwork, 2018a) Instructional Pieces: • “suggested ways to improve contributions in each dimension” (Loughry, Ohland, &amp; Woehr, 2014) which list the desired behaviours for that dimension • Team Management guide for Faculty • Rater Practice • No strategies for developing those behaviours currently provided, although videos are currently being piloted at Purdue as “Student Teamwork Training” (CATME SMARTER Teamwork, 2018a)</td>
<td>• Reliability of Assessments and Validity of Inventory testing to develop the long and short inventories (Loughry, Ohland, &amp; Moore, 2007) • Development and testing of (BARS) to reduce the number of items in the inventory (Ohland, et al., 2012) • Validation that the system can be used to meet the accreditation requirements of business schools (Loughry, Ohland, &amp; Woehr, 2014)</td>
</tr>
<tr>
<td>Online Tool</td>
<td>Description and Purpose</td>
<td>Assessment Criteria</td>
<td>Learning Scaffolding</td>
<td>Analyses Undertaken</td>
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<tr>
<td>ITP Metrics • Peer Feedback Tool (ITP Metrics, 2016)</td>
<td>• Support student learning of teamwork through feedback on their behaviour in teams</td>
<td>• Uses the same five dimensions from CATME but with different titles for the dimension • Dimensions (corresponding to CATME dimensions previously): commitment, communication, standards, focus, knowledge skills and abilities • Uses a slider with point values to allow students to rate each other relatively with no behavioral anchors to describe high or low ratings • Rates each team member along each dimension where a description of behaviours associated with each dimension are provided as a list to describe the dimension • Anonymous textual feedback</td>
<td>Feedback Provided: • PDF Report (ITP Metrics, 2016) • Self, peer-average plotted on the 5-dimensions in a radar plot • List of example behaviours for each dimension • Intra-team textual feedback Instructional Pieces: • &quot;potential improvement behaviors&quot; which list the desired behaviours for that dimension • Prompts in the report to document a development goal for each dimension • PowerPoints for instructors to use in class to introduce peer feedback and facilitate students in an individual debrief</td>
<td>• Intention to change based on feedback – found positively correlated to perceived accuracy of feedback (Smith, Hoffart, &amp; O’Neill, 2016)</td>
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</table>
TeamDeveloper (McGourty & DeMeuse, 2001) was the first online self and peer assessment system of this type and is no longer available. The system was licensed through John Wiley & Sons as an integrated textbook and software system package. Students assessed each other along four dimensions of teamwork. Three of these dimensions focused on the interactions of teamwork (collaboration, decision making and communication), and one focused on the individual’s self-management. Students were provided with a self and average-team rating along each of the dimensions and were given a list of recommended behaviours to develop based on the feedback. Assessments of the system showed that students’ ratings improved when used twice in a team-based project and that student ratings were positively correlated with team project grades (McGourty, 2000).

CATME (CATME SMARTER Teamwork, 2018) – the Comprehensive Assessment of Team-member Effectiveness – was the next widely adopted self and peer assessment system for teamwork. The software was developed through an NSF grant in a multi-university collaboration spearheaded by Purdue University and made available to other schools in the late 2000s. A strong focus in the development of this system was the design of a reliable and valid instrument for the evaluation and development of “team members’ contributions to the team” (Loughry, Ohland, & Woehr, 2014). CATME assesses five dimensions of teamwork; contributing to the team’s work, interacting with team mates, expecting quality, keeping the team on track, and having the relevant knowledge skills and abilities. It uses a behaviourally anchored rating scale for each of the dimensions so that students only need to provide 5 assessments for each team member (Ohland, et al., 2012), although instructors can choose to include individual behavioural questions (the long inventory contains 87 items). Students are provided with their self, peer, and average team rating on each of the dimensions as feedback, along with “suggested ways to improve contributions in each dimension” (Loughry, Ohland, & Woehr, 2014). Much of the research on CATME has focused on the reliability and validity of the inventories and dimensions (Loughry, Ohland, & Moore, 2007). No research on the assessment of student improvement is listed on the CATME website, although future work into providing textual feedback and integrating online videos to support student training are described (CATME SMARTER Teamwork, 2018a). The ITP Metrics team tested CATME in their context and found that 68% of students in their sample agreed that the feedback was useful and 83% agreed that “they would use the feedback to change” (O'Neill, et al., 2015).
ITP Metrics – Individual and Team Performance Metrics – are a set of self and peer assessment systems for teamwork that evaluate both team and team-member effectiveness. The software was developed through grant funding at the University of Calgary and made available to other schools in 2015/2016. At the team-member level their peer-feedback system, based on the CATME system, asks students to provide feedback along the same five dimensions but using a different rating scheme (Smith, Hoffart, & O'Neill, 2016). ITP Metrics leverages social comparison theory. Students rate each other in comparison to themselves instead of to a fixed definition of ideal behaviours. Students are provided with feedback in a similar manner to CATME, including a self and peer assessment along the five dimensions shown visually on the same radar plot, and a list of “potential improvement behaviours” that describe ideal behaviours for the five dimensions. Unlike CATME, intra-team textual feedback is provided to students as part of their feedback report. Upon receiving their feedback, students are asked to articulate their intention to change their behaviour based on the feedback. Intention to change based on feedback provided has been assessed and was positively correlated with the students’ perceived accuracy of their feedback (Smith, Hoffart, & O'Neill, 2016). No assessment of improvement or change in ratings over time has been published in relation to the use of ITP Metrics.

Looking across these systems, in particular these last two, it is important to note some key similarities and their effects on student learning. Engineering students previously have been described as having an inclination to work on their own and avoid social interaction unless necessary; this indicates a potentiality to privilege the task side of teamwork over the interpersonal or relational aspect. The dimensions of teamwork included in both CATME and ITP Metrics discuss only 1 dimension directly related to this interpersonal effectiveness, 3 related to work coordination, and 1 related to student competency in the technical skills necessary for the project. As a result of this, engineering students may not be encouraged to focus on building the relationships necessary to have highly productive conversations if the total implies this is only 1/5th of the skills necessary for effective teamwork. Following up on the work of Riebe et al. (2010) who found that students need a “clear conceptual framework for developing team skills”, providing a task-focused framework may not encourage students to invest their time in developing the behaviours necessary to create effective interpersonal relationships that lead to team success (Barr, Dixon, & Gassenheimer, 2005).
Both CATME and ITP metrics measure dimensions which incorporate multiple behaviours. A poor rating on one of the dimensions may not indicate to a student which behaviours specifically contributed to the poor rating. If a student performs one behaviour well and one poorly which are aggregated in a dimension, it is unclear how those specifics will be communicated to the feedback recipient in the absence of textual feedback. This can provide unclear feedback to students, as well as an unclear framework of high performance. Assuming behaviours are binary (demonstrated productively, or not demonstrated as evident in the dimension descriptions of the two tools (ITP Metrics, 2016; Ohland, Loughry, Carter, & Yuhasz, 2004) does not cover the ways in which students can partially or destructively demonstrate the behaviours and the impact those may have on student teamwork environments. In terms of scaffolding student learning, neither system provides students with tools or techniques to improve their behaviour.

Providing a list of behaviours to demonstrate (which are aligned with the assessment criteria) affords students no additional support or assistance in knowing how to improve their behaviour. While it has been proven that continued use of systems like these for self and peer assessment does result in improved ratings over time (Donia, O'Neill, & Brutus, 2018), it has not been shown how students improve their behaviour based on this feedback. As a result, while these systems provide a reliable way of assessing student teamwork skills on dimensions applicable to completing a team project successfully, they do not appropriately scaffold engineering student learning of teamwork towards specific behavioural improvement.

1.3. Researcher Beliefs and Experience

I have spent six years working as a teaching assistant in design classrooms, overseeing student learning of design, and assessing and mediating team (dys)function. While conducting this research I worked as a TA in both of the courses used in this study to develop an understanding of the type of teamwork requested of the students, and the way in which the students approached their teamwork. During my time in these courses I saw a handful of students who would act as hitch-hikers (doing no teamwork) or highjacker (taking over all of the team’s work). However, the majority of team dysfunction situations I mediated were miscommunication issues. In these situations, the teams either did not take the time to get to know one another and as a result did not know how to talk to each other, or did not see what value they each could
bring to the team. The two most frequent complaints I experienced were that “someone would not talk during meetings and the team didn’t know how they felt about the design”, or “some would talk all the time never listening to the other team members or allowing their ideas into the discussion”. As a result, my personal intention has been to find ways to ensure students know that they need to build relationships with each other to succeed in their projects, and to recognise that their team members were valuable people who can neither be ignored nor excluded from the conversations which are critical to effective design work.

My beliefs about teaching and learning are those of a social constructivist who has been heavily influenced by Vygotsky, and his concept of the Zone of Proximal Development (Vygotsky, 1987). I believe that learning, as approached in this thesis, is the negotiated construction of meaning that occurs in a context, is derived from a combination of both theory and practice, and is translated into knowledge and understanding through experimentation and reflection. This negotiation of meaning begins with a student’s current understanding, and through the introduction of new (or different) approaches, opinions, and perspectives provides opportunities through which the student can further develop their understanding. However, learning is reciprocal; the learner and the one engaging the learner negotiate their meanings of the concept in a way that develops a greater understanding of it for both. As such, knowledge is socially constructed through conversational experiences with others, in which the exchange of concepts (or behaviours) develops greater understanding.

Conversation is not a purely verbal process; non-verbal components provide significant learning opportunities for those engaged in the discussion. In particular, when looking at learning behaviour-based concepts students must be given the opportunity to appreciate the full context and process of the conversation. By seeing behaviours modelled by others and by having a model through which to interpret these behaviours, students can begin to see, contextualise, and practice these behaviours in their own work.

Returning specifically to the concept of the Zone of Proximal Development, it is important to note that each first-year student enters the design classroom with a different appreciation for and experience with teamwork. As a result, the areas that each student needs to develop are different, and the learning must be individualised so that each student addresses deficiencies where needed. Providing students with individualized, targeted learning which develops both an awareness of
their behaviours and how to improve them, will afford students the ability to leverage the collaborative and conversational learning environments of their project teams to improve.

1.4. Conceptual Framework and Research Questions

The objective of this research is to understand how student competency in teamwork can be improved through the use of the on-line, team-effectiveness learning system described in Chapter 2.

Student improvement in teamwork requires leveraging the experiential learning in team-based projects to incorporate reflection, assessment, and means to improve based on those assessments. The foundation of this improvement process is learning through providing and receiving high quality feedback. A conceptual framework of how students could develop based on the feedback in TELS was adapted from the feedback model developed by Hewson and Little (1998). Thus, the conceptual framework of learning utilised in this thesis is present in Figure 1-1. How it will be manifested in the Team-effectiveness Learning System will be discussed in Chapter 2.

![Figure 1-1: Conceptual framework of student development of team-member effectiveness through self and peer assessment in the Team-effectiveness Learning System.](image)

Students first require a framework for understanding what it means to be an effective team member. This is analogous to the “orientation and climate” component of Hewson and Little’s model and aims to set clear expectations of what feedback will be provided and the purpose of the feedback. This framework needs to articulate both the behaviours of effective team members and provide a gradation of performance levels so that students know how well they are demonstrating those behaviours to their team. This framework provides the student with a model
of what exemplary teamwork looks like and a clear set of expectations for them to achieve. Second, students need to develop an awareness of their behaviour through utilising the vocabulary for self-assessment and receiving feedback through peer assessment. This is analogous to the “self-assessment” and “diagnosis and feedback” components of Hewson and Little’s model. For TELS in full-term team-based projects, this would be conducted at the mid-point of a project to provide time for students to understand their own behaviour, yet still leave enough time for them to improve their behaviour within that team. Through leveraging both self and peer assessment students will be able to identify the discrepancies between their self-perception and reality as a way to identify behaviours that require improvement. Hewson and Little discuss recommended feedback techniques that will be used to analyse the feedback students provide and receive in TELS. These include: providing feedback that is based in observations, focuses on specifics and behaviours, provides both strengths and weaknesses in a good balance (adapted from ‘right amount of feedback’), and provides suggestions for improvement. Third, students need to be provided with a means to improve based on their feedback so that they are further guided to develop their behaviour along the descriptions of effectiveness outlined in the vocabulary. This is analogous to the “improvement plan” and “application” components of Hewson and Little’s model. Finally, students can determine their improvement through a second round of assessment and feedback to identify their learning about their behaviour from the project.

It is important to note a key difference between this conceptual framework and Hewson and Little’s feedback model. Hewson and Little’s feedback model is meant to occur during conversation between a feedback provider and recipient. As a result, the recipient can negotiate the feedback with the provider. In TELS, the feedback is not negotiated between recipient and provider. Instead, the framework of team-member effectiveness and levels of engagement on TELS are meant to provide what would ideally be the results of a negotiated and socially-constructed understanding of the assessment criteria and performance expectations created between recipient and provider. This difference is addressed in the conceptual framework through the feedback loops connecting the first three components. These feedback loops show that the development in TELS does not happen in a linear process which each component occurring in isolation, but that the learning from one can inform student development in another.
This models what would happen if the provider and recipient were negotiating this feedback in conversation.

Following from the conceptual framework of student improvement in Figure 1-1 the overarching research question guiding this work is:

_How can student competency at teamwork be improved through the use of an online team-effectiveness learning system?_

This research question is understood through three hypotheses that guide the studies comprising this work. These hypotheses explore the different modes of improvement provided through TELS which are cumulative and as a result not tested in isolation. These are that _student competency at teamwork can be improved by:_

**Hypothesis 1:** _providing students a framework to self and peer assess team-member effectiveness that highlights the interpersonal nature of teamwork_ (Study 1 – Chapter 3)

**Hypothesis 2:** _using self and peer feedback with this framework to facilitate student awareness of their behaviour_ (Study 2 – Chapter 4)

**Hypothesis 3:** _providing scaffolding and resources to facilitate student improvement based on feedback received._ (Study 3 – Chapter 5)

Each of the latter hypotheses builds from the previous hypothesis ultimately creating a multi-phase research endeavour that spanned three years of data collection. Study 1 describes the development of the team-effectiveness inventory (TEI) necessary to create the framework of team-member effectiveness. Study 2 investigates the feedback students received from the TEI and holistic comments as presented in TELS. Study 3 investigates how students used the surveys, reports, and lessons on TELS to improve their behaviour.

Study 1 involved the development of the team-effectiveness inventory used in TELS to guide behavioural feedback. The objective of the study was to develop a vocabulary/framework of team-member effectiveness that was applicable to engineering student teams, was understandable, and produced reliable assessments of student behaviour.

The following four incremental questions were used to guide data collection and analysis to facilitate a response to hypothesis 1.

1. Does the use of a framework of team-member effectiveness facilitate higher quality feedback for students than unstructured feedback?
2. Do students understand the behaviours/items in the inventory?
3. Does the inventory describe a model of team-member effectiveness that highlights the interpersonal nature of teamwork and describes successful teams?
4. Do students provide reliable assessments about their team members when using the inventory?

Study 2 involved characterising the quantity, quality and perceived utility of the feedback students received from their team-members when using the inventory and providing holistic feedback in TELS.

The following five incremental questions were used to guide data collection and analysis to facilitate a response to hypothesis 2.

1. Do students receive quality feedback from their team-members? Is it specific, actionable, and relevant?
2. Are students’ strengths and weaknesses differentiable in the feedback they receive?
3. What consistency is there amongst team-member feedback?
4. How do the inventory feedback and free-form holistic feedback relate to each other? Do they complement, confirm, or contradict each other?
5. How do students respond to their feedback?

Study 3 involved characterising the relationship between student use of TELS and their behavioural improvement over the duration of a team’s project.

The following four incremental questions were used to guide data collection and analysis to facilitate a response to hypothesis 3.

1. Which TELS scaffolding do students access (providing assessments, reviewing feedback, accessing lessons and exercises), when and how frequently?
2. How do students respond to, and describe using, the lessons and exercises in TELS?
3. How do students work to improve their behaviour based on feedback received?
4. Does students’ behaviour improve over the duration of a team-project? What factors differentiate those that do improve from those that do not?
Based on data collected to respond to the overarching research question, I found that there were important findings about student use of and response to the TEI and TELS that would be relevant to those engaging in teamwork instruction. As a result, a second overarching research question was constructed to encompass these important findings.

*What does student use of and response to an online team-effectiveness learning system tell us about how they understand teamwork?*

This will inform future recommendations for teaching and learning teamwork in the engineering context.

### 1.5. Studied Population and Course Context

The population this research studied was the first-year engineering student body at the University of Toronto that completed their first-year of engineering between 2012 and 2014. First-year was selected as the target population through a desire to prompt students’ thinking and development around teamwork competency from their first team-project.

Students were invited to participate as part of their course-work in two first-year engineering design courses: APS112 – Engineering Strategies and Practice, a client-based consulting engineering design course of approximately 900 students, and ESC102 – Praxis II, a student-driven entrepreneurial engineering design course of approximately 250 students. Over the three academic years studied, 23.4 – 25.4% of the students in these courses identified as female, and 23.9 – 30.4% were classified as international students (University of Toronto Faculty of Applied Science and Engineering, 2014).

Both courses provide first-year engineering students with an introduction to engineering design and communication through a service- and team-based project. Students are assigned to work in teams of three to four students in ESC102 and five to seven students in APS112. Students spend the 13-week term meeting for a minimum of two-hours per week and working to collaboratively specify a design problem in engineering language and develop (and test) a conceptual design that addresses it. Both courses require the teams to work together to define and address a design challenge in their geographic area and interact directly with the clients and stakeholders involved. Deliverables for the courses consisted of written documentation specifying their design as well as a presentation to course instructors and interested stakeholders.
Students work in self-managed teams in both courses under the supervision of engineering teaching assistants (TAs) and other instructors in tutorials or studios. The ratio of TAs and instructors to students ranged from 1:12 to 1:15. Tutorials act primarily as student work time, with the instructors and TAs circulating around teams and supporting them on-demand. The two courses have different leadership models for their teams with students in APS112 having a designated team leader who was responsible for coordinating the team. In ESC102 despite their being no designated team leader, it was found through observation as a teaching assistant, that most teams had a student emerge as the de facto leader in their team.

In terms of teamwork instruction, students in both courses received lectures on teaming and teamwork before engaging in their team-based projects. Topics discussed in these lectures included: Tuckman’s stages of group communication (Tuckman, 1965), time-management and project management strategies, and how to facilitate constructive disagreement. In terms of assessment of teamwork, the focus in advance of this research had been on identifying students who were not completing their fair share of the work. In APS112, students would report to a course instructor their perceived breakdown of work completed by each team member as a percent of the whole work at the mid-point and end of the course. In ESC102, students would provide textual feedback to their instructors on the contributions of their team mates in situations where the balance of work was not perceived as equitable. In both courses, no feedback on a student’s ability to be an effective team member was provided to the student.

1.6. Thesis Overview

This thesis is written to highlight both the engineering and education components of the work. As such, it is structured as design research, first presenting the engineering technology designed and its key design decisions (Chapter 2), then presenting the research supporting the design decisions that informed it (Chapter 3), and finally assessing its effectiveness in the context for which it was designed (Chapters 4 and 5). Thus, this thesis is not presented chronologically, but instead presents the end product first as a means of framing the way in which the research was understood and conducted. Interim publications which form a seminal component of the work and justify arguments made in the chapters of the thesis, are included in the appendices.
Chapter 2 presents the engineering technology developed – the online Team-effectiveness Learning System (TELS). This chapter presents the requirements of the system as defined by its stakeholders as well as highlights the key design features of the system.

Chapter 3 presents the research supporting the design decisions made in the Team-effectiveness Learning System. This chapter discusses the findings from three years of developing and iterating the assessment instrument to ensure that it could facilitate reliable feedback to students.

Chapters 4 and 5 present an assessment of the effectiveness of TELS in providing students a way to enhance their capability in teamwork. Chapter 4 presents an analysis of the feedback students received and Chapter 5 presents an analysis of how students leveraged their feedback and the resources on TELS to improve their performance.

Chapter 6 concludes this thesis by connecting the findings from developing and assessing TELS to an understanding of how students learn and develop their teamwork capabilities. Implications for teaching and supporting student development of teamwork are discussed.

This thesis provides a novel contribution to the literature on student teamwork development and to engineering education. It provides a novel contribution to the literature by: i) integrating lessons on teamwork with self and peer assessments to scaffold student learning and ii) capturing students’ methods of improvement through both self-reported data and online system use tracking. This contribution will provide instructors with an understanding of how students work to improve their behaviour given feedback and strategies to improve provided to them through an online system. It provides a novel contribution to engineering education through the development and production of the online Team-effectiveness Learning System (TELS). This system provides engineering educators with a way to facilitate teamwork development in their students through feedback and integrated lessons on teamwork that are tailored to engineering students.
2. Design of an Online Team-effectiveness Learning System (TELS)

This chapter describes the design of the Team-effectiveness Learning System (TELS) from the objectives and principles that motivated its design, through to the way in which it was built. TELS is a web-based self and peer assessment system with integrated feedback and lessons that facilitates student learning of individual team-effectiveness behaviours. TELS aims to create a learning experience in student project-teams by scaffolding students’ movement through the Kolb experiential learning cycle (Kolb, 1984) thereby providing a means to integrate teamwork theory with their teamwork practice. Incorporation of TELS in team-based projects is intended to move students away from a work-only focus in their teams, and to encourage them to think about the other people-related components of teamwork necessary to create an effective team-environment.

An initial outline of TELS was presented at the American Society for Engineering Education Annual Conference in 2012 (Sheridan, Evans, & Reeve, 2012). This chapter presents the final version of TELS that was tested and analysed in Chapters 4 and 5.

2.1. Design Requirements – Student and Instructor Needs

The design of TELS was founded in two high-level objectives:

1) to focus on individual students not teams, and
2) to create personalised learning experiences.

TELS focuses on individual students and not teams by providing students a way to become aware of how they are behaving in teams. This objective was motivated by two needs. First, the CEAB graduate attribute related to teamwork focuses on building individual student competency (Canadian Engineering Accreditation Board, 2016). Second students need to develop teamwork behaviours that they can use beyond the team in which they receive instruction. As a result, the system focuses on building students’ competency as team members, rather than simply focusing on building one-off effective teams. From this, students can develop individual, transferable teamwork behaviours that will extend beyond the project team in which they used TELS.
TELS creates a personalised learning experience for each student, by allowing them to tailor their learning to the areas in which they need to improve. Students enter their first-year of engineering from a variety of backgrounds and education. While there is some standardisation in the maths and sciences that students have been taught, there is no common requirement around having participated in team experiences. As a result, the range of experiences of the first-year engineering class are large, ranging from having never participated in a team-based school project, to only having participated in teams in extra-curricular activities like sports or music, to having participated in both curricular and extra-curricular teams. Thus, TELS needed to create a personalised learning experience, where students can develop their capabilities along the most relevant behaviours for them.

While facilitating these two high-level objectives, TELS additionally had stakeholder-specific objectives and constraints to meet to ensure it would be adoptable in (at minimum) the first-year engineering design courses (J. Bazylak, J. Foster, R. Irish and P. Weiss, personal communication, 2013). These stakeholder objectives and constraints are discussed below.

Students in team-based projects required:

1) A vocabulary and framework with which to understand effective team behaviour
2) A way to develop an awareness of how they are behaving in their teams
3) To feel safe discussing how they perceive themselves and their team-members to be behaving in their teams
4) An ability to track their progress in teams over projects and courses

Instructors teaching team-based projects required:

1) TELS instruction/development to not require significant instructional time in lecture
2) Student interaction with TELS to not require a significant amount of homework time to provide feedback – instructors were comfortable with 15-30 minutes
3) A secure environment to ensure the correct students were providing feedback to each other, and a way to know which students did/did not provide feedback
4) A way to review the feedback from their students to know how their teams were doing
The designer/researcher intended:

1) That students be working together long enough to have observed how each team member behaves before providing feedback – approx. 3-5 weeks
2) That students be able to determine how their teamwork behaviours have improved over the duration of a team experience through multiple rounds of feedback

2.2. Design Principles - Conceptual and Theoretical Frameworks

TELS is designed to leverage the experiential learning context of teamwork, and to scaffold students’ movement through Kolb’s experiential learning cycle. The system is built with Kolb’s cycle as its guiding theoretical framework, and instantiates the model of team-member effectiveness developed in this thesis (the Team-effectiveness Inventory or TEI) as its conceptual framework of team-member effectiveness.

2.2.1. Experiential Teamwork Learning Cycle

TELS leverages the four components of Kolb’s experiential learning cycle to create an integrated learning experience for students, Figure 2-1.

Teamwork in first-year engineering design courses at the University of Toronto already incorporated the concrete experience component of Kolb’s cycle. Students in these courses are put in teams where they are asked to work with others to collaboratively solve a problem in which they share ownership over the outcomes. These courses have also historically provided some lecture-based information on teamwork, wherein students are provided with strategies to work effectively at the group-process level. These lectures could provide some abstract conceptualisation of teamwork with which students could actively experiment. However, no activity or interface previously existed in these courses to close the loop around the cycle – students were not asked to explicitly reflect on their individual teamwork behaviour or on how their teams were operating.

TELS aims to close the loop around the cycle through explicitly forcing students to reflect on how they are behaving in teams. TELS moves students from concrete experience to reflective observation by asking students to reflect on how they and their team-members are behaving in their team, and to complete a self and peer assessment using the TEI. In TELS, the reflective observation component is extended to include reflection on feedback received to enhance
students’ understanding of their behaviour through integrating the perspectives of others. From this a student can reflect on the similarities and differences between their and their team-members’ perceptions of their behaviour, and identify areas where they could improve their behaviour.

To keep students focused on improving their individual behaviour, TELS provides scaffolding to move students through *abstract conceptualisation* and *active experimentation* based on their feedback by incorporating lessons about teamwork at a practical level. These are intended to motivate particular behaviours and provide actionable tools and strategies to help develop these behaviours in team environments.

Through providing students with an awareness of how they are behaving as well as lessons and actionable strategies all in one place on TELS, it is anticipated that students will be motivated to leverage these resources to enhance their competency at teamwork.

Figure 2-1: Diagram of the stages of teamwork learning with TELS superimposed on the stages of the Kolb Experiential Learning Cycle.
2.2.2. Conceptual Framework of Team-member Effectiveness

To provide students a vocabulary with which to self and peer assess within their teams, a framework of team-member effectiveness was developed. The framework, or Team-effectiveness Inventory (TEI), was built around two founding principles: 1) engineering students under-value the ‘who’ in their engineering teams compared to the ‘what’ that they produce, and 2) that there was a perceived need to shift engineering students from seeing team contribution as quantity of work, to engagement with the team.

To get engineering students to address more of the ‘who’ in their engineering teams, the framework was built to intentionally include behaviours needed to demonstrate to team members that they were seen as valuable within the team. This foundational principle came from the experience of teamwork and leadership educators at ILead (E. Oliva-Fisher and A. Simpson, personal communication, 2011) and from a desire to counteract the tendencies of engineering students to privilege only the technical aspects of their work (Faulkner, 2000; Seat, Parsons, & Poppen, 2001). Much of engineering teamwork instruction has focused on the project management and task coordination aspects of teamwork, (Smith & Imbrie, 2007) with limited instruction on how to build strong relationships with team members that will encourage them to engage in the team’s work.

As a result, the TEI endeavoured to explicitly address these issues through defining behaviours onto three aspects of teamwork which were already in use at ILead. Behaviours were defined onto these aspects in a way that focused on exceptional behaviour being that which encouraged team-members to engage more effectively with each other. Organisational behaviours addressed the project management and work organisation component of the team’s work. Relational behaviours focused on fostering positive interpersonal relationships that demonstrate to each team member that they bring value to the team. Communication behaviours looked at the way in which issues are presented and discussed, and how information flows within the team. Each aspect was refined to have an equal number of behaviours to demonstrate that each are equally necessary and valuable to creating an effective team. A discussion of the development of the initial items in the inventory and its revisions to the final version are presented in detail in Chapter 3.
Unlike other inventories used in engineering teamwork (see literature review in Chapter 1), this inventory was designed to not explicitly assess percentage work contribution of each team member, or the quality of work provided by each team member. Percent work contribution was explicitly excluded as I historically saw students calculate this based on the number of pages or sections each team member wrote for the team’s deliverables, and not the thought and development of ideas that went into the deliverable. As a result, I felt this metric did not appropriately capture contribution to the team’s work holistically. Quality of work was excluded during revisions of the inventory as it was considered to be a technical component of the project’s work and not a teamwork behaviour. I specifically wanted the inventory to capture only teamwork related behaviours and as a result, quality of work produced by a team member was excluded.

To normalise student assessments along the twelve items in the TEI, a behaviourally anchored rating scale was provided for each behaviour. The continuum that grounds the rating scale focuses on engagement (the way in which the behaviour encourages engagement from other team-members in that behaviour) rather than quantity of demonstration to avoid engineering students’ tendency to always do more to get a higher grade. Within teamwork, always doing more can be a problem as when one team-member takes over the majority of any aspect of the work, others are left with little they can contribute to, and a feeling of not being valuable to the team. The behaviourally anchored rating scale describes four levels of engagement with the team and the project, Figure 2-2.

![Figure 2-2: Progression of levels of engagement used for the behaviourally-anchored rating scale in the Team-effectiveness Inventory (TEI).](image-url)
The first level is unengaged – the student does not demonstrate the behaviour. The second level is self-focused – the student demonstrates the behaviour when it is either useful or convenient to them. The third-level is project-focused – the student demonstrates the behaviour sufficiently to provide an individual contribution to the project. The fourth-level is team-focused, the student demonstrates the behaviour in a way that provided contribution to the project and encourages other team members to do so as well. By defining the behaviours in this way it is anticipated that students who hijack or hoard the whole project will be rated equally as poorly as those who engage in social loafing. Only team members who work to bring out the skills and perspectives of all their team members and incorporate them in the work will be rated highly. A copy of the final version of the 12-item Team-effectiveness Inventory and its behaviourally anchored rating scale are provided in Appendix A.

2.3. System Design and Features

TELS works as a fully integrated online learning environment that comprises four key features: a dashboard of recent activity, surveys for intra-team assessment, reports of feedback provided by team members, and lessons and exercises.

2.3.1. System Design

The TELS is hosted internally at https://ilead.utoronto.ca/teamlearning/tels and was developed using Ruby on Rails with a PostgreSQL backend on an Apache server. This environment was selected as Ruby on Rails is specifically designed for building web applications and has many integrated libraries that simplified the development process. PostgreSQL and Apache were used as they were pre-existing on the web server on which I hosted TELS. The system is accessible through computer web-browsers and has a mobile view for use on internet-enabled smart-phones. TELS uses students’ university logins for authentication to ensure that students only have access to their own assessments and feedback.

TELS additionally provides a course instructor with information about who in their class has completed their surveys (assessments) as well as some diagnostics about their teams from those assessments. Only the student interface will be described in detail as it has been the focus of the research in this thesis. Descriptions of the design of the instructor interface can be found in the
proceedings of the Canadian Engineering Education Association annual conference where it was presented (Sheridan, Malone, Reeve, & Evans, 2015; Sheridan, Korhani, Reeve, & Evans, 2016).

2.3.2. TELS Dashboard

The TELS dashboard is designed to provide students with the information they need as quickly as possible, highlighting any items needing immediate attention, Figure 2-3. Upon login, a student is routed to their personal dashboard, which shows surveys (assessments) they need to complete along with their due dates, and reports (feedback) which have been made available to them. Surveys which have been completed are shown on the dashboard with a completion date to confirm that their assessments have been submitted and will be given to their team-members as feedback. All items are sorted from most recent at the top to oldest at the bottom. As a result, the dashboard additionally serves as a repository of feedback for students where they can see the reports (feedback) that have been made available to them over multiple uses of TELS. This allows a student to track their progress over time across different teams in different courses.

Figure 2-3: A student’s dashboard that they see upon login, showing which surveys (assessments) they have completed and which reports (feedback) are available for them to review.
2.3.3. Completing a Survey – providing self and peer assessments

Students complete self and peer assessments for the team members in their project teams in a survey. The first 12 questions of the survey are the behaviours from the Team-Effectiveness Inventory (TEI), with a 13th holistic feedback question providing a space for students to include any textual feedback that the 12 items did not address or to provide an example of a poor or good behaviour. The TEI behaviours are assessed by students in an item-by-item manner (Figure 2-4) – a student rates all their team members along each behaviour before moving on to rate all their team members on the next behaviour. Assessing team-members concurrently along each behaviour has been shown to provide more accurate assessments (Festinger, 1954).

Figure 2-4: Relative assessment of two sample team members along the behaviour “Seek and include input from team members.”

2.3.4. Receiving Feedback from Peers

Students receive both their self and anonymized peer assessments as feedback in the form of a report. Assessments from the team-effectiveness inventory are presented using self and peer rose diagrams (Figure 2-5), and in a summary table of assessment values (Figure 2-6). Verbatim holistic feedback from peers is available to students immediately below the summary table with no identifying information as to who provided any piece of textual feedback.

Rose diagrams were selected to provide a way of visually identifying behaviour-level differences in self and peer assessments at-a-glance. Each 1/12th wedge of the circle represents one behaviour from the team-effectiveness inventory, with its length representing the magnitude of the student’s assessment along that behaviour. Behaviours are grouped and colour-coded by aspect, with the actual behaviour name and assessment value available to the student on mouse-over. The benefit of the rose diagram is that each behaviour holds an equal share of the whole
circle, demonstrating to the viewer that each behaviour has equal importance.

Figure 2-5: Example rose diagrams of a fictitious student demonstrating differences in self and peer assessment along the twelve behaviours of the TEI.

Figure 2-6: Summary table of a fictitious student’s assessments ranked according to the algorithm provided in Appendix B, highlighting the student’s three strength behaviours, and three weakness behaviours.
Below the rose diagrams is a summary table of the student’s assessment values along the TEI behaviours sorted in order of competency from their strengths to their weaknesses. Behaviours are sorted according to the algorithm provided in Appendix B with a focus on identifying for students, discrepancies between their self and peer assessments. The top three behaviours are highlighted for students as their strengths and the bottom three behaviours are highlighted as areas for improvement, or weaknesses. An equal number of strengths and weaknesses are highlighted to ensure that each student does not feel that they are exceptional or terrible at teamwork, but that they have both strengths that they contribute to a team and areas in which they can improve. Three strengths and weaknesses were chosen to be highlighted as the mean memory capacity in adults to hold information while completing another task is 3-5 items (Cowan, 2000). By highlighting three weaknesses, students can work to remember these behaviours and attempt to monitor their performance along them while engaging in their teamwork. It is not anticipated that students would desire to remember their strengths while working in the same way, however three strengths are still highlighted to show to students that there equally are areas in which they are doing well.

2.3.5. Operationalising feedback through integrated lessons

The TELS incorporates lessons on both the individual behaviours of the inventory as well as some important group level processes, Figure 2-7. Lessons could be accessed through the ‘Lessons & Exercises’ option on the left-hand menu bar, first selecting “Lessons & Exercises” and then selecting the corresponding lesson.

Each TEI-based lesson contains three components to help students develop along that behaviour. First, it includes a description of the action(s) that behaviour comprises, second a discussion of the importance of the behaviour to creating an effective team, and third a series of tools and techniques that provide students with implementable strategies for improving that behaviour.

Strategies were sourced from one of three locations: i) strategies that were suggested as part of the first-year design courses at the University of Toronto or are listed generally in the teamwork literature, ii) existing ILead internal material/workshops and teaching plans that had been used successfully with engineering students, and iii) online equivalents of resources.
referenced to me by ILead leadership and teamwork instructors (A. Simpson, E. Oliva-Fisher, and R. Sacks, personal communication, 2013). Content for the lessons was compiled and categorised according to each of the 12 behaviours; some strategies were listed for more than one behaviour. Each lesson was meant to connect students directly with resources that would help them improve their competence along a specific behaviour.

Figure 2-7: Demonstration of the lesson and linked tools and exercises for the behaviour ‘Demonstrate Accountability’. Links to external sites can be seen in pale blue text in the lesson.

### 2.4. Ideal Use of TELS in Courses

TELs is designed to be used in courses as a way of facilitating student improvement of behaviour during a team-based project. However, to be able to provide quality feedback students need to have been working together long enough that they have been able to observe each others’ behavioural competency along the TEI behaviours. As a result, it is suggested that students be working together for at least 3-5 weeks before using TELS for feedback, and that they have completed at least one team deliverable together. This deliverable must be one that requires all team members to have contributed to the work, and requires interdependent components to be completed in line with a team-developed vision and inter-component coherence.
It is recommended that TELS be completed twice in any team that works together for a full-term project. In such situations, it is recommended that TELS be completed around the mid-point of the project immediately following a major deliverable, and again at the end of the project. The desired integration of TELS in a course is shown in Figure 2-8 describing the ideal student participation. Ideal use of TELS anticipates students working to improve their behaviour between rounds of feedback using the lessons and exercises in TELS as well as having intra-team assessments become more consistent as students get to know each other’s behaviour more. In this case, TELS feedback should show evidence of growth between the rounds of feedback.

Figure 2-8: Description of ideal student activity with TELS during a team-based project that includes two assessments at the middle and end of a project.

For TELS to work ideally, it is necessary for students to receive feedback from all their team members. As a result, it is recommended to incent students to complete TELS as part of a course deliverable or as a separate deliverable in a course grading scheme. Having feedback from all team-members provides a greater probability of anonymity being kept in returning holistic feedback, and in ensuring that a student has a sense of how their entire team is perceiving their behaviour.
3. Development of a Behavioural Team-member Effectiveness Inventory

This chapter discusses the development, testing, and refinement of a behavioural team-member effectiveness inventory in two first-year design courses. The behavioural team-member effectiveness inventory (TEI) was iterated to define and refine both the items of assessment (behaviours) and their rating scales to best represent the conceptual frameworks of the team-effectiveness learning system (TELS) described in Chapter 2.2.2. The objective of this work was to develop a vocabulary/framework/inventory of team-member effectiveness behaviours that was applicable to first-year engineering student teams, understandable, produced reliable assessments, and had construct validity.

3.1. Study Design

This study was designed as a three-year, iterative testing and revision process that followed a multi-phase mixed-methods research design (Figure 3-1). An initial inventory of team-member effectiveness behaviours was developed from pre-existing inventories in the literature to form a 27-item inventory. This inventory was then used to gather first-year students’ assessments of their own and their team-members’ behaviour to: i) reduce the number of behaviours and time to assess while maintaining ii) the reliability of the assessments, iii) the validity of the behaviours against the conceptual frameworks, and iv) the utility of the feedback received from the inventory. This occurred over three phases, reducing the initial 27-item inventory first into an 18-item inventory, and finally into a 12-item inventory.

Each phase of the study had a similar data collection design for student participants. Students were asked to provide assessments of their and their team-members behaviours twice: i) at mid-project (typically in mid-February) and ii) at the end-of-project (typically in late March or early April). At the end of the project, students additionally were asked to complete a survey on how they perceived the utility of their feedback, and the method and inventory they used to provide it.
Figure 3-1: Visualisation of the multi-phase design of the study. Each box shows a different type of data used in the analysis, with arrows showing which data informed decisions in subsequent phases. Red boxes represent qualitative feedback, blue boxes quantitative inventory self and peer assessments, green boxes responses (or feedback) about the inventory or feedback process, and orange boxes inventory ratings of students from outside observers. The yellow background of Phases 1 and 2 represent assessments that occurred outside of TELS and the grey background of Phase 3 assessments that occurred within TELS.

Providing mid-project and end-of-project team feedback in each phase was directly integrated into the courses involved in the study as a required deliverable in each course. Participation in the study consisted of allowing students’ provided-feedback to be used additionally for research purposes in an anonymized manner. Students in each class were eligible to win an $100 gift card for allowing their data to be used for research purposes. All three phases of the study were approved by the University of Toronto’s Research Ethics Board for Social Sciences, Humanities, and Education.
3.1.1. Phase 1 – 27-item inventory

Phase one of the study was conducted in ESC102 in Winter 2012 as a randomized controlled experiment (Figure 3-2). This phase sought to:

- compare the 27-item inventory-based feedback to unstructured feedback as a way of determining how students provide and receive feedback differently using the two mechanisms,
- reduce the number of items in the inventory through analysing student assessment patterns, and
- compare student and teaching assistant (TA) assessments to determine if students produce reliable assessments.

Figure 3-2: Design of Phase 1 of the study showing how participants were involved in data collection. Blue boxes represent intra-team TEI-feedback from students and orange boxes TEI-feedback from teaching assistants. Red boxes represent unstructured textual feedback from students, and green boxes represent student responses to the feedback they received from their team.

Teams in the class were randomly divided 52:48 into the unstructured feedback group and TEI feedback group respectively. At mid-project students were asked to submit intra-team feedback according to the mechanism of their feedback group (Data Collection One). Students in the unstructured group provided freeform textual feedback to the question: “Please provide feedback to yourself and your team members based on your/their team-effectiveness over the course of this project.” Students in the inventory group provided quantitative self and peer
assessments using the 27-item inventory shown in Appendix C. Approximately a week after students provided feedback, they received feedback according to their feedback group (examples of 27-item TEI feedback can be found in Appendix D and examples of unstructured feedback can be found in Appendix E). At the end of the project students were asked to reflect on the utility of the feedback they received through an end-of-term survey that can be found in Appendix F (Data Collection Two). A few weeks after the project had ended, students who used the TEI were asked to participate in a focus group on their use of the TEI (questions included in Appendix G, Data Collection Three). All data collection occurred through LimeSurvey and student feedback was provided to individual students by PDF download from a controlled-access site.

To determine the reliability of the assessments provided by students, Teaching Assistants (TAs) were asked to provide an assessment for every student in their tutorial sections using the TEI. TAs provided these assessments shortly after the students provided theirs. At the end of the term, TAs were invited to participate in a focus group on their ability to provide assessments of students using the TEI (questions included in Appendix G). TAs were paid at union rates for their time involved in the study.

Based on student and TA assessment patterns the number of items in the inventory was reduced. Behaviours were reduced through elimination and combination, and were clarified through rephrasing or relocation across aspects in the inventory.

3.1.2. Phase 2 – 18-item inventory

Phase two of the study was conducted in APS112 and ESC102 in Winter 2013 (Figure 3-3). This phase sought to:

- determine changes in student assessment patterns and feedback utility between the 27 and 18 item inventories,
- reduce the number of items in the inventory through analysing student assessment patterns, and
- compare self and peer assessments to determine the reliability of those assessments.
Figure 3-3: Design of Phase 2 of the study showing how participants were involved in data collection. Blue boxes represent intra-team feedback, and green boxes represent student responses to the feedback they received from their team.

All teams in both courses were required to provide feedback to their team members using the 18-item TEI shown in Appendix H. At mid-project students provided self and peer assessments of team-member effectiveness using the TEI (data collection one), and approximately a week later received feedback from their team-members (examples of feedback can be found in Appendix I). At the end of the project, students again provided self and peer assessments using the TEI (data collection two), and additionally were asked to provide feedback to the researchers on the utility of the feedback they received from their team members (end-of-term survey available in Appendix J). All data collection occurred through LimeSurvey and student feedback was provided to individual students by PDF download from a controlled-access site.

As in Phase 1, the number of items in the inventory was reduced based on student assessment patterns. Behaviours were reduced through elimination and combination, and were clarified through rephrasing or relocation within aspects in the inventory.

3.1.3. Phase 3 – 12-item inventory

Phase three of the study was conducted in APS112 and ESC102 in Winter 2014 (Figure 3-4). This phase sought to:

- determine changes in student assessment patterns and feedback utility between the 18 and 12 item inventories,
- analyse assessment patterns to determine construct validity of the inventory as compared to the guiding conceptual framework, and
• compare self, peer and knowledgeable-observers’ assessments to determine the reliability of these assessments.

Figure 3-4: Design of Phase 3 of the study showing how students were involved in data collection. Blue boxes represent intra-team feedback, green boxes represent student responses to the feedback they received from their team, and orange boxes represent additional data collection points for students involved in the video-recorded component of this phase.

All teams in both classes were required to provide feedback to their team members using the 12-item TEI shown in Appendix A on the Team-Effectiveness Learning System (TELS). At mid-project students provided self and peer assessments of team-member effectiveness using the TEI (Data Collection One), and approximately a week later received feedback from their team members (example feedback can be found in Appendix K). At the end of the project, students again provided self and peer assessments using the TEI (Data Collection Two), and additionally were asked to provide feedback to the researchers on the utility of the feedback students received from their team members (end-of-term survey available in Appendix L). While students also provided holistic feedback in addition to their TEI feedback in this phase of the study, only the TEI-based feedback is analysed in this chapter. The utility of the feedback students received as well as comparisons between holistic and TEI-based feedback are discussed in Chapter 4.

During this phase of the study, student teams were given an opportunity to participate in the research at an increased level. Teams in both courses were invited to have three of their team-meetings video recorded, and to individually meet with two researchers after the course ended for a stimulated recall interview to discuss their teamwork and communication behaviours (orange boxes in Figure 3-4). Team meetings that were video-recorded were held in a separate
room where a large shared writing space and writing instruments were present. Three cameras simultaneously captured student gaze, gesture, expression, and speech as well as any writing on the shared writing space. Stimulated recall interviews were conducted independently for each student, where they were shown critical incidents from their team meetings and were asked about them, as well as general concepts relating to teamwork and communication (see interview protocol in Appendix M). From these interviews, data related to how the team worked between meetings, what happened as a result of intentions discussed during meetings, and team members’ perceptions of their team-effectiveness were obtained. Additionally, these provided information on behaviours which would not be directly assessable from just observing a team meeting.

I partnered with Dr. Penny Kinnear in this part of the study. Dr. Kinnear holds a PhD in second language education and provides communication learning support to students in both courses. Students who participated in this increased level of involvement were each awarded a $30 gift card in addition to being eligible to win the $100 gift card for allowing their self and peer assessments to be used for research.

3.1.4. Research Methods

The research methods used in this study are discussed across the three phases of the study based on the type of analysis being conducted; similar analyses were conducted across the phases to determine whether inventory revisions were beneficial or not.

For each phase of the study, the assessment trends of the students were determined. Feedback was analysed across raters to determine whether students were providing ratee-oriented assessments, and across items to determine whether the entire rating scale was being used. Feedback provided by a rater (both self and peer assessments) was analysed across all ratees to determine if there was any variance in the ratings provided by the student. Students’ ratings which had no variation across ratees or items were categorised as ‘unconsidered.’ Students’ ratings which had the same rating for each ratee on each item, but varied ratings across items were categorised as ‘item-oriented’, and students’ ratings which had variance across both ratees and items were categorised as ‘ratee-oriented’.

Unstructured feedback was collected only in Phase 1 of the study to ensure that providing students with an inventory would guide more useful feedback for students. Qualitative feedback
that students received in response to the unstructured feedback prompt was coded according to the 27-item inventory. The number of occurrences of each of the behaviour codes was then calculated for comparison with the inventory-feedback group and overlaps between codes investigated. Additional codes were created for themes that emerged in the unstructured feedback but were not directly mappable to an item in the inventory. The type of feedback provided to a student (individual or team-level) as well as the content of the feedback (course related, teamwork related, etc.) was also coded.

The reliability of the students’ assessments using the inventory were explored within the aspects of the inventory (Organisational, Relational and Communication) and across raters. The internal consistency of the inventory was assessed using Cronbach’s alpha to ensure a single concept was being assessed, in this case team-member effectiveness. Student self and peer ratings were compared to determine the level of agreement between them using both a consensus approach and intra-class correlations as a measure of consistency, and Spearman’s rank correlations as a proxy for accuracy. In cases where there were external observers (teaching assistants in Phase 1, and knowledgeable observers in Phase 3) these assessments were compared to students’ self and peer assessments using the same analyses.

The inventory was assessed for face, and construct validity in all phases of the study. Face validity was assessed using student responses to providing feedback and their responses to the feedback they received. Data for face validity was collected primarily through the end-of-term survey, which contained a combination of both qualitative and quantitative questions. Quantitative questions were used to categorise students according to their perceived utility of the inventory and feedback process. Qualitative questions were thematically coded around utility (were students able to understand the inventories, did they feel they could provide the feedback they wanted with them) to identify the areas in which the inventory was not effective. Construct validity was assessed using factor analyses to identify if the items in the inventory separated into the three aspects of the conceptual framework governing them. The order of items in the inventory was changed between phases of the study to ensure that nearby questions did not adversely impact the factor separation. In Phase 3 for the video-recorded teams, predictive validity was explored through comparing a team’s average self and peer assessments to the
knowledgeable observer’s ranking of their team with respect to all teams in the video-recorded study.

The inventory was revised between phases of the study to reduce the number of items in the inventory. Inventory revisions were guided by: items discussed in the unstructured feedback in Phase 1, inter-item correlations and item location within the factor analyses, student responses in the end-of-term survey about questions they did not understand or see value in, and student responses to the inventory from the focus group in Phase 1.

All qualitative analysis was completed in NVivo, with quantitative analyses completed in SPSS and Microsoft Excel.

3.1.5. Study Participation

Consent rates for students to participate in the study were high as there was no additional effort required to participate in all phases of the study except for the video-recorded study in Phase 3 (Table 3-1).

Table 3-1: Number of study participants in each phase of the study across the courses involved.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Year</th>
<th>Courses Involved</th>
<th>No. of Participants</th>
<th>Consent Rate, %</th>
<th>No. of Inventory Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: 27-item Inventory</td>
<td>2012</td>
<td>ESC102</td>
<td>218</td>
<td>78</td>
<td>1</td>
</tr>
<tr>
<td>2: 18-item Inventory</td>
<td>2013</td>
<td>APS112 / ESC102</td>
<td>616 / 204</td>
<td>78 / 86</td>
<td>2</td>
</tr>
<tr>
<td>3: 12-item Inventory</td>
<td>2014</td>
<td>APS112 / ESC102</td>
<td>743 / 212</td>
<td>83 / 87</td>
<td>2</td>
</tr>
<tr>
<td>3: Video-recorded Study</td>
<td>2014</td>
<td>APS112 / ESC102</td>
<td>17 / 14</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

A small number of students participated in the video-recorded study as there was limited space – six student teams had been sought. Seven student teams joined the study, three in APS112 and four in ESC102. However, data from only five teams is included in this study as one team had a team-member who left the course mid-project and thus the team was not a consistent one for comparison across both mid-project and end-of-project feedback. A second team did minimal project work during the video-recorded sessions and thus insufficient behaviours were evident in the video-recordings for the observers to make reliable assessments using the inventory.
3.2. Development of the Initial Inventory

The initial inventory was derived from existing models and inventories of team-member effectiveness as well as from feedback obtained on common team-dysfunction issues and concerns from instructors of team-based project courses at the University of Toronto. The initial inventory was intended to be a starting point for this research with the inventory intending to be revised and reduced. The first iteration of the inventory focused on creating a broad list of behaviours (items) across the three aspects of the team-effectiveness conceptual framework presented in Section 2.2.2, and on creating a rating scale that incorporated instructors’ concerns. By combining both instructor experience with literature on teamwork, the initial inventory developed was designed to address both the stakeholder objectives and constraints outlined in Chapter 2.

A survey of instructors that utilize team-based projects as a mechanism for students to learn about teamwork was conducted to obtain information about common team-dysfunction issues and areas in which students struggle. Six instructors were interviewed by Estelle Oliva-Fisher as part of the Engineering Undergraduate Curriculum Team Skills Study in 2010-2011 (E. Oliva-Fisher, personal communication and interview notes, June 2011). Common concerns expressed by instructors included:

- A need to identify and deprivilege highjacking team members – making sure that a team member who was manipulative and took over the project could not do well on the TEI
- A need to identify and privilege those that help take charge of the project’s success – making sure that team members demonstrated initiative in dividing up the work and monitoring the workflow
- A way to identify team members who weren’t contributing and were expecting/letting their team members to do the project for them
- A need to privilege interdependence in team-member work and behaviour – making sure that team members support each other and build on each other’s contributions.

These concerns informed both behaviour selection for the inventory as well as the rating scale for each behaviour.
To develop the initial inventory, a synthesis of other inventories was created in Summer 2011 and redundancy between behaviours eliminated. It was decided to create the inventory from a series of pre-existing inventories to ensure content validity in the initial items being tested and refined. Inventories that were screened to be included were those that had undergone some validation and referenced sources in the teamwork literature for the development of their items. Based on those inventories, only those tested in undergraduate education (STEM preferred) or previously used by instructors at ILead were included. A synthesis of five inventories ultimately informed the development (Bushe & Coetzer, 1995; Lingard, 2010; Maxwell, 2011; Moore, Diefes-Dux, & Imbrie, 2006; Loughry, Ohland, & Moore, 2007). As all of these inventories either defined individual behaviours or team-level processes that could be described as individual behaviours, it was decided that items were sufficiently consistent that they could be merged across these inventories; measures to ensure all the items were assessing a similar construct would be addressed during revisions to the inventory.

Based on the conceptual framework presented in Section 2.2.2 the items were divided into the three aspects of team-member effectiveness: Organisational, Relational, and Communication. The Organisational aspect dealt with managing the workflow of the team, the Relational aspect dealt with fostering positive interpersonal relations and demonstrating to team-members that they were valuable to the team, and the Communication aspect dealt with the way in which issues and work were presented and discussed. Bushe and Coetzer’s and Maxwell’s inventories focused heavily on Relational (conflict management, decision making, cohesion, interdependency) and Organisational (team-member and team performance expectations, direction/goal setting, work processes, etc.) behaviours, and Lingard’s presented primarily Communication behaviours (share opinions and knowledge, listen to others’ opinions, consider others’ suggestions). Moore et. al’s inventory focused on the skills needed to engage in short-term team-based activities; thus only the behaviours in the interdependency category were incorporated and focused on the Organisational aspect. Loughry et al.’s inventory focused on five categories of team-member contribution of which two were not included in the superset of items as they focused on technical skills. Their remaining three categories that were included were heavily focused on the Organisational (doing their work, planning work, and attending meetings) and Communication (exchanging information, providing feedback) aspects.
Once a complete list of behaviours was developed, redundant behaviours were eliminated, and similar behaviours were grouped together and phrased to best represent the engineering teamwork context. These modifications were made in consultation with two engineering professors and two leadership development professionals to ensure face validity with those that would be using the inventory (G. Evans, E. Oliva-Fisher, D. Reeve, and A. Simpson, personal communication, August 2011). This resulted in the initial 27-item inventory to be tested and refined, Table 3-2.

Table 3-2. The initial 27 behaviours of the Team-effectiveness Inventory divided into the three aspects

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

As discussed in Section 2.2.2, the rating scale for each of the items uses a continuum of engagement – the way in which the student encourages engagement from other team-members in
demonstrating that behaviour. This gives focus to the quality of the behaviour rather than quantity of demonstration, recognizing engineering students’ tendency to always do more to get a higher grade. Seven rating points were provided along the continuum with those corresponding to odd numbers having descriptions. Intermediate options were provided in case a rater did not feel their ratee fit perfectly in either category. The rating scale of three items from the initial inventory is provided in Table 3-3 for reference with the full version of the initial inventory with all rating descriptions provided in Appendix C.

Table 3-3: Examples of the behaviourally-anchored rating scales for three of the behaviours listed in the inventory.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Unengaged</th>
<th>Self-focused</th>
<th>Project-focused</th>
<th>Team-focused</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Deliver their work on time</strong></td>
<td>Did not complete their work on time</td>
<td>Completed some of their work on time; or only completed their work when requested</td>
<td>Completed all their work on time</td>
<td>Completed all their work on time and assisted other team members in meeting deadlines as well</td>
</tr>
<tr>
<td><strong>Solicit input before proceeding</strong></td>
<td>Proceeded without asking for others’ opinions</td>
<td>Solicited input before proceeding on areas that were contentious only</td>
<td>Solicited others for input before proceeding in all tasks</td>
<td>Solicited others for input before proceeding in all tasks, and encouraged all team members to provide input</td>
</tr>
<tr>
<td><strong>Openly express opinions</strong></td>
<td>Did not express opinions</td>
<td>Expressed opinions in a manner which demonstrated hesitation or reservation</td>
<td>Expressed opinions in an open manner</td>
<td>Expressed opinions in an open and unbiased manner that solicited input from others</td>
</tr>
</tbody>
</table>

Note: The items are emphasized according to their aspect in the TEI. Organisational items are blue and bold, Relational items are green in regular type face, and Communication items are red and italicised.

3.3. 27-item Inventory Analysis – Phase 1

The findings of Phase 1 are published in three articles: 1) “Teaching Team-effectiveness in Large Classes” (Sheridan, Evans, & Reeve, 2015), 2) “A Team-effectiveness Inventory for Guided Reflection and Feedback” (Sheridan, Phillips, El Gammal, Evans, & Reeve, 2013), and 3) “Understanding Teaching Assistants’ Assessment of Individual Teamwork Performance”
(Sheridan, Reeve, & Evans, 2014). These publications make up a foundational component of this work, and thus are included in pre-formatted versions in Appendices N, O and P.

Phase 1 was designed as a pilot-study and focused on comparing the initial inventory to unstructured feedback which was standard practice in the courses studied. The inventory was only used once for feedback at the mid-point of the term. A comparison of the unstructured feedback to the 27-item inventory feedback revealed the following key differences (Sheridan, Evans, & Reeve, 2015):

- Students using the inventory found the feedback they received to be more actionable than those who received unstructured feedback
- Students who received unstructured feedback received feedback on less than half the behaviours as those who received inventory feedback, and received little feedback on Relational behaviours
- Students who received unstructured feedback had strengths frequently identified and weaknesses rarely identified
- Students who received unstructured feedback commented that their feedback made them feel more committed to their team, as it demonstrated that their team members had an interest in them and in the team as a whole
- Students who received inventory-based feedback received more feedback that demonstrated considered reflection than those who received unstructured feedback

From these findings, utilizing the inventory to provide intra-team feedback was better than the unstructured feedback as it provided students with more specific and actionable feedback across a broader range of team-member effectiveness behaviours.

3.3.1. Assessment Trends

Assessments were categorised for each rater according to how they provided their feedback. Three types of assessment categories were defined: 1) unconsidered assessment – the rater provided the same value to every team-member along every item, 2) item-oriented – the rater provided the same value to every team-member along each item, varying the values across items, and 3) ratee-oriented – the rater provided different values to team-members along different items. As can be seen in Table 3-4, almost all students provided ratee-oriented assessments, and there
were no item-oriented assessments. Given that students who provided feedback using the inventory did so for each of their team-members sequentially it is not surprising that there are no item-oriented assessments. This type of assessment would have required students to remember how they assessed themselves or their team members across the uses of the inventory as students were directed to complete the whole inventory for each team member before progressing to the next team member.

Table 3-4: Types of assessments provided by students using the 27-item inventory to provide feedback.

<table>
<thead>
<tr>
<th>Percent of Students a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconsidered</td>
</tr>
<tr>
<td>Item-oriented</td>
</tr>
<tr>
<td>Ratee-oriented</td>
</tr>
</tbody>
</table>

a n = 94

3.3.2. Reliability

The reliability of the inventory-developed assessments was analysed using three modes: internal consistency, correlation between self and peer assessments, and correlation between student and teaching assistant (TA) assessments.

For internal consistency four analyses were conducted. The Cronbach’s alphas were calculated for the entire 27-item inventory, and for each of the aspects separately. Raters assessments for each separate ratee were used totalling 318 individual assessments, meaning that all self and peer assessments were considered in this analysis. The overall inventory, as well as its three underlying constructs, all had a high level of internal consistency ( > 0.7) (DeVellis, 2003), as determined by Cronbach’s alpha (Table 3-5).

Table 3-5: Internal Consistency of the overall inventory as well as the three aspects of the inventory calculated using Cronbach’s alpha.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Cronbach’s α a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.96</td>
</tr>
<tr>
<td>Organizational</td>
<td>0.93</td>
</tr>
<tr>
<td>Relational</td>
<td>0.90</td>
</tr>
<tr>
<td>Communication</td>
<td>0.91</td>
</tr>
</tbody>
</table>

a n = 318
To assess the agreement of the feedback a student received, the inter-rater reliability between peer assessors and the correlation between students’ self and peer assessments were determined (Sheridan, Evans, & Reeve, 2015). Inter-rater reliability was determined using the intra-class correlation coefficients (ICCs) for peer assessments, using a two-way random effects model for consistency. Ninety-one of the 95 students had at least two peer assessors and were considered in this analysis. Peer ICCs were then grouped according to their level of agreement between the peer assessors (Table 3-6). Thirty-one percent of the feedback showed no agreement between the peer assessors. Sixty-nine percent of assessments showed some agreement, ranging from slight to substantial agreement.

Agreement was also determined by comparing the average self assessments to the peer assessments across the three aspects of the inventory. Using a Spearman’s rank correlation (Table 3-7), it can be seen that there is a significant correlation between the students’ self and peer assessments in the organizational aspect. However, there is no significant correlation between students’ self and peer assessments in the Relational and Communication aspects. This is further confirmed by the R² values for these two aspects which demonstrate that next to none of the variance in the self assessments can be explained by the peer assessments. This strong correlation in self and peer assessments along only the organizational aspect may explain the limited agreement seen in the peer agreement discussed above.

Table 3-6: Distribution of agreement between peer assessments of a student as measured using ICCs in a two-way random effects model for consistency (Sheridan, Evans, & Reeve, 2015)

<table>
<thead>
<tr>
<th>Level of Agreement</th>
<th>Number of Students</th>
<th>ICC value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>No agreement</td>
<td>28 (31%)</td>
<td>&lt; 0</td>
</tr>
<tr>
<td>Slight agreement</td>
<td>18 (20%)</td>
<td>0 - 0.2</td>
</tr>
<tr>
<td>Fair agreement</td>
<td>20 (22%)</td>
<td>0.21 - 0.4</td>
</tr>
<tr>
<td>Moderate agreement</td>
<td>17 (19%)</td>
<td>0.41 - 0.6</td>
</tr>
<tr>
<td>Substantial agreement</td>
<td>8 (9%)</td>
<td>0.61 - 0.8</td>
</tr>
<tr>
<td>Perfect agreement</td>
<td>0</td>
<td>0.81 – 1</td>
</tr>
</tbody>
</table>
Table 3-7: Spearman’s rank correlation and R² values between students’ self and peer assessments for each aspect of the 27-item inventory

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Correlation</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational</td>
<td>0.45**</td>
<td>0.24</td>
</tr>
<tr>
<td>Relational</td>
<td>0.19</td>
<td>0.05</td>
</tr>
<tr>
<td>Communication</td>
<td>0.16</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note: Students’ self assessments (n = number of items) and peer assessments (n = number of items x number of peers) were averaged separately to determine each student’s self assessment and peer assessment for the aspect. These averages for each aspect were then correlated over all the students. ** - p ≤ 0.01.

To look at the reliability of student assessments for both self and peer assessments, they were compared to the assessments of trained teaching assistants (TAs) who observed the teams working in tutorial for 2 hours every week. After 9 weeks of class, the TAs assessed each student in their tutorial using the inventory. Findings from this analysis are presented in previous publications (Sheridan, Evans, & Reeve, 2015; Sheridan, Reeve, & Evans, 2014) included in Appendices N and P, respectively, and summarised below:

- TAs provided assessments that were on average lower than those of the students
- TAs and students rarely agreed on strengths and weaknesses for any given student
- TA assessments were significantly correlated with students’ peer assessments across all aspects and only correlated with self assessments in the Organisational aspect (Table 3-8)

Table 3-8: Spearman’s rank correlation between students’ and TAs’ assessments along the three aspects of the 27-item inventory (Sheridan, Evans, & Reeve, 2015)

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Peer assessments</th>
<th>Self assessments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational</td>
<td>0.35**</td>
<td>0.26**</td>
</tr>
<tr>
<td>Relational</td>
<td>0.27**</td>
<td>0.00</td>
</tr>
<tr>
<td>Communication</td>
<td>0.24*</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Note: Students’ peer assessments (n = number of behaviours x number of peers) were averaged separately to determine each student’s peer assessed level of behaviour for the aspect. Students’ self assessments (n = number of behaviours) were averaged separately to determine each student’s self assessed level of behaviour for the aspect. * p ≤ 0.05, ** p ≤ 0.01

Therefore, in terms of the reliability of students’ assessments using the 27-item inventory, there is high internal consistency between the behaviours demonstrating that students are assessing a similar construct (Table 3-5). Students have significant reliability as self assessors when assessing Organisational behaviours (Table 3-7), and demonstrate significant reliability as peer assessors along all three aspects as compared to teaching assistants (Table 3-8).
3.3.3. Validity

The validity of the inventory was analysed to determine the construct validity of the aspects. As with reliability all raters’ assessments for each separate ratee were used totalling 318 individual assessments, meaning that all self and peer assessments were considered in this analysis. An exploratory factor analysis (principal components analysis) with normalized varimax rotation was run to attempt to surface any common underlying constructs students were using to assess the behaviours. A principal component analysis approach was appropriate as the data was ordinal, the correlation between all variables was > 0.4, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.96 and Bartlett’s Test of Sphericity was significant. The number of factors was specified at 3 to determine the way in which the items grouped together and to determine how closely they resembled the aspects of the conceptual framework. Using three factors to describe the assessments, the eigenvalues of each factor were greater than 1.15, and the factors explained 63% of the variance. Given that the objective was to refine and reduce the inventory, behaviours were then represented on the three factors based on these results (Table 3-9).

Any item which had a factor loading greater than 0.4 was represented on that factor, with some items being represented on multiple factors (Garbin, 2017). This provided a representation of which behaviours might be candidates for combination due to a common underlying construct or might need to be relocated as students assessed them differently.

As can be seen from the factor loading representation, the behaviours largely separate along the aspect lines, with some overlap. As the aspects of the inventory were assessed sequentially (Organisational, then Relational, then Communication) it is possible that this factor representation was due to proximate behaviours rather than behavioural correlations. As a result, for the second iteration of the inventory, behaviours were assessed in an alternated manner to reduce the potential for proximity being the underlying cause of an aspect being represented in a factor. Behaviours which required a communication component to be demonstrated were most often cross-represented or loaded on a factor other than the one with the majority of the Communication behaviours. These behaviours were selected for further consideration to be refined or removed.
Table 3-9: Representation of the exploratory factor analysis of the 27-item inventory, emphasised by aspect with items listed under the factors with which they most strongly correspond.

<table>
<thead>
<tr>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support team rules</td>
<td><em>Raise contentious issues in a constructive way</em></td>
<td><em>Build the trust of teammates</em></td>
</tr>
<tr>
<td>Attend team meetings</td>
<td><em>Introduce new ideas</em></td>
<td><em>Solicit input before proceeding</em></td>
</tr>
<tr>
<td>prepared</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contribute to making meetings effective</strong></td>
<td></td>
<td><strong>Adopt suggestions from other members</strong></td>
</tr>
<tr>
<td>Do their fair share of the work</td>
<td><em>Openly express opinions</em></td>
<td><em>Accept feedback about strengths and weaknesses</em></td>
</tr>
<tr>
<td>Deliver their work on time</td>
<td><em>Promote constructive brainstorming</em></td>
<td><em>Show respect for other teammates</em></td>
</tr>
<tr>
<td>Produce high quality work</td>
<td></td>
<td><strong>Collaborate effectively</strong></td>
</tr>
<tr>
<td>Help to plan, set goals, and organize work</td>
<td></td>
<td><strong>Demonstrate accountability</strong></td>
</tr>
<tr>
<td>Track team progress vs. project timeline</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encourage progress to meet goals and deadlines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Display dedication and determination</td>
<td></td>
<td><strong>Provide constructive feedback</strong></td>
</tr>
<tr>
<td><strong>Motivate others on the team to do their best</strong></td>
<td></td>
<td><strong>Make sure that teammates understand important information and instructions</strong></td>
</tr>
<tr>
<td>Exchange information in a timely manner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The items are emphasised according to their aspect in the initial 27-item inventory. Organisational items are blue and bold, Relational items are green in regular type face, and Communication items are red and italicised. * n = 317.

3.3.4. Revisions to the inventory

Based on the above reliability and validity analyses and the utility of the inventory as compared to unstructured feedback (Sheridan, Evans, & Reeve, 2015), revisions to the inventory were completed to reduce the number of items in the inventory and to have an equal number of items in each of the three aspects. Three types of changes were made: removal of items, combining of items, and relocation of items between aspects. Revisions made to the inventory,
their motivation and rationale are presented in a previous publication (Sheridan, Phillips, El Gammal, Evans, & Reeve, 2013) included in Appendix P and summarised below. These modifications resulted in an 18-item inventory with 6 behaviours across each of the three aspects (Table 3-10).

Six behaviours were removed from the inventory. Within the organizational aspect, three behaviours were removed: support team rules, contribute to making meetings effective, and display dedication and determination. Within the Relational aspect, two behaviours were removed: accept feedback about strengths and weaknesses and collaborate effectively. Within the Communication aspect only one behaviour was removed: make sure that team members understand important information and instructions.

Table 3-10. The 18 behaviours of the Team-effectiveness Inventory divided equally into the three aspects.

<table>
<thead>
<tr>
<th>Organisational Aspect</th>
<th>Relational Aspect</th>
<th>Communication Aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourage progress to meet goals and deadlines</td>
<td>Build the trust of teammates</td>
<td>Exchange information in a timely manner</td>
</tr>
<tr>
<td>Attend team meetings prepared</td>
<td>Motivate others on the team to do their best</td>
<td>Openly express ideas and opinions</td>
</tr>
<tr>
<td>Do their fair share of the work</td>
<td>Help the team build consensus</td>
<td>Promote productive discussion</td>
</tr>
<tr>
<td>Deliver their work on time</td>
<td>Adopt suggestions from other members</td>
<td>Actively listen to teammates</td>
</tr>
<tr>
<td>Produce high quality work</td>
<td>Show respect for other teammates</td>
<td>Solicit input before proceeding</td>
</tr>
<tr>
<td>Help to plan and organize workflow</td>
<td>Demonstrate accountability</td>
<td>Raise contentious issues in a constructive way</td>
</tr>
</tbody>
</table>

Within the Organisational aspect the two behaviours help to plan, set goals, and organize work and track team progress vs. project timeline were combined into help to plan and organize workflow. Within the Communication aspect, the behaviours introduce new ideas and openly express opinions were merged into openly express ideas and opinions, and provide constructive feedback, and promote constructive brainstorming were combined into promote productive discussion.
Two behaviours were relocated from the Relational to Communication aspect: *raise contentious issues in a constructive way* and *solicit input before proceeding*. One behaviour was moved from the Communication aspect to the Relational aspect: *help the team build consensus*.

3.4. 18-item Inventory Analysis – Phase 2

The focus in the second phase of the study was to expand the studied population to the entire first year class, to utilise the inventory as a feedback mechanism twice in the term, and to continue to reduce and refine the inventory. Both first-year engineering design courses took part in this phase of the study, and 820 students consented to participate. Students used the 18-item inventory at the mid-point and end of the project to provide intra-team feedback to their peers and additionally completed a survey at the end of the term on the utility of the feedback they received. The full 18-item inventory with its rating scale is presented in Appendix H, with example feedback a student would receive included in Appendix I.

Two changes were made between Phase 1 and Phase 2 in terms of how students completed the inventory. First, students completed the inventory for each team member relatively across each item instead of sequentially across team members. Second, the order of the items in the inventory that students used was not categorised according to the aspects and was different between their first and second use of the inventory. In the both uses, items were sequentially alternated through Organisational, Relational, and Communication behaviours, and the order of the items was reversed between the first and second use.

As with Phase 1, raters’ assessments for each separate ratee were used totalling 5579 individual assessments, meaning that all self and peer assessments were considered in these analyses.

3.4.1. Assessment Trends

Two assessment trends were of note in the use of the 18-item inventory – quantity and type of assessments. In terms of quantity, there was a different number of students who completed the inventory in each of its uses, with more students completing the inventory in its second use. Of the 820 students in the study, only 570 completed the inventory during both uses, with 80 only completing the inventory at mid-project, and 170 only completing it at the end of the project.
Assessments were categorised for each rater according to how they provided their feedback in the same way as Phase 1 of the study. Almost all students (83%) provided ratee-oriented assessments with very few (4-6%) providing item-oriented assessments (Table 3-11). The number of unconsidered assessments increased from the 27-item inventory and increased between the two uses of the inventory (from 11 to 13%). However, there are sufficiently few unconsidered that the inventory can be seen to promote students to provide individualized feedback to their team members.

Table 3-11: Types of assessments provided by students using the 18-item inventory to provide feedback.

<table>
<thead>
<tr>
<th>18-item Inventory</th>
<th>Use 1 – mid project a</th>
<th>Use 2 – end of project b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconsidered</td>
<td>11%</td>
<td>13%</td>
</tr>
<tr>
<td>Item-oriented</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>Ratee-oriented</td>
<td>83%</td>
<td>83%</td>
</tr>
</tbody>
</table>

a n = 650, b n = 740

Assessments that fell into the ‘unconsidered’ category were removed from any further analysis. All ‘unconsidered’ assessments provided a 5, 6, or 7 for all items, for every individual.

Each of the 18 behaviours were analysed to identify the distribution of assessments provided by students. All behaviours were left-skewed along the rating scale; the majority of assessments occurred in the self-focused [3-5] to team-focused [6-7] range with few assessments occurring in the unengaged [1-2] range. The mean and median of all behaviours was between 5 and 6, implying that the majority of students are fairly competent team members. Each behaviour received assessments across the full range of values, with all behaviours other than ‘Encourage progress to meet goals and deadlines’ having their 25th-75th double-quartile range spanning the 5-6 or 5-7 assessment range. The ‘Encourage progress to meet goals and deadlines’ behaviour had a 25th percent quartile range that began at 4.

3.4.2. Reliability

The reliability of the inventory-developed assessments was analysed using two modes: internal consistency, and correlation between self and peer assessments.
For internal consistency four analyses were conducted as with Phase 1 of the study. The Cronbach’s alphas were calculated for the entire 18-item inventory, and for each of the aspects separately. All individual assessments from both uses of the inventory were included. The overall inventory, as well as its three underlying constructs, all had a high level of internal consistency ($> 0.7$), as determined by Cronbach’s alpha (Table 3-12).

Table 3-12: Internal Consistency of the overall inventory as well as the three aspects of the inventory calculated using Cronbach’s alpha for the 18-item inventory.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Cronbach’s $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.96</td>
</tr>
<tr>
<td>Organizational</td>
<td>0.91</td>
</tr>
<tr>
<td>Relational</td>
<td>0.88</td>
</tr>
<tr>
<td>Communication</td>
<td>0.88</td>
</tr>
</tbody>
</table>

$n = 5579$

To assess the reliability of the students’ self assessments, the correlation between students’ self and peer assessments were determined. All students for which there were at least two peer assessors for a given use of the inventory were included. Using a Spearman’s rank correlation (Table 3-13) it can be seen that there is a significant correlation between the students’ self and peer assessments in the organizational aspect in both uses of the inventory, and significant correlation across all aspects in the second use of the inventory. Additionally, the magnitude of the correlation increases for all aspects across the uses of the inventory. This increase in correlation and significance may indicate that students’ self assessments improved and were more reliable in the second use of the inventory. The lack of significant correlation between students’ self and peer assessments in the Relational and Communication aspects in the first use of the inventory confirms the same first-use assessment-trend of Phase 1; students are more reliable when self assessing their organizational behaviours.

However, while the correlation does increase, the $R^2$ value does not increase noticeably between the two uses of the inventory. Even though the data was not normally distributed, the assumption that normality should be present was appropriate as perfect correlation between self and peer assessments would have resulted in a linear relationship, and because the normality plots for the residuals were sufficiently linear to perform the analysis. These $R^2$ values demonstrate that while the amount of variance in the self assessments that can be explained by
the peer assessments does increase between uses, it is very limited and thus the significance in correlation may simply be attributed to the size of the dataset.

Table 3-13: Spearman’s rank correlation and R² values between students’ self and peer assessments for each aspect of the 18-item inventory

<table>
<thead>
<tr>
<th></th>
<th>Use 1 – mid project a</th>
<th></th>
<th>Use 2 – end of project b</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spearman’s ρ</td>
<td>R²</td>
<td>Spearman’s ρ</td>
<td>R²</td>
</tr>
<tr>
<td>Organisational</td>
<td>0.14**</td>
<td>0.01</td>
<td>0.27**</td>
<td>0.07</td>
</tr>
<tr>
<td>Relational</td>
<td>0.03</td>
<td>0.00</td>
<td>0.18**</td>
<td>0.03</td>
</tr>
<tr>
<td>Communication</td>
<td>0.06</td>
<td>0.00</td>
<td>0.16**</td>
<td>0.02</td>
</tr>
</tbody>
</table>

Note: a n=555, b n=619, ** p ≤ .01

Therefore, in terms of the reliability of students’ assessments using the 18-item inventory, there is high internal consistency between the behaviours demonstrating that students are assessing a similar construct (Table 3-12). Students have significant reliability as self assessors when assessing Organisational behaviours and demonstrate increased self assessment capability across all three aspects with two uses of the inventory (Table 3-13).

3.4.3. Validity

The construct validity of the inventory was analysed using an exploratory factor analysis as was done with the 27-item inventory. A principal component analysis approach was appropriate as the data was ordinal, the correlation between all variables was > 0.4, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.98 and Bartlett’s Test of Sphericity was significant. Using three factors to describe the assessments, the eigenvalues of each factor were greater than 0.65, and the factors explained 68% of the variance. An eigenvalue of that magnitude at three factors indicates that there are likely less than three underlying constructs based on students’ assessments using the inventory. As a result, it was important to look at how the behaviours cross-represented on the factors (Table 3-14). Any item which had a factor loading greater than 0.4 was represented on that factor, with some items being represented on multiple factors (Garbin, 2017). This provided a representation of which behaviours might be candidates for combination due to a common underlying construct or might need to be relocated as students assessed them differently. Factor loadings that were above this cut-off are detailed in Table 3-15.
One interesting finding from this analysis was that no factor wholly represented an aspect of the inventory, with two aspects spread across all three factors. Analysing the item groupings within the factors, the first factor appears to be addressing task completion components of teamwork, the second factor appears to be dealing with behaviours that require conversation to be demonstrated, and the third factor appears to be dealing with demonstrating that others on the team are valuable. One anomaly to this understanding is the presence of *build the trust of team members* and *motivating others on the team to do their best* in the first column with all the other task completion behaviours. While these behaviours are required to engage in effective task completion it was expected that they would have been represented in either of the other two factors.

Table 3-14: Representation of the exploratory factor analysis of the 18-item inventory, emphasised by aspect with items listed under the to which factors they most strongly correspond.

<table>
<thead>
<tr>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attend team meetings prepared</td>
<td>Solicit input before proceeding</td>
<td></td>
</tr>
<tr>
<td>Do their fair share of the work</td>
<td>Encourage progress to meet goals and deadlines</td>
<td>Adopt suggestions from other members</td>
</tr>
<tr>
<td>Deliver their work on time</td>
<td>Help the team build consensus</td>
<td>Show respect for other team members</td>
</tr>
<tr>
<td>Exchange information in a timely manner</td>
<td>Openly express ideas and opinions</td>
<td>Actively listen to team members</td>
</tr>
</tbody>
</table>

*Motivate others on the team to do their best*

*Produce high quality work*

*Help to plan and organize workflow*

*Demonstrate accountability*

*Build the trust of team members* | Promote productive discussion | *Built the trust of team members*

| Raise contentious issues in a constructive way |

Note: The items are emphasised according to their aspect in the initial 18-item inventory. Organisational items are blue and bolded, Relational items are green in regular typeface, and Communication items are red and italicised. *n = 5579*

Overall, the previous revisions to the inventory did not enhance the construct validity of the TEI in the 18-item inventory. This may be due to the fact that the ordering of the items in the 27-item inventory presented factors that were more closely representative of the order of the items...
in the inventory rather than the aspects of the inventory. Thus, previous revisions were more informed by item order rather than by an aspect-level construct across the items.

Table 3-15: Factor loadings for each of the behaviours in the 18-item inventory that were above the cut-off of 0.4

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1 - Attend team meetings prepared</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O2 - Do their fair share of the work</td>
<td>0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O3 - Deliver their work on time</td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
<tr>
<td>O4 – Produce high quality work</td>
<td>0.59</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>O5 - Help to plan and organize workflow</td>
<td>0.52</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>O6 – Encourage progress to meet goals and deadlines</td>
<td></td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>R1 – Built the trust of team members</td>
<td>0.58</td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>R2 – Motivate others on the team to do their best</td>
<td>0.55</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>R3 – Adopt suggestions from other members</td>
<td></td>
<td></td>
<td>0.65</td>
</tr>
<tr>
<td>R4 - Show respect for team members</td>
<td>0.55</td>
<td>0.45</td>
<td></td>
</tr>
<tr>
<td>R5 - Demonstrate accountability</td>
<td>0.55</td>
<td>0.51</td>
<td>0.70</td>
</tr>
<tr>
<td>R6 – Help the team build consensus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1 - Exchange information in a timely manner</td>
<td>0.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C2 - Openly express ideas and opinions</td>
<td></td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>C3 - Promote productive discussion</td>
<td></td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>C4 - Actively listen to team members</td>
<td>0.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C5 - Raise contentious issues in a constructive way</td>
<td>0.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C6 - Solicit input before proceeding</td>
<td></td>
<td>0.55</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Note: The items are emphasised according to their aspect in the initial 18-item inventory. Organisational items are blue and bolded, Relational items are green in regular typeface, and Communication items are red and italicised. a n = 5579

3.4.4. Revisions to the inventory

Based on the above reliability and validity analyses of the inventory, revisions were completed to further reduce the number of items in the inventory and to have an equal number of items in each of the three aspects. Three types of changes were made: removal of items, combining of items, and relocation of items between aspects. Both the analyses from Phase 1 and Phase 2 were used to inform revisions.

A Spearman’s rank correlation was first completed to determine behaviours which should be flagged for further investigation. Overall, all 18 behaviours were highly correlated with each other; no two behaviours had a correlation of less than 0.28. As a result, the standard critical limit of 0.1 was not useful in completing this flagging and a cut-off of 0.52 was decided on as it
identified an appropriate number of behaviours to be investigated to reduce the inventory (13). All item correlations which were above this cut-off value are presented in Table 3-16.

Table 3-16: Spearman’s rank correlation of all behaviours which met the threshold value for potential reduction from the 18-item inventory.

<table>
<thead>
<tr>
<th>BEHAVIOUR</th>
<th>BEHAVIOUR</th>
<th>ρ</th>
</tr>
</thead>
<tbody>
<tr>
<td>O – Help to plan and organize workflow</td>
<td>O – Encourage progress to meet goals and deadlines</td>
<td>0.57</td>
</tr>
<tr>
<td>O - Do their fair share of the work</td>
<td>O - Deliver their work on time</td>
<td>0.56</td>
</tr>
<tr>
<td>O - Do their fair share of the work</td>
<td>O - Produce high quality work</td>
<td>0.52</td>
</tr>
<tr>
<td>O - Deliver their work on time</td>
<td>O - Produce high quality work</td>
<td>0.52</td>
</tr>
<tr>
<td>O – Help to plan and organize workflow</td>
<td>O - Produce high quality work</td>
<td>0.52</td>
</tr>
<tr>
<td>O – Attend team meetings prepared</td>
<td>C – Exchange information in a timely manner</td>
<td>0.52</td>
</tr>
<tr>
<td>O - Do their fair share of the work</td>
<td>C – Exchange information in a timely manner</td>
<td>0.53</td>
</tr>
<tr>
<td>O - Deliver their work on time</td>
<td>R – Demonstrate Accountability</td>
<td>0.52</td>
</tr>
<tr>
<td>R – Help the team build consensus</td>
<td>O – Encourage progress to meet goals and deadlines</td>
<td>0.55</td>
</tr>
<tr>
<td>R – Build the trust of team members</td>
<td>R – Motivate others on the team to do their best</td>
<td>0.52</td>
</tr>
<tr>
<td>R – Help the team build consensus</td>
<td>C – Solicit input before proceeding</td>
<td>0.53</td>
</tr>
<tr>
<td>C – Openly express ideas and opinions</td>
<td>R – Motivate others on the team to do their best</td>
<td>0.52</td>
</tr>
<tr>
<td>C – Openly express ideas and opinions</td>
<td>C – Promote productive discussion</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Note: Organisational behaviours are shown in blue and bold, Communication behaviours in green with regular type face, and Relational behaviour in red and italicised.

As can be seen in the table above, behaviours in the Organisational aspect tended to be more strongly correlated with other behaviours, and in particular with other behaviours within the aspect. This flagged these behaviours as ones to be strongly considered for modification.

Within the Organisational aspect two behaviours were removed: produce high quality work, and encourage progress to meet goals and deadlines. The produce high quality work behaviour was removed as it was highly correlated with at least three other behaviours (rows 3, 4, and 5 of Table 3-16) and was difficult to interpret. During the focus groups in Phase 1 students could not agree on what constituted high quality work as they all had different definitions of quality. As a result, this behaviour was removed. The encourage progress to meet goals and deadlines behaviour was removed as it was highly correlated with help to plan and organize workflow, and it was discussed in the focus groups as less important. Without a plan and workflow, there would be few goals and deadlines to push towards, therefore given the need to reduce the number of items, encourage progress to meet goals and deadlines was removed in favour of keeping help to plan and organize workflow.
Within the Relational aspect, three behaviours were removed: *build the trust of team members, motivate others on the team to do their best, and help the team build consensus*. The *build the trust of team members* item was removed as it appeared to be related to task-focused follow through from the factor analysis, and as a result appeared to be interpreted in the way that the *demonstrate accountability* behaviour was phrased. With a desire to focus on following through on commitments (which is only one aspect of trust), it was decided to keep *demonstrate accountability* in favour of *build the trust of team members*. The *motivate others on the team to do their best* behaviour was removed as it was highly correlated with *openly expressing ideas and opinions* and *helping to build consensus*. This particular combination indicated that students may have been interpreting the motivation aspect of the behaviour towards determining the best decision when engaging in decision making, rather than trying to develop each team member to be their best self in the role they play on the team. As a result, this behaviour was removed as many of the constructs underlying it are encompassed in the *team-focused* aspects of all the behaviours and did not need to be doubly articulated. The *help the team build consensus* behaviour was removed as it was indicated by students in focus groups as privileging one particular type of decision making. Therefore, if a team’s policy was to make decisions using another mechanism that worked well for them, they would all perform poorly on this behaviour. Given the type of decision making required in design teams, where the team must pick an idea to move forward with from several ideas, to indicate to students that only one of the methods they are being instructed on is valued would contradict the lessons of the course. As a result, that behaviour was removed.

Within the Relational aspect as well, two behaviours were created out of a combination of others. The behaviours *adopt suggestions from other members* and *solicit input before proceeding* were combined into *seek and include input from others*. During the focus groups in Phase 1 students expressed concern that the *solicit input before proceeding* behaviour described a team member who was not capable of making any decisions on their own or completing their own work and wholly relied on the team to make decisions for them. This was not the intention of the behaviour and as a result the *before proceeding* section needed to be removed. These students also commented on how ‘annoying’ it was to be asked for their thoughts and then see a team member disregard them. In an effort to demonstrate that as a team, they should be trying to create a design that is representative of the whole group, both seeking and including input are
necessary. The behaviour *listen and pay attention to others* was created out of a combination of the behaviour *actively listen to team members* and concerns that surfaced in students’ free-form feedback from Phase 1 that many team members are constantly playing games or on their mobile devices and not paying attention to whomever is speaking. As paying attention and listening are co-dependent and can be behaviourally identified using similar markers of eye contact or nods/words of acknowledgement they integrated well.

3.4.4.1. Changing the rating scale

Two types of changes were made to the rating scale of the inventory: a reduction in the number of data points and a rewriting of one set of descriptors.

In student feedback on the inventory from both Phase 1 and 2, the 7-point rating scale for each behaviour was discussed as having either too many or too few points resulting in a clustering of the data around the high end of the scale. As it could not be determined whether the clustering was due to students not needing to use the lower end of the scale, or whether students were hesitant to use this end of the scale, it was difficult to recommend a modification to the scale that would encourage students to use the full range more often. Based on the advice of Dr. Seifert (a previous committee member), it was decided to move from a 7-point rating scale with 4 descriptors and 3 intermediate points as shown in Table 3-3, to a 4-point rating scale where every point has a clear behavioural descriptor (Table 3-17). This decision was made as it would allow the researcher to more clearly understand the meaning of the assessments, and it would force raters to pick which behaviour most represented a student, rather than selecting an intermediary from which the researcher would have no means of interpreting the student’s exact behaviour.

The *demonstrate accountability* behaviour scale was rewritten to incorporate a more explicit element around following through on commitment. Given that the *demonstrate accountability* behaviour was factored in Phase 2 with the task completion items, the rephrasing was intended to focus more on the relationship aspect of accountability – following through on promises and admitting when you did not complete work. Table 3-17 demonstrates this change in wording. The resultant 12-item inventory tested in Phase 3 is presented in Table 3-18.
Building on student feedback from the end-of-term surveys during both Phase 1 and 2 as well as the finding from Phase 1 that textual feedback enhanced a student’s motivation to improve their performance, an option for textual holistic feedback was incorporated into the revised 12-item inventory. This provided students an opportunity to comment on why they assessed a student in a particular way and give additional information that might motivate a student to improve their performance in a desired manner.

Table 3-17: Example of the behaviourally-anchored rating scale for the 12-item inventory for the modified demonstrate accountability behaviour.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Unengaged (1)</th>
<th>Self-focused (2)</th>
<th>Project-focused (3)</th>
<th>Team-focused (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demonstrate Accountability</td>
<td>Did not follow through on commitments and did not admit when they had not completed work</td>
<td>Followed through on some commitments when reminded and admitted when something was not completed if there was little repercussion to the admission</td>
<td>Followed through on commitments and admitted when something was not done</td>
<td>Followed through on commitments and if something was not done, presented an alternate plan for success</td>
</tr>
</tbody>
</table>

Table 3-18: The 12-item Team-effectiveness Inventory divided equally into the three aspects of team-effectiveness.

<table>
<thead>
<tr>
<th>Organisational Aspect</th>
<th>Relational Aspect</th>
<th>Communication Aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1 - Attend team meetings prepared</td>
<td>R1 - Demonstrate accountability</td>
<td>C1 - Exchange information in a timely manner</td>
</tr>
<tr>
<td>O2 - Do their fair share of the work</td>
<td>R2 - Seek and include input from team members</td>
<td>C2 - Openly express ideas and opinions</td>
</tr>
<tr>
<td>O3 - Deliver their work on time</td>
<td>R3 - Show respect for team members</td>
<td>C3 - Promote productive discussion</td>
</tr>
<tr>
<td>O4 - Help to plan and organize workflow</td>
<td>R4 - Listen and pay attention to team members</td>
<td>C4 - Raise contentious issues in a constructive way</td>
</tr>
</tbody>
</table>
3.5. 12-item Inventory Analysis – Phase 3

The focus in the third phase of this study was to integrate the inventory into the Team-effectiveness Learning System and determine if utilizing the inventory within the full system affected the way in which students provided assessments. Unlike the previous two phases where the objective was to use the information to refine and reduce the number of items in the inventory, Phase 3 focused on determining whether students were able to provide reliable assessments that would provide an opportunity for relevant student learning and improvement. As in Phase 1, external raters were used to analyse the reliability of the students’ assessments using the inventory. As teaching assistants proved to be overstretched in their responsibilities already and did not feel confident in their assessments (Sheridan, Evans, & Reeve, 2015), I partnered with a communications instructor with a PhD in Education to act as external raters for a subset of the teams.

Students used the 12-item inventory and provided feedback on their use of it in the same manner as during Phase 2 of the study – students assessed their team-members relatively across each item, and the order of the items were alternated sequentially through the three aspects. The full 12-item inventory with its rating scale is presented in Appendix A, with examples of feedback a student would receive included in Appendix K.

The analyses discussed herein will only look at the individual assessments provided by students as self or peer assessments using the inventory. Analysis of the inventory-based and holistic feedback students received from these assessments is presented in Chapter 4, and its impact on their motivation and effort to improve their performance in Chapter 5.

3.5.1. Assessment Trends

Two trends were of note in the use of the 12-item inventory – the quantity and type of assessments. In terms of quantity, more students completed the inventory in its first use. Of the 955 students in the study, only 724 completed the inventory during both uses, with 181 completing the inventory only at mid-project, and 50 completing it only at the end of the project. This trend was the opposite of the assessment pattern in Phase 2, where more students completed the inventory at the end of the project.
In terms of type, assessments were categorised for each rater according to how they provided their feedback in the same way as Phase 1 and 2 of the study. Almost all students (80-83%) provided ratee-oriented assessments with very few (3-4%) providing item-oriented assessments (Table 3-19). The number of unconsidered assessments increased between the two uses of the inventory as in Phase 2 (from 13 to 17%). However, as at least 80% of the class provided ratee-oriented assessments, the probability of a student receiving only unconsidered assessments from their team members is low. Thus, the inventory can be seen to promote individualized feedback.

Table 3-19: Types of assessments provided by students using the 12-item inventory to provide feedback.

<table>
<thead>
<tr>
<th></th>
<th>Use 1 – mid project a</th>
<th>Use 2 – end of project b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unconsidered</td>
<td>13%</td>
<td>17%</td>
</tr>
<tr>
<td>Item-oriented</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Ratee-oriented</td>
<td>83%</td>
<td>80%</td>
</tr>
</tbody>
</table>

\(^{a}n = 905, ^{b}n = 774\)

Each of the 12 behaviours were analysed to identify the distribution of assessments provided by students. All behaviours were left-skewed along the rating scale; the majority of assessments occurred in the self-focused [2-3] to team-focused [4] range with few assessments occurring in the unengaged range [1]. The mean and median of all behaviours was between 3 and 4. Each behaviour received assessments across the full range of values.

To determine if the change from a 7 to 4 item scale affected the distribution of assessments, or encouraged students to use more of the scale, the distribution of assessments was compared at the midpoint of the project for both studies (first use of the inventory). As the descriptors on the 7-point scale at (1,3,5,7) corresponded to the descriptors on the 4-point scale (1,2,3,4) respectively, the two distributions could not simply be overlaid as it would have shifted the alignment between the two scales.

To keep these scales consistent, the scale from the 18-item inventory was modified from a 7-point scale into a 4-point scale. This was completed by taking the number of ratings at each intermediary point (2,4,6) and dividing them equally between the two points on either side that had a description. While there is no way of verifying in exactly which direction these students would have leaned, splitting the midpoints 50/50 across the behaviourally anchored ratings on either side attempts to mitigate any bias introduced in converting the scales.
As can be seen in Figure 3-5, the distribution of assessments is very similar across the two studies. This implies that changing the rating scale did not significantly affect students’ assessment patterns, and that there may be some consistency in team-member effectiveness across the two years (classes) of students in the two studies.

Figure 3-5. Comparison of percent distributions of assessments across the behaviourally anchored rating options.

3.5.2. Reliability

The reliability of the inventory-developed assessments was analysed using three modes: internal consistency, correlation between self and peer assessments, and correlation between student and knowledgeable observer assessments.

3.5.2.1. Internal Consistency

For internal consistency four analyses were conducted as in Phases 1 and 2. The Cronbach’s alphas were calculated for the entire 12-item inventory, and for each of the aspects separately. Raters assessments for each separate ratee were used totalling 6104 individual assessments, meaning that all self and peer assessments were considered in this analysis. The overall inventory, as well as its three underlying constructs, all had a good level of internal consistency ( > 0.7), as determined by Cronbach’s alpha (Table 3-20) (DeVellis, 2003). Thus, the aspects and the inventory as a whole are assessing a consistent construct – team-member effectiveness.
3.5.2.2. Inter-Rater Reliability

To assess the reliability of students’ assessments, three analyses were completed: i) correlation between students’ self and peer assessments, ii) agreement between a student’s peer assessments, and iii) correlation between peer-assessment agreement and peer-assessment rating. All students for which there were at least two peer assessors for a given use of the inventory were included (799 for mid-project use, and 610 for the end-of-project use).

Table 3-20: Internal Consistency of the overall inventory as well as the three aspects of the inventory calculated using Cronbach’s alpha in the 12-item inventory.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Cronbach’s α</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>0.91</td>
</tr>
<tr>
<td>Organisational</td>
<td>0.80</td>
</tr>
<tr>
<td>Relational</td>
<td>0.75</td>
</tr>
<tr>
<td>Communication</td>
<td>0.77</td>
</tr>
<tr>
<td>n = 6104</td>
<td></td>
</tr>
</tbody>
</table>

Using a Spearman’s rank correlation (Table 3-21), it can be seen that there is a significant correlation between the students’ self and peer assessments in all aspects of the inventory. The only aspect along which there is an increase in correlation is the Communication aspect which increases by 0.09 from first to second use of the inventory. This trend is different from the trend seen in both Phase 1 and 2, in which an increase in correlation and significance occurred between the uses of the inventory. It is important to note that the magnitude of the correlation in the first use of the inventory is similar to that of the second use of the inventory in Phase 2.

However, while the correlation increased only for the Communication aspect, the $R^2$ value did increase between the two uses of the inventory for both the Organisational and Communication aspects. These $R^2$ values demonstrate that while the amount of variance in the self assessments that can be explained by the peer assessments does increase between uses, it is very limited and thus the significance in correlation may simply be attributed to the size of the dataset.

It is important to note that the Relational aspect of the inventory had again the lowest correlation and $R^2$ values as was consistent across Phase 1 and 2 of the study and was also
consistent across TA ratings in Phase 1. This may indicate that students struggle more to self assess reliably along the Relational aspect as compared to the other two aspects.

In terms of the agreement between a student’s peer assessments, a consensus approach was taken to determine the level of agreement for any case in which there were at least 2 peer assessors. A consensus approach was taken due to the small number of points on the scale (4). Because of this, the variance within assessments was not sufficient to use a consistency approach for cases in which there were few peer assessors (n <=3) as the covariance of the assessors was often calculated as negative. Agreement was determined from both a student perspective (percent agreement between peers across all item) and from an item perspective (number of students who had peers that agreed on a level of performance for that item).

Table 3-21: Spearman’s rank correlation and $R^2$ values between students’ self and peer assessments for each aspect of the 12-item inventory

<table>
<thead>
<tr>
<th></th>
<th>Use 1 – mid project a</th>
<th>Use 2 – end of project b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spearman’s ρ</td>
<td>$R^2$</td>
</tr>
<tr>
<td>Organisational</td>
<td>0.26**</td>
<td>0.06</td>
</tr>
<tr>
<td>Relational</td>
<td>0.12**</td>
<td>0.02</td>
</tr>
<tr>
<td>Communication</td>
<td>0.14**</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note: Students’ self assessments (n = number of behaviours) and peer assessments (n = number of behaviours x number of peers) were averaged separately to determine each student’s self-assessed and peer-assessed level of behaviour for the aspect. These averages for each aspect were then correlated over all the students. a n=799, b n=610. ** - p ≤ .01

Agreement from a student perspective was measured as the percent of all items (12) in which there was consensus across peer assessments. The distribution of agreement was similar between both uses of the inventory, with the majority of students receiving assessments which had slight to moderate peer agreement (Table 3-22). Approximately 25% of the class had peer consensus on half (6) to all (12) items in the inventory, indicating a strong agreement in the performance of the student being assessed.

Agreement from an item perspective looked at the number of students for which all peer assessors achieved consensus on a given item. Each item had at least 22% of all assessments given by peers in consensus, with an average of 28% of all assessments per behaviour in consensus. The Communication behaviours had the lowest number of peer assessments in consensus (25% average), with Relational behaviours having the highest (30% average). The two lowest number of peer assessments in consensus were in exchange information in a timely
manner (22%) and promote productive discussion (25%). The two highest number of peer assessments in consensus were show respect for team members (34%) and does their fair share of the work (33%). It is interesting to note that it is the Relational behaviours along which peers have the greatest consensus, but the area along which there is the least correlation between self and peer assessments. This may indicate that students are able to reliably peer assess Relational behaviours but are not able to reliably self assess them.

Table 3-22: Distribution of agreement between peer assessments of a student as measured using percent absolute agreement in ratings across all peer assessors.

<table>
<thead>
<tr>
<th>Level of Agreement</th>
<th>Number of Students</th>
<th>Percent Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Use 1 a</td>
<td>Use 2 b</td>
</tr>
<tr>
<td>No agreement</td>
<td>101 (12%)</td>
<td>99 (14%)</td>
</tr>
<tr>
<td>Slight agreement</td>
<td>195 (24%)</td>
<td>169 (25%)</td>
</tr>
<tr>
<td>Fair agreement</td>
<td>205 (25%)</td>
<td>148 (22%)</td>
</tr>
<tr>
<td>Moderate agreement</td>
<td>195 (24%)</td>
<td>172 (25%)</td>
</tr>
<tr>
<td>Substantial agreement</td>
<td>84 (10%)</td>
<td>65 (9%)</td>
</tr>
<tr>
<td>Perfect agreement</td>
<td>47 (6%)</td>
<td>35 (5%)</td>
</tr>
</tbody>
</table>

To determine if students were better able to peer assess high or low performing students, a Spearman’s rank correlation was performed between students’ average peer-assessment rating and the percent agreement between peer assessors. The correlation between students’ average peer-assessment rating and percent agreement was significant, meaning that students were able to more consistently peer assess high performing students (Table 3-23).

Table 3-23: Spearman’s Rank Correlation between students’ average peer assessment rating and the percent agreement between peer assessors over both uses of the inventory.

<table>
<thead>
<tr>
<th>Spearman’s Rank Correlation a</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.532**</td>
</tr>
</tbody>
</table>

Therefore, in terms of inter-rater reliability between self and peer assessments:

- the 12-item inventory prompts assessments of similar reliability in each use of the inventory
• students’ self assessments along the Relational aspect are less reliable than those along the Organisational and Communication aspects
• students are able to more reliably peer assess high-performing students
• peer assessments provide some new information to students that they cannot readily self assess.

3.5.2.3. External Rater Reliability

As in Phase 1, external raters were used to analyse the reliability of the students’ assessments. As teaching assistants proved to be overstretched in their responsibilities with students already and did not feel confident in their assessments (Sheridan, Evans, & Reeve, 2015), I partnered with Dr. Penny Kinnear (a communications instructor in both courses specialising in activity theory research) to act as external raters for a subset of the teams. As discussed in the study design and research methods sections, we video-recorded three team-meetings and met with each student individually at the end of the term for a stimulated recall interview. We independently watched the recordings and rated the individual students using the inventory. We also assessed the effectiveness of the teams to compare to their and the students’ self and peer assessments to determine if high-performance across all team members on the inventory indeed correlated to high team-effectiveness.

An assessment of the effectiveness of the teams was performed using Radford and Roth’s togethering framework (Radford & Roth, 2011) to determine the relative effectiveness of the teams. Togethering is a concept based in activity theory that is defined as “an analytical category that accounts for the ethical manner in which individuals engage, respond, and tune to each other, despite their cognitive, emotional, and other differences.” The three types of interactions defined therein (engaging, responding, and tuning) provide a framework with which to describe how involved team members are with each other and their shared work. A description of a typical interaction within the teams was noted and the teams were categorised as either:

• effective - team members are attuned to each other,
• functional - team members are responding to each others’ contributions and are interacting with each other, or
• ineffective - team members are each engaged with their own conception of the work without interacting with each other to create a shared understanding.
This categorisation was determined and presented in a previous publication and is included in Appendix Q (Kinnear, Sheridan, Evans, & Reeve, 2016). These five teams and their students’ (n = 22) assessments from their second use of the inventory were analysed to determine the reliability of students’ assessments as compared to those of us, the knowledgeable observers.

Reliability was analysed in three ways. First, our assessments were compared to assess their inter-rater reliability. Second, our assessments were compared to the self and peer assessments of the students. Third, our team-level categorisation of the effectiveness of the teams (Kinnear, Sheridan, Evans, & Reeve, 2016) was correlated to our and the students’ assessments.

In terms of our inter-rater reliability, this was analysed both across the aspects of the inventory and across the students in the study. It can be seen that there is a significant correlation between our assessments in all three aspects of the inventory, with the correlation along the Organisational aspect being the lowest (Table 3-24). The strength of correlation along the aspects is inverted from the trend seen in student assessments, where the Organisational correlation is the strongest and the Relational the weakest and at times not significant.

Table 3-24: Spearman’s Rank Correlation between the external raters’ assessments for the observed students along the aspects of the 12-item inventory

<table>
<thead>
<tr>
<th>Spearman’s Rank Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational</td>
</tr>
<tr>
<td>Relational</td>
</tr>
<tr>
<td>Communication</td>
</tr>
</tbody>
</table>

n = 22, ** - p ≤ .01

Inter-rater reliability was also looked at on a per-student basis to determine if our ratings were more reliable for certain students than others. A consensus approach was taken to determine the level of agreement between our ratings (Table 3-25). The distribution of agreement was much higher than that of the students with there being at least substantial agreement for more than 75% of the students assessed. In discussion to assess the causes behind these assessment trends, we observed that students that were either high or low performing were assessed with greater agreement, and students who were ‘in the middle’ had less agreement in their assessments. This trend was the same as expressed by the teaching assistants in Phase 1, and different from how students’ peer assessments trended in Phase 3, where the assessments were more reliable with higher performing students.
To further explore the inverted trend in correlation strength (Table 3-24), our assessments were correlated with students’ self and peer assessments along the three aspects of the inventory (Table 3-26). The strength in correlation between students’ and our assessments followed the same trend as between teaching assistants and students in Phase 1 (Table 3-8); students’ self assessments were only significantly correlated with the external raters’ along the Organisational aspect, but were correlated with students’ peer assessments along all aspects of the inventory. Additionally, the $R^2$ values demonstrate that while the amount of variance in the self assessments that can be explained by the external raters’ assessments is limited, the amount of variance explained in the peer assessments is substantially larger. This means that the external-raters’ assessments were much more closely aligned with students’ peer assessments than their self assessments.

Table 3-25: Distribution of assessment agreement between the external raters by student.

<table>
<thead>
<tr>
<th>Level of Agreement</th>
<th>Number of Students $^a$</th>
<th>Percent Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>No agreement</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Slight agreement</td>
<td>0</td>
<td>1 – 20</td>
</tr>
<tr>
<td>Fair agreement</td>
<td>1</td>
<td>21 – 40</td>
</tr>
<tr>
<td>Moderate agreement</td>
<td>4</td>
<td>41 – 60</td>
</tr>
<tr>
<td>Substantial agreement</td>
<td>7</td>
<td>61 - 80</td>
</tr>
<tr>
<td>Perfect agreement</td>
<td>10</td>
<td>81 - 100</td>
</tr>
</tbody>
</table>

$^a n = 22$

Table 3-26: Spearman’s rank correlation and $R^2$ values between the external raters’ assessments and students’ self and peer assessments for each aspect of the 12-item inventory

<table>
<thead>
<tr>
<th></th>
<th>Self assessments $^a$</th>
<th>Peer assessments $^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spearman’s $\rho$</td>
<td>$R^2$</td>
</tr>
<tr>
<td>Organisational</td>
<td>0.49*</td>
<td>0.26</td>
</tr>
<tr>
<td>Relational</td>
<td>0.24</td>
<td>0.11</td>
</tr>
<tr>
<td>Communication</td>
<td>0.43</td>
<td>0.16</td>
</tr>
</tbody>
</table>

Note: Students’ self assessments (n = number of behaviours) and peer assessments (n = number of behaviours x number of peers) were averaged separately to determine each student’s self-assessed and peer-assessed level of behaviour for the aspect. These averages for each aspect were then correlated over all the students. $^a n=18$, $^b n=22$, * - $p \leq .05$, ** - $p \leq .01$

To determine the consistency between our and the students’ assessments, intra-class correlation coefficients (ICCs) were determined using a two-way random effects model for consistency (Table 3-27). Following a similar trend to the agreement between our (the external
raters’) assessments, 90% of our and student assessments had substantial consistency. Two students were the exceptions with one only having fair consistency, and the other having assessments that were so uniform that the ICC could not be calculated. The student for whom the consistency was only fair was a student who received assessments that spanned 3 points on the rating scale for five of the items in the inventory. Ratings for this student were equally as inconsistent across our assessments as they were across the students’ self and peer assessments.

Therefore, based on both the correlation and consistency analyses the students, when acting as peers, are as reliable as the external raters who are trained and experienced in observing and assessing teamwork. However, when providing self assessments, students are not as reliable as us, but are more reliable when assessing the Organisational aspect as compared to the Relational and Communication aspects.

Table 3-27: Distribution of assessment consistency between all assessments provided by the students and the external raters, by student.

<table>
<thead>
<tr>
<th>Level of Consistency</th>
<th>Number of Students</th>
<th>Percent Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>No consistency</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Slight consistency</td>
<td>0</td>
<td>1 - 20</td>
</tr>
<tr>
<td>Fair consistency</td>
<td>1</td>
<td>21 - 40</td>
</tr>
<tr>
<td>Moderate consistency</td>
<td>0</td>
<td>41 - 60</td>
</tr>
<tr>
<td>Substantial consistency</td>
<td>6</td>
<td>61 - 80</td>
</tr>
<tr>
<td>Perfect consistency</td>
<td>14</td>
<td>81 - 100</td>
</tr>
</tbody>
</table>

Note: n = 21, one student could not be calculated as there was not sufficient variation between their assessments to calculate the ICC.

3.5.2.4. Prediction of Team-level Performance

To determine the reliability of the assessments in terms of indicating high and low performing teams, we assessed and ranked the five teams studied according to their team-level effectiveness. A description of a typical interaction within the teams and resultant categorisation using Radford and Roth’s togethering framework from effective to ineffective was presented in a previous publication and is included in Appendix Q (Kinnear, Sheridan, Evans, & Reeve, 2016). Teams will be referred to below according the team number with which they are referred to in Appendix Q. A team-level assessment was calculated for each team by averaging the students’ or the external raters’ assessments across all team-members across all items of the inventory (Table...
There is perfect alignment between the researchers’ average assessments of the teams and their rank, and similar alignment between the students’ average assessments of their team and their rank.

Table 3-28: Comparison between ranking of teams based on their team-effectiveness and the average of their teams’ assessments provided by the external raters and students.

<table>
<thead>
<tr>
<th>Team-effectiveness Rank&lt;sup&gt;a&lt;/sup&gt;</th>
<th>External Raters’ Average Assessment of Team&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Students’ Average Assessment of Team&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Team 4</td>
<td>4.00</td>
<td>3.74</td>
</tr>
<tr>
<td>1. Team 2</td>
<td>3.76</td>
<td>3.81</td>
</tr>
<tr>
<td>3. Team 5</td>
<td>3.63</td>
<td>3.13</td>
</tr>
<tr>
<td>4. Team 3</td>
<td>2.81</td>
<td>3.37</td>
</tr>
<tr>
<td>5. Team 1</td>
<td>2.39</td>
<td>2.88</td>
</tr>
</tbody>
</table>

<sup>a</sup> Team number corresponds to the number of the team in the analyses presented in Appendix Q from (Kinnear, Sheridan, Evans, & Reeve, 2016), <sup>b</sup> average of (12 assessments x (number of team members) x (2 researchers)), <sup>c</sup> average of (12 assessments x (number of team members) x (number of team members))

Teams 4 and 2 were the most effective across all their interactions, demonstrating high effectiveness but in different ways. Team 2 was a high-efficiency single-leader team, in which much of the team time was dedicated to planning and defining the requirements of the project. All students on the team followed the directives of their leader, and openly challenged her when they disagreed. Team decisions were made through consensus and all deliverables were iterated on until the team felt the work captured their shared intentions. Team 4 was an exploratory team in which there was no clear leader nor a designated one. The team operated towards deadlines in a manner that allowed the team to explore tangential ideas and conversations and allowed them to develop a greater understanding of each other and their work. Two common trends showed up in Teams 4 and 2 that made it difficult for the researchers to argue that there was a difference in their effectiveness: 1) the two teams had strong trust and respect for each other, there was an assumption that everyone would follow through on their work and that it only needed to be checked for consistency with others, not for quality; and 2) the members within each of the two teams were always on the same page with each other, having similar understandings of work and their designs that they confirmed with each other. While the ratings of the researchers and the students are inverted for these two teams, the difference in the ratings is not significant; having
the two most effective teams have the two highest student and external-rater average assessments is significant.

Team 5’s ratings for themselves are lower than those of the researchers as was expected based on the culture of the team. Team 5 was a team that focused heavily on personal growth as their desired outcome for the project. As a result, they spent a lot of time critiquing each other, each other’s work, and providing feedback on ways to improve. Team 5 put much effort into getting on the same page as each other which was visible in their team meetings in particular through their critiquing process. While they succeeded, the amount of time and effort put into this detracted from the time they could spend leveraging it to create a great team dynamic and work product. However, their success at creating a team where the team-members were in tune with each other’s ideas and decisions demonstrated an effective team to us, resulting in their categorisation as ‘tuned’ and their rank.

Team 3 was a team that tried to work well together but was not effective due to a number of challenges. First, they were a team that during their stimulated recall interviews expressed explicitly that they did not focus on team-building and worked to prevent their team leader from establishing team building activities. Second, their team-leader was heavily positivist and struggled when there were multiple possible solutions, to the point of contradicting his team-members, shutting them down when talking, and over-correcting their language to conform to his model of the world when either could have been used effectively. Third, they had a team member who had a strong religious affiliation and needed accommodation for religious observances that the team was not willing to accommodate. Based on the three other team-members’ personal schedules they continually insisted on meeting when their fourth team-member was not available excluding him from decision making. As a result, while they managed to create a great design that provided them the grade they wanted, they were not able to create an effective team. Thus, we believe the discrepancy between our and the students’ ratings can most likely be attributed to an inflation in their assessments based on creating a successful product.

Team 1 was completely ineffective, as seen in their and our assessments. Team 1 did not have mutual respect and did not demonstrate accountability. During meetings they frequently raised their voices in annoyance, completely ignored each other, or even once, during brainstorming, the scribe was found to be solving calculus problems on their shared whiteboard.
During their stimulated recall interviews three of five team-members expressed that they knew they were ineffective and described measures they took to try to make the team more effective. Each described giving up on trying to create an effective team between mid- and end-of-project assessments and feeling like their team-members did not value them in the team.

When we reflected on the process of providing these ratings using the inventory three themes emerged. First, it was a challenge to assess some of the Organisational behaviours as they were less visible in the video-recorded team meetings. The information that created these assessments we agreed primarily came from the stimulated recall interviews and how students discussed the process of working with each other. Only for students who did not complete their work (low ratings of 1 or 2) was the behaviour evident in the team meetings because the teams discussed it. Second, we both provided assessments with no variation to one of the teams studied (Team 4). As per the analyses for all three phases of the study, students’ assessments like this would have been categorised as “unconsidered” and therefore removed from the reliability and validity analyses. Therefore, it is important to note that even the knowledgeable observers found a condition in which “unconsidered” assessments were in fact considered. Third, Dr. Kinnear found it challenging to not be able to provide assessments between the rating levels of the scale. At times when she was undecided, she hesitated to pick in either direction as neither was ‘quite right.’ As a result, using the inventory to provide feedback presented to her similar challenges to those expressed by the students.

From this analysis it can be seen that the inventory is successful in differentiating effective and ineffective teams. There is a strong correlation between average team-member scores and team-effectiveness. The inventory prompts students to provide assessments of team-member effectiveness that are equally as reliable as knowledgeable observers.

3.5.3. Construct Validity

The inventory was analysed to determine the construct validity of the aspects. An exploratory factor analysis (principal components analysis) with normalized varimax rotation was run to surface the underlying constructs students were using to assess the behaviours. A principal component analysis approach was appropriate as the data was ordinal, the correlation between all variables was > 0.4, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.95 and
Bartlett’s Test of Sphericity was significant. In the both uses of the inventory, the order of the items was randomised.

Using three factors to describe the assessments resulted in eigenvalues for each factor being greater than 0.73, with the factors explaining 63% of the variance. An eigenvalue of that magnitude at three factors indicates that there are likely fewer than three underlying constructs based on students’ assessments using the inventory; the scree plot additionally indicated that one factor best represented the assessments. As a result, when looking at the factor loading on the three factors, it is important to note behaviours which overlap across factors. Any item which had a factor loading greater than 0.4 was represented on that factor, with some items being represented on multiple factors (Garbin, 2017). This provided a representation of the behaviour relationships in a way that accounted for the high internal-consistency of the entire inventory which suggests that the three aspects are components of one fundamental construct – team-member effectiveness. Factor loadings that were above this cut-off are represented in Table 3-29, with the loadings corresponding to this representation presented in Table 3-30.

Table 3-29: Representation of the exploratory factor analysis of the 12-item inventory, emphasised by aspect with items listed under the to which factors they most strongly correspond.

<table>
<thead>
<tr>
<th>Factor 1 (Organisational)</th>
<th>Factor 2 (Communication)</th>
<th>Factor 3 (Relational)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attend team meetings prepared</td>
<td>Openly express ideas and opinions</td>
<td></td>
</tr>
<tr>
<td>Do their fair share of the work</td>
<td>Promote productive discussion</td>
<td>Show respect for team members</td>
</tr>
<tr>
<td>Deliver their work on time</td>
<td></td>
<td>Listen and pay attention to team members</td>
</tr>
<tr>
<td>Demonstrate accountability</td>
<td></td>
<td>Raise contentious issues in a constructive way</td>
</tr>
<tr>
<td>Help to plan and organize workflow</td>
<td></td>
<td>Seek and include input from team members</td>
</tr>
<tr>
<td>Exchange information in a timely manner</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The items are emphasised according to their aspect in the 12-item inventory. Organisational items are blue and bolded, Relational items are green in regular type face, and Communication items are red and italicised. n = 6104
Table 3-30: Factor loadings for each of the behaviours in the 12-item inventory that were above the cut-off of 0.4

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attend team meetings prepared</td>
<td>0.64</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do their fair share of the work</td>
<td>0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliver their work on time</td>
<td>0.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Help to plan and organize workflow</td>
<td>0.44</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Demonstrate accountability</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seek and include input from team members</td>
<td></td>
<td>0.54</td>
<td>0.41</td>
</tr>
<tr>
<td>Show respect for team members</td>
<td></td>
<td></td>
<td>0.88</td>
</tr>
<tr>
<td>Listen and pay attention to team members</td>
<td></td>
<td>0.45</td>
<td>0.52</td>
</tr>
<tr>
<td>Exchange information in a timely manner</td>
<td>0.58</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Openly express ideas and opinions</td>
<td></td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>Promote productive discussion</td>
<td></td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Raise contentious issues in a constructive way</td>
<td>0.44</td>
<td>0.48</td>
<td></td>
</tr>
</tbody>
</table>

As can be seen in the representation of behaviours in Table 3-29, the data does factor in a manner that represents distinctions in the aspects of the conceptual framework. All organizational behaviours load on to Factor 1, all Communication behaviours load on to Factor 2, and almost all Relational behaviours load on to Factor 3. While this separation is not a clean division across factors, it is a substantial improvement over the factor separation of the 27- and 18-item inventories. Additionally, because teamwork and team-member effectiveness behaviours can not be perfectly categorized as one aspect or another (i.e. *helping to plan and organize the workflow* requires both Organizational planning abilities and Communication between team members to decide on a workflow) it is not of concern that the factor separation is not perfect. The only behaviour that is not partially loaded onto the factor representing its aspect is *demonstrate accountability*. This behaviour is still strongly loaded onto the Organisational factor and demonstrates that students may be thinking of it differently than I intended.

To confirm that the behaviours within each aspect have sufficient commonality to hold together when analysed individually, similar factor analyses were completed for each aspect of the inventory separately (Table 3-31). No aspect separated into more than one factor, and each aspect had a large eigenvalue corresponding to a similar amount of variance as explained with the three-factor separation of the entire inventory. As a result, the constructs of Organisational, Relational, and Communication, are an acceptable way of categorizing the behaviours in the inventory to define different (but not distinct) aspects of team-member effectiveness. The
revisions to the inventory from Phase 2 categorise behaviours that better represent the conceptual framework of team-member effectiveness.

Table 3-31: Factor analysis eigenvalue and variance explained for the aspects of the 12-item inventory when analysed separately.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Eigenvalue</th>
<th>Percent Variance Explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organisational</td>
<td>2.5</td>
<td>63%</td>
</tr>
<tr>
<td>Relational</td>
<td>2.3</td>
<td>57%</td>
</tr>
<tr>
<td>Communication</td>
<td>2.4</td>
<td>60%</td>
</tr>
</tbody>
</table>

3.5.4. Usability and Face Validity

Usability was determined from students’ responses to the end-of-term survey questions about the inventory (see end-of-term survey in Appendix L). Of the 955 students in Phase 3 of the study, 467 completed the free-form questions related to face validity:

1. Did you understand all of the questions in the peer-evaluation survey? Were there aspects of providing feedback you found difficult? If so, please describe.

2. What information would you have liked to see in feedback to you that wasn’t there? What was provided that was unnecessary?

Four-hundred and five (405) students answered the first question about understanding the questions in the inventory. Three-hundred and thirty-two (332) students’ answers indicated that they could use the inventory and understood all the questions, 36 students understood some of the inventory, and 37 students indicated that they had trouble using the inventory (Figure 3-6). Responses to whether students felt the questions were appropriate for assessing teamwork were coded. Responses were coded according to the area the inventory they related to: terminology (2 students), rating scale (26 students), items (47 students), complexity (2 students). As can be seen by these low response numbers as compared to the total number of students who completed the survey (467), few students commented on the actual content of the inventory in the questions.

In terms of terminology two students commented on the language. One student commented that they needed to use an online dictionary to complete the inventory, and another student
struggled with understanding what a “contentious issue” was. This indicates that the language may not be readily accessible to non-native speakers of English.

Figure 3-6: Aggregation and coding of student textual descriptions of understanding into 3 levels of understanding (n=405).

In terms of the rating scale, there were two themes of comments: 1) that there were not enough rating points to provide accurate or differentiated assessments between team members, and 2) that the difference between the points on the rating scale was very large and pushed students to provide ratings with which they were not comfortable. This is well described by two students in their survey comments:

“I understood all of the questions on the survey, but did not always like the answers that I had to select. There seemed to be massive jumps between each number, particularly between 1 - 2 and 2 - 3. I feel that I may have erred towards responses that were too high just because I felt that options 1 and 2 were too harsh.”

“The questions didn't apply in every case. For example, some team members just simply didn't contribute much but didn't actively only think of themselves. Some people were quiet and I felt the options only had room for either "team player" or "non-team player" but there are some people that just contribute less but do so in such a way that still includes the team.”

In particular, looking at the second comment, while the rating scale explicitly focuses on engagement, the student wanted to rate according to frequency. The descriptions on the
behaviourally anchored rating scale were explicitly intended to eliminate this conflation but did not fully succeed in doing so.

In terms of the items in the inventory, three items that were in the inventory were questioned, and a number of additional items were suggested. The Relational behaviour *raise contentious issues in a constructive way* was the most frequently discussed item (7 students), followed by *demonstrating accountability* (2 students), and *promoting productive discussion* (1 student). Students articulated that the *raising contentious issues constructively* question was not relevant to their teams as they felt they did not discuss any contentious issues nor have any conflict. As a result, they did not know how to assess their team members along this behaviour. This was described by two students in their survey comments:

“The contentious issues question I didn't understand so I marked everyone as one as we did not have issues that "caused argument or controversial””

“Yes, some were difficult for me because my group, over this semester, had very little conflict. So some questions of any negative events throughout the term weren't really relevant.”

With respect to the other two items, the three students articulated not understanding what they meant but were no more specific.

In terms of items that the students felt were missing, there was a strong theme around wanting the quality of their work or contributions to be assessed. This corresponds to the *produce high quality work* item that was removed in the previous iteration of the inventory. While students may have wanted to know about their work quality because they believe their work corresponds to their value to their team members, the focus of the inventory does not include this as it pushes students to look beyond the task and work completion component of teamwork. It is worth noting that students desiring this item in the inventory reinforces that engineering students privilege the work-related aspect of teamwork.

Overall, since the majority (82%) of students who responded to the survey understood the inventory, and few indicated issues with the items or the scale, I can conclude that the inventory is usable and holds face validity with first-year engineering students.
3.6. Discussion

The goal of developing an inventory of team-member effectiveness behaviours for students was to provide them with a vocabulary for understanding how an effective team-member behaves. This chapter focused on developing a vocabulary that was applicable, accessible, and assessable by first-year engineering students so that they could develop that understanding from the vocabulary (inventory).

As can be seen in students’ self-assessment reliability, simply providing students with a vocabulary with which to understand what constitutes good team-member behaviour is not sufficient for them to know how they are performing. Students’ self-assessment reliability was poor as compared to their peers, teaching assistants, and the external raters along the Relational and Communication aspects. As these two aspects require students to remember their behaviour and its impact on others to be assessed accurately, it is not surprising that students struggled with these two aspects. Students were better able to self-assess along the Organisational aspect which looks at items that are measurable based on the deliverables they produced. Having this external entity to refer to when reflecting on their behaviour may be what led to these assessments being more reliable. However, this combined with students articulating that they felt a feedback item on the quality of their work was missing from the inventory may be indicative of a valuing of products produced over the relationships needed to develop them.

This focus on Organisational items may limit students’ development and understanding of what it means to be a good team-member. As was seen in the external raters’ assessment of team-level performance, the behaviours in the Relational aspect of the inventory are more visible predictors of team effectiveness. Seeking the input of others and listening and paying attention were the two behaviours that were demonstrated continuously by the high-performing teams and were ignored by the low-performing teams. Similarly, only on the two lowest ranked teams did a student receive a poor rating along the shows respect to team members item. Thus, student focus on the Organisational behaviours may be diverting their attention towards areas where self-improvement may not best predict team improvement or effectiveness.

Student assessments were high across the items in all three iterations of the inventory indicating that students may be reluctant to use the low end of the scale. The similarity of this trend between the 4-point and 7-point rating scale (Figure 3-5) indicates that changing the
number of assessment items does not change the trend in student assessment patterns. However, when students were provided with both the 7 and 4 point rating scales their feedback on the usability of the inventory indicated that they wanted more points along the rating scale. This desire for more granularity may be indicative of a desire for precision that they believe is inherent in a large rating scale. Given the comments of students in their feedback on the usability of the inventory that having fewer well-described options forced them to really consider which option to select may indicate an improved accuracy in student assessments. However, it may also indicate that students have the desire to provide individualised feedback that differentiates their peers, but only so long as they can do so on the upper half of a rating scale.

The results of the exploratory factor analyses (EFA) repeatedly indicated that there were fewer than three factors present in the inventory. However, I decided to keep the three aspects of the inventory as defined in the conceptual framework. I chose to maintain the three aspects of the conceptual framework as they encourage students to look beyond the work product and work management part of being an effective team member. A singular representation of each item on the aspect from which it is most greatly composed was maintained as it simplifies the framework and provides a more easily accessible vocabulary for students.

Items were rephrased or moved between aspects in an effort to get the inventory to better align with the conceptual framework. Based on the results of the EFAs and my understanding of teamwork behaviours, it was clear that a distinct factor separation would not be possible with the inventory. Despite their being three different underlying constructs from which the different items are composed, no item should fully be comprised by one aspect. Take for example the Communication aspect which can be assessed similarly to the Relational or Organisational aspect based on what is being discussed. The exchange information in a timely manner behaviour is cross-represented on the Organisational aspect as this behaviour demonstrates communication about work products and project management. Whereas raise contentious issues in a constructive way is cross-represented on the Relational aspect as this behaviour demonstrates communication about the relationships between team members. Because of this cross-representation a confirmatory factor analysis was not performed; the aspects cannot be separated to be independent as they do not fully assess different constructs but do represent different components necessary to achieve the overall construct of effective teamwork.
3.7. Conclusions

The objective of this work was to develop a framework (or inventory) of team-member effectiveness behaviours that was relevant to first-year engineering student teams, understandable, produced reliable assessments, and had construct validity. Reviewing the iterations of the inventory that led to the 12-item inventory it is evident that the revisions produced an inventory that has better construct validity, first-use reliability, and ease of understanding than the initial 27-item inventory.

Based on student assessment patterns, it can be seen that students are not able to self assess accurately along the Relational and Communication aspects and need feedback from others to be able to understand their performance. Feedback from peer assessments was seen to be as reliable as the ratings from teaching assistants or observers trained in teamwork observation. Improved self and peer assessment correlation with two uses of the inventory indicates that peer feedback to help students better understand their performance is effective. This will be explored in more detail in the next Chapter.

The value that using this inventory had on student learning and the development of a framework with which to describe team-member-effectiveness is best articulated in this comment from a student:

“I found the questions in the peer evaluation survey better served as a feedback or guide to the areas I should improve on as opposed to the feedback. I became conscious of all the actions I was taking and took time to think about whether I was being respectful enough and I payed keen attention to everything everyone was saying. Although I’m not sure if I improved in this regard compared to before, I did become more conscious of all these aspects during team meetings. I thought the questions before the final, ... were very important as they addressed all the questions no one would be comfortable explicitly pointing out to their peers if they thought they were being disrespectful for example or not contributing to their team positively.”
4. TELS-elicited Feedback on Team Member Behaviour

This chapter discusses the feedback students received from the Team-effectiveness Learning System (TELS) and their responses to that feedback. Whereas Chapter 3 looked at the types of assessments (ratings) students provided, this chapter looks at the feedback received by students. This chapter will first present the feedback composition, discuss the characteristics of that feedback, and then discuss how students reported the feedback they received motivated them to improve their competence.

TELS-generated feedback contains two components: numerical Team-effectiveness Inventory (TEI) ratings and freeform holistic feedback. Students received feedback that contained both components in a report that articulated their strengths and weaknesses, and demonstrated the difference between their self and peer (team-member) TEI-ratings. An example of the report structure can be found in Appendix K. A description of the design of the report structure and its components was outlined previously in Chapter 2.3.4.

4.1. Study Design and Research Methods

The population analysed in this chapter is that of students on teams that had full-team consent to participate in the study, and that provided feedback to me on their experiences using TELS. Since consent was provided individually, only for teams where every team member provided consent could I see all the information a student received in their feedback. As a result, only for students with full-team consent, could I accurately identify the strengths and weaknesses a student received feedback on. This was needed to be able to draw appropriate conclusions about why students responded to their feedback in a particular way and track student improvement. A summary of students by participation type can be found in Table 4-1. This limitation reduced the study population from a potential 955 students to 451 student participants. These 451 students comprised 95 full teams, with 59 teams from APS112 and 36 from ESC102 (course descriptions can be found in Section 1.5). Of the 451 students for which I could see all feedback received, 317 provided some comments to me in an end-of-term survey on TELS. As a result of being able to see and understand how these students perceived their feedback, the 317
students became the study population for this chapter. These students’ feedback reports were analysed for both the mid-term and end-of term feedback rounds.

Table 4-1: Number of students involved in the study by participation type and course.

<table>
<thead>
<tr>
<th>Participation Type</th>
<th>APS112</th>
<th>ESC102</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Consent</td>
<td>743</td>
<td>212</td>
<td>955</td>
</tr>
<tr>
<td>Full Team Consent</td>
<td>308</td>
<td>143</td>
<td>451</td>
</tr>
<tr>
<td>Full Team Consent and started the End-of-Term Survey</td>
<td>215</td>
<td>102</td>
<td>317</td>
</tr>
</tbody>
</table>

Analysis of student feedback took the form of a mixed-methods concurrent triangulation study. Student feedback reports from TELS which contained a combination of TEI-based feedback and holistic feedback were analysed for both the mid-term feedback and then end-of-term feedback. TEI-ratings and holistic feedback were independently analysed to determine the composition, quality, presence of differentiated strengths and weaknesses, and consistency of the feedback students received. Then, students’ TEI-ratings and holistic feedback items were compared to each other to understand how the holistic feedback complemented, confirmed, or contradicted the TEI-identified strengths and weaknesses.

TEI-based feedback was analysed through similar means as it was in Chapter 3. However, whereas in Chapter 3 the TEI-ratings were analysed to determine the capability of students to provide reliable assessments, in this Chapter these ratings are analysed to determine the quality of feedback they combined to create for a receiving student. In terms of quality, the completeness (number of team members who provided feedback as compared to total team membership) and individualisation (percent of feedback received that came from ratee-oriented assessments) was determined. In terms of affording opportunities for improvement, the algorithm-identified strengths and weaknesses were compared to determine the amount of difference in their ratings. In terms of consistency the level of agreement between peer assessors was calculated. TEI-ratings are discussed in this chapter according to the numeric representation of the description a student was given, please refer to the 12-item TEI in Appendix A.

Holistic feedback was coded to determine its length, content, type, and quality. Feedback was first coded by student for length using two units – characters and sentences (as demarcated by periods). Each student’s response was then divided up into ideas which were coded individually.
according to the remaining three coding criteria; ideas were sentences or components of sentences that presented a unified description of the recipient’s actions.

In terms of content, each idea was coded to identify which TEI behaviours were present in students’ feedback (12 codes). Coding definitions for the behaviours came from the multi-sentence descriptions of the behaviour and its importance outlined in the lessons on TELS. Ideas could be coded into multiple behaviours. Ideas which did not fit the 12 TEI behaviours, but did describe teamwork related actions were grouped separately and then read for other behavioural categories. Three other teamwork themes emerged (leadership, motivation, and demeanour) were coded separately (3 codes). Course-related content (project contributions, and technical strengths/weaknesses) was also coded to assess the distribution of teamwork content a student received (1 code).

In terms of type, each idea in a student’s holistic feedback was additionally coded into one of three categories: i) a strength (behaviour discussed positively and as though it contributed to making the team more effective); ii) a weakness (behaviour discussed negatively and as though it detracted from the team’s effectiveness); or iii) neither (statement of what a team member did, not how they did it).

In terms of quality, holistic feedback was also coded according to one of five categories, which were not mutually exclusive. The categories are listed below and are ordered in increasing quality.

1. Non-specific feedback: comments that contained single words, or random characters.
2. Generic statements: comments that either were a generic statement of accomplishment (e.g. “good job”, “great team member”),
3. Generic feedback: comments that discussed a behaviour so vaguely a team member would not be able to improve their behaviour from it (e.g. “poor communication,” “contribute more to the team”).
4. Explanations or Justifications of a behavioural assessment: comments that discussed the impact of a student’s behaviour on the team as-a-whole
5. Specific events: comments that discussed a specific event that motivated the feedback
Ultimately, each idea was categorised into one or more content codes, one type code, and one or more quality codes. Feedback was then analysed by coding category to determine the frequency of particular types of feedback, and by student to determine the distributions of coding categories received.

Student responses to their mid-term feedback were obtained at the end-of-term through a survey. When students logged on to TELS to provide their end-of-term feedback they were also asked to complete a “Survey on the Use of Peer Evaluations and Feedback”. While 317 students started the survey, only 263 completed the entire survey. A copy of the survey can be found in Appendix L. Survey responses were compared to the type and amount of holistic feedback a student received, feedback consistency and how differentiated a student’s strengths and weaknesses were.

Qualitative questions focused on how students perceived their feedback, and whether or not it motivated them to improve their behaviour. The results were coded thematically. Quantitative questions measured students’ level of agreement with statements regarding the feedback they received. Due to the limitations of the TELS question structure in the system, four choices were provided: Strongly Disagree, Slightly Disagree, Slightly Agree, Strongly Agree. There was no neutral option as the TELS system limited the number of options for such items to four.

4.2. Analysis of TEI-based Feedback Received by Students

Students received feedback from the Team-effectiveness Inventory in two forms: visualisations and a table (see Appendix K for the report structure). The visualisations showed each student the differences between their self and peer (team-members) average ratings along each of the 12 behaviours. The table demonstrated a ranking of students’ behaviours according an algorithm in Appendix B, that demarcated their top 3 rated behaviours as strengths, and bottom 3 rated behaviours as weaknesses.

4.2.1. Feedback Composition

All students received feedback on all 12 behaviours in the Team-effectiveness Inventory as was required by the TELS system, as well as three demarcated strengths, and three demarcated weaknesses. Ratings that students received along all behaviours were generally high, with
students’ average rating across all 12 behaviours having both a mean and median between 3 and 4 (the two highest options on the rating scale). The 12-behaviour averages did shift nominally lower from mid- to end-of-term feedback (Table 4-2). This indicates that students were more willing to give a lower rating in end-of-term feedback. This decrease was seen across all aspects in both self and peer ratings.

Table 4-2: Distributions of mid-term and end-of-term 12-behaviour-averaged TEI-ratings.

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term</td>
<td>1.83</td>
<td>3.55</td>
<td>3.61</td>
<td>4.00</td>
<td>0.31</td>
</tr>
<tr>
<td>End-of-term</td>
<td>1.21</td>
<td>3.48</td>
<td>3.52</td>
<td>4.00</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Differences in self and peer ratings for rounds of feedback were compared using a Wilcoxon-Signed Ranks Related-Samples test. The differences between self and peer ratings were significant across all aspects in mid-term feedback, with the magnitude of difference and level of significance decreasing in end-of-term feedback (Table 4-3). These more similar self and peer ratings in end-of-term feedback demonstrated that students may have become better calibrated with the rating scale over two uses, and/or that they developed a greater self-awareness through receiving their mid-term feedback.

Table 4-3: Self and Peer TEI-based feedback differences by aspect in midterm and end-of-term feedback.

<table>
<thead>
<tr>
<th></th>
<th>Midterm Feedback a</th>
<th>End-of-term feedback b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Self Avg</td>
<td>Peer Avg</td>
</tr>
<tr>
<td>Organisational Aspect</td>
<td>3.63</td>
<td>3.49</td>
</tr>
<tr>
<td>Relational Aspect</td>
<td>3.69</td>
<td>3.60</td>
</tr>
<tr>
<td>Communication Aspect</td>
<td>3.60</td>
<td>3.47</td>
</tr>
</tbody>
</table>

Note: * - p < 0.05, ** p <0.01, a n = 297, b n = 262

4.2.2. Quality of Feedback

Quality of feedback from the TEI ratings was assessed along two criteria: completeness, and individualisation. Feedback that contained ratings from all team members, and that was ratee-oriented was judged to be high quality. Feedback that was complete was seen of as higher quality...
as it contained a full-picture of how all team members rated the receiving student, and could
direct a student’s behavioural changes towards those most desired by the whole team.
Individualised feedback consisted of assessments that were specific to the student receiving
them. As discussed in Chapter 3, students in the broader study provided three types of
assessments: i) unconsidered assessments, in which the provider gave all team members the same
rating across all 12 behaviours; ii) item-oriented assessments, in which the provider gave all
team members the same rating on each behaviour, but different ratings across behaviours; and
iii) ratee-oriented, in which the provider gave each team member ratings that were different
within and across behaviours. Feedback that contained predominantly ratee-oriented assessments
was deemed individualised. This individualised feedback was considered to be of higher quality
as there was a greater probability that the feedback described specific behaviours for the
receiving student.

In terms of completeness, the number of team members who provided ratings in each round
of feedback was determined by team, Table 4-4. Completeness was calculated at the team-level,
as the percentage was the same for all team members on the same team. In the mid-term
evaluation, 74 teams (78% of teams) had all team members provide feedback and 2 teams (2%)
had 50% or fewer team members provide feedback; that is to say the majority of students in this
study received feedback from their whole team at the mid-term evaluation. However, this
completeness dropped significantly for the end-of-term evaluation (Related-Samples Wilcoxon
Signed Rank Test, Standard Score $Z=-6.507, p < 0.01$). In this evaluation only 29 teams (31%)
had all team members provide feedback, and 14 teams (15%) had 50% or fewer team members
provide feedback; that is to say, mid-term feedback received by students was substantially more
complete than students’ end-of-term feedback, and as a result, of higher quality.

Table 4-4: Distributions of the percent of team members who provided feedback in both rounds of
feedback.

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term</td>
<td>40%</td>
<td>94%</td>
<td>100%</td>
<td>100%</td>
<td>13%</td>
</tr>
<tr>
<td>End-of-term</td>
<td>25%</td>
<td>78%</td>
<td>80%</td>
<td>100%</td>
<td>19%</td>
</tr>
</tbody>
</table>

In terms of individualisation, feedback was categorised according to the three types of
assessments discussed above to determine the percent of feedback a student received in each
category, Table 4-5. The type of feedback a student received from their team members was assessed according to the percentage of feedback a student received (i.e. if only 3 out of 4 team members provided feedback, the percentages discussed in this section are assessed out of 3). Individualisation, like completeness, can be assessed at the team-level as it is dependent on the aggregate behaviour of the team-members who provided feedback. In the mid-term evaluation, 50 teams (53%) received all ratee-oriented feedback, and 9 teams (10%) received 50% or less ratee-oriented feedback. In the end-of-term evaluation, 46 teams (48%) received all ratee-oriented feedback, and 22 teams (23%) received 50% or less ratee-oriented feedback.

Additionally, the number of ‘unconsidered’ assessments as a percentage of student feedback rose between the mid-term and end-of-term feedback. In mid-term feedback, 59 teams had no unconsidered assessments in their feedback, students on 36 teams (38%) received at least one unconsidered assessment in their feedback, and students on 4 teams (4%) had at least half of the feedback they received come from unconsidered assessments. By contrast, in end-of-term feedback, 53 teams had no unconsidered assessments in their feedback, students on 42 teams (44%) received at least one unconsidered assessment in their feedback, and students on 4 teams (4%) had at least half of the feedback they received come from unconsidered assessments.

Table 4-5: Distributions of the percent of team members who provided ratee-oriented feedback in both rounds of feedback.

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>Mean</th>
<th>Median</th>
<th>Max</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mid-term</strong></td>
<td>17%</td>
<td>84%</td>
<td>100%</td>
<td>100%</td>
<td>22%</td>
</tr>
<tr>
<td><strong>End-of-term</strong></td>
<td>0%</td>
<td>78%</td>
<td>83%</td>
<td>100%</td>
<td>27%</td>
</tr>
</tbody>
</table>

4.2.3. Differentiated Strengths and Weaknesses

Strengths and weaknesses were determined according to the algorithm presented in Appendix B that sorts the 12 TEI behaviours according to their average peer rating and difference between self and peer assessments. Post-sorting the top three rated behaviours are identified as strengths and the lowest three rated behaviours are identified as areas of weakness. Having a differentiation in a student’s strengths and weaknesses is necessary for the system to reliably inform students how they might improve.
The strengths and weaknesses identified to students in their feedback were fairly common across the study population. Almost half of the study population had the same three behaviours identified as their strengths, and approximately a third of the study population had the same three behaviours identified as their weaknesses. Table 4-6 identifies these behaviours with the percent of students that received them as strengths or weaknesses in their mid-term and end-of-term feedback.

Table 4-6: Most frequently identified strengths and weaknesses from TEI-feedback according to the ranking algorithm. (n=317)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>C4 - Raise Contentious Issues in a Constructive Way (50%, 48%)</td>
<td>C1 - Exchange Information in a Timely Manner (44%, 44%)</td>
</tr>
<tr>
<td>R4 - Listen and Pay Attention to Team Members (49%, 47%)</td>
<td>O1 - Attend Team Meetings Prepared (34%, 44%)</td>
</tr>
<tr>
<td>R3 - Show Respect for Team Members (49%, 45%)</td>
<td>R1 - Demonstrate Accountability (33%, 36%)</td>
</tr>
</tbody>
</table>

Note: The first number in parentheses is the percent of students who received the behaviour in their mid-term feedback, and the second is the percent in their end-of-term feedback.

The strengths and weaknesses that appear in Table 4-6 seem to follow the order of the behaviours in the assessment inventory; the weaknesses correspond to the first three behaviours students provided feedback on, and the strengths correspond to items in the last four behaviours. However, the order of the assessment inventory is not the cause for this identification. There is no correlation between behaviour order and average assessment value (Spearman’s ρ = -0.01).

To determine if there was a difference between the strengths and weaknesses identified to students, the top three behaviours identified as strengths were averaged and compared to the average of the bottom three behaviours that were identified as weaknesses. In their mid-term feedback 309 students (out of the 317 students involved in the study) had strengths that were rated higher than their weaknesses, and 8 students had strengths and weaknesses were rated the same. In the end-of-term feedback, 293 students had strengths that were rated higher than their weaknesses, and 24 students had strengths and weaknesses rated the same. A Wilcoxon signed-rank test determined that there was a statistically significant difference between strengths and weaknesses of 0.66 in the mid-term, and 0.55 in the end-of-term feedback, Table 4-7. Given the
large effect sizes of these two tests, it is clear that the difference between strengths and weaknesses was meaningful.

Table 4-7: Median ratings for students’ strengths and weaknesses that demonstrate a significant difference for both rounds of feedback. (n = 317)

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weakness</th>
<th>Difference</th>
<th>Standard Score (Z)</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term</td>
<td>3.88</td>
<td>3.22</td>
<td>0.66</td>
<td>-15.25**</td>
</tr>
<tr>
<td>End-of-term</td>
<td>3.83</td>
<td>3.16</td>
<td>0.55</td>
<td>-14.85**</td>
</tr>
</tbody>
</table>

Note: * p ≤ 0.05, ** p ≤ 0.01.

4.2.4. Consistency in Feedback

Feedback was assessed to determine the consistency in ratings between peer (team member) assessors. Having an agreed upon set of strengths and weaknesses would indicate to a student that there was consistency in terms of how they were behaving, and would thus motivate students to improve along the agreed-upon behaviours. It was not relevant to determine whether self and peer ratings were consistent for two reasons: i) the presentation of feedback contained separate visualisations for self and peer ratings to allow students to compare their self and peer ratings, and ii) these visualisations were built under the assumption that team members would have a new perspective to provide to a student about their behaviour that should change their awareness of how they behave in teams.

Consistency in assessments was investigated using two approaches: 1) consensus in ratings across all 12 behaviours to determine the amount of absolute agreement, and 2) concordance across the behaviours to determine the amount of relative agreement between peer assessors. All students that had at least two peer assessors were included in the consensus analysis, and students that had at least three peer assessors were included in the concordance analysis.

In terms of consensus, students were binned according to the level of agreement between their peer assessors as was previously done in Chapter 3; however, in this analysis mid-term and end-of-term ratings are differentiated. Percent agreement was calculated as the percent of total behaviours (12) along which there was consensus. As can be seen in Table 4-8, in mid-term feedback, 31% of students had moderate agreement or greater in their peer feedback, with 19% of students having no agreement in their peer feedback. In end-of-term feedback, 37% of students had moderate agreement or greater in their peer feedback, with 24% of students having
no agreement in their feedback. Thus, peer feedback received by students in both rounds did not have significant agreement in terms of specific rating values.

Table 4-8: Distribution of agreement between peer assessments of a student as measured using percent absolute agreement in ratings across all peer assessors.

<table>
<thead>
<tr>
<th>Level of Agreement</th>
<th>Mid-term no. Students a</th>
<th>End-of-term no. Students b</th>
<th>Percent Agreement (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No agreement</td>
<td>58 (19%)</td>
<td>73 (25%)</td>
<td>0</td>
</tr>
<tr>
<td>Slight agreement</td>
<td>83 (27%)</td>
<td>65 (22%)</td>
<td>0.1 – 20</td>
</tr>
<tr>
<td>Fair agreement</td>
<td>71 (23%)</td>
<td>48 (16%)</td>
<td>20.1 – 40</td>
</tr>
<tr>
<td>Moderate agreement</td>
<td>55 (18%)</td>
<td>61 (21%)</td>
<td>40.1 – 60</td>
</tr>
<tr>
<td>Substantial agreement</td>
<td>22 (7%)</td>
<td>23 (8%)</td>
<td>60.1 – 80</td>
</tr>
<tr>
<td>Perfect agreement</td>
<td>18 (6%)</td>
<td>25 (8%)</td>
<td>80.1 - 100</td>
</tr>
</tbody>
</table>

\[ ^a n = 307, \, ^b n = 295 \text{ (at least two peers)} \]

To determine if there was a difference in peer-assessor agreement between mid-term and end-of-term feedback, the percent agreement scores of students were compared between rounds. Of the 285 students who had more than two peer assessors for both rounds of feedback, 113 students had greater agreement in their end-of-term feedback, 109 had greater agreement in their mid-term feedback, and 63 students had the same level of agreement in both rounds. A Wilcoxon-signed rank test determined that there was no significant difference in agreement between the two rounds. This means that students did not develop any greater agreement on team members’ behaviour over the duration of the project.

In terms of concordance, Kendall’s co-efficient of concordance (W) was calculated for each student based on their team-members’ peer assessments. When converted into a percentage, Kendall’s W represents the percent of agreement between assessors. Kendall’s W was calculated and is reported on for all students who at least three team-member assessors in Table 4-9. In mid-term feedback, only 34 of 294 students had significant concordance in their peer feedback, meaning that their team-members had significant agreement in their ranking of the ratee’s behaviours. No significant increase in concordance was found in students’ end-of-term feedback. The consistency in peer assessments did not increase along either measure between the two rounds of feedback.
Table 4-9: Distribution of agreement between peer assessments of a student as measured using Kendall’s W for concordance.

<table>
<thead>
<tr>
<th>Level of Agreement</th>
<th>Mid-term no. Students a</th>
<th>Significant Agreement no. Students</th>
<th>Percent Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>No agreement</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Slight agreement</td>
<td>31</td>
<td>0</td>
<td>0.1 – 20</td>
</tr>
<tr>
<td>Fair agreement</td>
<td>180</td>
<td>5*</td>
<td>20.1 – 40</td>
</tr>
<tr>
<td>Moderate agreement</td>
<td>67</td>
<td>11*,2**</td>
<td>40.1 – 60</td>
</tr>
<tr>
<td>Substantial agreement</td>
<td>11</td>
<td>8*,3**</td>
<td>60.1 – 80</td>
</tr>
<tr>
<td>Perfect agreement</td>
<td>5</td>
<td>-</td>
<td>80.1 - 100</td>
</tr>
</tbody>
</table>

*a n = 294, (at least three peers), *p ≤ 0.05, **p ≤ 0.01.

4.3. Analysis of Holistic Feedback Received by Students

Students received holistic feedback from their team-mates in addition to their feedback from the TEI. Holistic feedback was provided to students verbatim from their team members and was not labelled to indicate which team member the feedback came from. Students received holistic feedback from the same percent of team members as they did TEI feedback as all students who provided TEI feedback also provided holistic feedback.

4.3.1. Feedback Composition

Students received holistic feedback on a combination of TEI behaviours, other teamwork attributes, course-related performance, and generic statements not related to teamwork from their team members, Table 4-10. The vast majority of feedback was focused on teamwork, primarily discussing students’ strengths and weaknesses. On average, students’ feedback across all providers was comprised of 4 TEI behaviours, 1 other teamwork item, and 1 course-related item. Students received on average 2 generic statements, 3 strengths and 2 weaknesses each. The number of strengths and weaknesses received by the average student mirrored the number provided by the TEI ratings. Students typically received 2 sentences of feedback per team member in both rounds of feedback. No differences are visible between mid- and end-of-term feedback, except that students received an average of 1 less strength in their end-of-term feedback, and had one more other teamwork item discussed. Other teamwork items comprised behaviours or team-level processes that were relevant to how the team was functioning, but were not part of the TEI.
Table 4-10: Holistic feedback content described as the average distribution of feedback a student received.

<table>
<thead>
<tr>
<th>Content descriptor</th>
<th>Mid-term Feedback</th>
<th>End-of-Term Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of feedback per team member (sentences / characters)</td>
<td>2 / 133</td>
<td>2 / 117</td>
</tr>
<tr>
<td>Total items</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>TEI items</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Other teamwork items</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Course-related items</td>
<td>&lt; 1</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Generic statements</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Strengths</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Weaknesses</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: All items rounded to the nearest whole number

Feedback received by students was predominantly focused on how they behaved in teams and not their technical skills or technical project contributions. Eighty (80) students (25%) received a description of their project contributions in their mid-term feedback, and 68 students (21%) in their end-of-term feedback. This percent of course-related feedback is significantly lower than the 48.5% of students that received course-related feedback when asked to provide holistic feedback without a TEI present (Sheridan, Evans, & Reeve, 2015).

It is interesting to note that the average length of feedback received from each team member in a student’s feedback was about the length of a tweet (140 characters long). While students received an average of approximately two sentences of feedback per team member, it is important to note that some students received less (Figure 4-1). In mid-term feedback, almost 10% of students received less than an average of one sentence per team member. This number doubled between the two rounds of feedback indicating more students received very brief feedback in their end-of-term feedback. The measure of a sentence is in part misleading, as many students did not use proper punctuation when providing their feedback and wrote in run-on sentences. A lot of feedback that was only one sentence long actually contained multiple items of feedback. The number of items (topics discussed) in one sentence in student mid-term feedback ranged from one to eight content items with an average of 2.4 items, and a median of two items.
In terms of TEI-related content, there is a change in the quantity of TEI content between the mid- and end-of-term feedback rounds (Figure 4-2). Students in their mid-term feedback received a slightly more consistent amount of feedback, focusing strongly around 3-4 items being present in their feedback. In students’ end-of-term feedback, there is a greater spread in the number of items received. In end-of-term feedback there were more students who received a lot or a little feedback, as compared to the moderate amount the majority of students received in their mid-term feedback.

4.3.1. Teamwork-Related Content

Teamwork-related content was categorised as being either TEI-related or not; over two-thirds of the teamwork-related holistic feedback discussed behaviours related to the TEI. Examples of comments related to each behaviour are shown in Appendix R, with select examples included in the text below. The percent of students that received feedback on each TEI behaviour is shown in Figure 4-3.

As was seen previously with first-year engineering students providing unstructured feedback (Sheridan, Evans, & Reeve, 2015), Relational behaviours were discussed substantially less in the feedback than either Organisational or Communication behaviours. Students received the majority of their feedback on behaviours related to completing work (O2 – does their fair share...
of the work, and O3 – *delivers their work on time*), and communication in person or in meetings (C2 – *openly expresses ideas and opinions*, and C3 – *promotes productive discussion*). As these are the items most directly related to decision making around their final deliverables and the production of the final deliverables, it is understandable that these would be most discussed.

Figure 4-2: Distribution of the number of TEI-coded behaviours discussed in a team member’s feedback in both rounds of feedback.

Figure 4-3: Percent of students that received a particular TEI-item in their feedback in both rounds of feedback. Behavioural descriptions for the codes used in the figure can be found in Table 3-18.
The number of students who received feedback on behaviours relating to communication in person or in meetings was higher than expected. When compared with the unstructured feedback from the 27-item inventory, the amount of feedback related to this topic was substantially higher (Appendix N, Figure 5-1). Feedback related to this topic area was described using a variety of verbs (e.g. participating in meetings, contributing to discussions, engaged in discussion). Very few students used the words of the TEI behaviour “promoting” discussion in their feedback. Additionally, when students discussed these behaviours they typically described them in a compound way that could not be parsed out cleanly into either C2 or C3 (Table 4-11) – students discussed speaking up in a meeting as a mode of promoting discussion. As a result, these comments were coded under both. This happened in 67 instances.

Table 4-11: Holistic feedback comments that were coded as both C2 and C3

<table>
<thead>
<tr>
<th>Feedback Comments that were coded as both openly express ideas and opinions, and promote productive discussion</th>
</tr>
</thead>
<tbody>
<tr>
<td>“You expressed ideas very openly (even when they were in conflict with what someone else in the group said) which lead to some great discussions in improving our RFP.”</td>
</tr>
<tr>
<td>“Proactive and engaged in all team activities. Willing to provide input and an excellent communicator.”</td>
</tr>
<tr>
<td>“Always likes to participate with strong ideas and arguments to help clarify every discussion to the rest of the team.”</td>
</tr>
<tr>
<td>“[student] was relatively active in the discussion contributed some ideas and listened to others. It would be better for [them] if [they] could be more confident to express [their] ideas.”</td>
</tr>
<tr>
<td>“More discussion and sharing of opinions would benefit the group as a whole.”</td>
</tr>
</tbody>
</table>

The changes in the prominence of four different behaviours in student feedback between mid-term and end-of-term feedback are worth noting. Feedback related to seeking and including the input of others (R2) and listening and paying attention to team members (R4) rose considerably in end-of-term feedback. Additionally, feedback related to showing respect for team members (R3), and raising contentious issues in a constructive way (C4) decreased considerably. R2 and R4 were typically discussed in a positive manner and R3 and C4 in a negative manner in both rounds of feedback. The combination of changes across these four behaviours indicates that students discussed exclusionary behaviours less in their end-of-term feedback and inclusionary ones more.

Looking specifically at R3 and C4, a significant vocabulary shift occurred from positive to negative (Table 4-12). When respect was spoken about positively the words of the behaviour, “respect” or “constructive” were used. In criticisms, these were rarely the selected words. Instead
students used words such as: stubborn, poor mannered, closed-minded, pushy, aggressive, rude, offensive, etc. This indicates that students may identify with the behaviour in situations where it is present, but will attribute its lack to personality, character or demeanour (i.e. Who they are versus what they do).

Table 4-12: Vocabulary shift in discussing behaviours R3 and C4 in holistic feedback.

<table>
<thead>
<tr>
<th>TEI Behaviour</th>
<th>Positive phrasing</th>
<th>Negative phrasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>R3 – Shows Respect for Team Members</td>
<td>“I appreciate all the hard work [they have] done and especially for the fact that [they are] always paying attentions to what others are saying and let others feel respectful.”</td>
<td>“[Student] is very stubborn and generally ends up having fights with members regarding team decisions. [They] need to proactively work on [their] attitude. Also [they are] very pushy and need to start trusting [their] team mates more.”</td>
</tr>
<tr>
<td>C4 – Raises Contentious Issues in a Constructive Way</td>
<td>“I really like how you will give your opinion respectfully and honestly. Please continue to do so we need everyone’s opinion and ideas moving forward in this project.”</td>
<td>“I think you should be more open-minded about other people’s opinions and stop criticizing ideas. Furthermore you should learn to express your opinions and communicate with people in a less aggressive manner.”</td>
</tr>
</tbody>
</table>

Beyond the TEI behaviours, students received feedback on three additional skills or orientations. Some of these areas could have been described as specific behaviours within the TEI, however students chose to discuss them differently (Table 4-13).

The first major area of focus pertained to motivation and dedication. Students frequently discussed whether someone was motivated to work on the project and show up to meetings, or whether they were dedicated to ensuring the project was completed or completed with high quality. This area showed up equally as a strength and a weakness in feedback and was not associated with a particular course. This item could have been related to the TEI-item R1 – Demonstrate accountability, as dedication or motivation to contribute to a project results in accountability, but students did not describe the behaviour of the students as such.

The second major area of focus pertained to character/demeanour. Feedback of this type pertained to whether people were nice, easy-going, brought a positive attitude to the team, or cheered people up when the teamwork was hard. These comments described students’ character or demeanour but at the heart of it focused on students’ likeability or trust abilities. This area showed up more prominently as a strength rather than a weakness, and showed up equally in both courses. There is no TEI-behavioural link for this area.
Table 4-13: Example holistic feedback comments relating to non-TEI behaviours that are relevant to teamwork.

<table>
<thead>
<tr>
<th>Motivation and Dedication</th>
<th>Character/Demeanour</th>
<th>Leadership</th>
</tr>
</thead>
<tbody>
<tr>
<td>“My feeling is that motivation was missing from the work produced. There were some tasks which needed to be done but were not and I would like better communication of that to the team.”</td>
<td>“Good job lightening the mood of the group and making it less stressful with your humorous personality.”</td>
<td>“As a team leader I think you should put more effort into assuming a leadership position as a problem solver/ tie breaker/ conflict resolver instead of idly standing by. As you know we have a lot of conflicts in our group and it would be great if you stepped up and assumed a conflict-resolver position”</td>
</tr>
<tr>
<td>“You make sure the team meets deadlines even if that means staying up but you need to make sure you coordinate more with your team members while working and you need to start early and not procrastinate.”</td>
<td>“If you trust your team members more and trust that they will do what they've been assigned instead of sending countless reminders through text and emails it would be better. As much as we as team members appreciate your concern trust us!”</td>
<td>“[Student] showed [their] self to be a very hardworking individual. [They] showed leadership qualities as [they] helped distribute the work among [their] peers and directed much [of] the decision making of the team.”</td>
</tr>
</tbody>
</table>

The third major area of focus pertained to leadership. Feedback typically did not describe what made the person a good leader, but rather stated whether they were or were not one. This item was commonly discussed with O4 – Helping to Plan and Organise the Workflow and was discussed equally as a benefit and detractor from the whole team’s effectiveness. This area was discussed more frequently in APS112 where teams had a designated team leader.

4.3.2. Quality of Feedback

Feedback quality was assessed in terms of the ability for a reader to identify the exact change in behaviour desired by the feedback provider. This was assessed along two criteria: specificity, and justification. In terms of specificity, holistic feedback was assessed as to whether a reader could determine which behaviour was being discussed, and whether it should be maintained or improved. In terms of justification, holistic feedback was assessed as to whether the feedback explained or qualified its content, and whether it discussed the impact of the discussed behaviour(s) on the team. A comparison of the number of students who received the different types of quality feedback in their mid-term to end-of-term feedback is summarised in Table 4-14.

In terms of specificity, in mid-term feedback the majority of students received some non-specific feedback (generic statement and/or non-feedback statement), but it did not dominate the feedback in most cases. Forty-seven (47) students (15%) received at least one non-feedback item
that contained no full words in it. These were usually either single characters, or a series of random characters in student feedback. Generic statements that could be interpreted in multiple ways were received by 232 students (73%). These types of statements came in two forms: i) generic statements such as “good job!” or “great team member” that provided no useful content to a receiver, and ii) generic behavioural feedback like “good communication” that discussed an area of teamwork but were not specific enough for a reader to understand exactly what the provider was commenting on. Three (3) students, all on different teams, received only non-specific statements in their mid-term feedback.

Table 4-14: Distributions of feedback type seen in both rounds of feedback, represented by number of students who received that type of feedback. (n = 317 students)

<table>
<thead>
<tr>
<th>Feedback Type</th>
<th>Mid-term Feedback</th>
<th>End-of-Term Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-feedback statements</td>
<td>47</td>
<td>78</td>
</tr>
<tr>
<td>Generic Statements</td>
<td>232</td>
<td>236</td>
</tr>
<tr>
<td>Only non-feedback and/or generic statements</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Thank you message</td>
<td>n/a</td>
<td>98</td>
</tr>
<tr>
<td>Best wishes for future teamwork</td>
<td>n/a</td>
<td>28</td>
</tr>
<tr>
<td>Explain or qualify behaviour</td>
<td>67</td>
<td>39</td>
</tr>
<tr>
<td>Discussed impact of behaviour on team</td>
<td>45</td>
<td>32</td>
</tr>
<tr>
<td>Discussed a specific incident</td>
<td>83</td>
<td>39</td>
</tr>
</tbody>
</table>

Specificity dropped in end-of-term feedback. Seventy-eight (78) students (25%) received at least one generic feedback item, 236 students (74%) received generic statements that could be interpreted in multiple ways, and 13 students (4%) received only non-specific feedback in their end-of-term feedback.

Quality in feedback also dropped from mid-term to end-of-term as more students provided thank-you messages, or best wishes for future teamwork instead of feedback. Ninety-eight students (31%) received at least one gratitude message in their feedback, and 28 students (9%) received a best wishes message. No students received feedback that only contained gratitude and best wishes messages; all still had some other behaviour-oriented feedback as well.

In terms of justification, approximately a quarter of students received some justification for the specific feedback they were receiving. Justifications took three forms (Table 4-15):
1) An explanation or qualification for the specific behaviour discussed,
2) A description of the impact of a specific behaviour on the team, and
3) An example of when the behaviour had happened previously with reference to specific events or outcomes.

Table 4-15: Example holistic feedback comments relating to non-TEI behaviours that are relevant to teamwork.

<table>
<thead>
<tr>
<th>Explanation/Justification</th>
<th>Impact of behaviour on team</th>
<th>Specific example of behaviour demonstration</th>
</tr>
</thead>
<tbody>
<tr>
<td>“One issue I had was that you would say that you were going to be late reschedule or miss a meeting without giving any reasons. This may be a personal issue but it was very suspicious for me to see you just saying that you wanted to reschedule for no apparent reason.”</td>
<td>“You held off writing the existing solutions section for a while which kept other team members back from writing parts of the report. Next time I would finished assigned work sooner.”</td>
<td>“You also recognized ways to assist other team members with their work. For example as you were conducting research for your part you found things that were not directly related to your section but that could be useful to other team members. You made sure to let them know of the information you found.”</td>
</tr>
<tr>
<td>“Try to express yourself and your opinions more; we won't mind if you disagree with anything we say in fact we encourage discussion as it can give us new and different perspectives that would allow us to accomplish more than we otherwise could.”</td>
<td>“Your opinion is always valuable. You should voice it more frequently and share your ideas more often. Don't be afraid to disagree with people and explain your position. The team will benefit from your input and we will all gain more team work experience.”</td>
<td>“Sometimes appears to be distracted and unattached to what the team is doing (using [their] phone in team meetings)”</td>
</tr>
</tbody>
</table>

Justification was substantially higher in mid-term feedback than it was in end-of-term feedback. In mid-term feedback, 67 students (21%) received an explanation or a qualification for a behaviour discussed in their feedback, as compared to 39 students (12%) at end-of-term. In terms of identifying the impact of a specific behaviour on the effectiveness of the entire team, 45 students (14%) received this in their mid-feedback compared to 32 students (10%) in their end-of-term feedback. In terms of having a behaviour described with reference to a specific event/outcome, 83 students (26%) had this discussed in their mid-term feedback as compared to 39 students (12%) of students in their end-of-term feedback.

Overall, high-quality comments explaining or justifying a student’s behaviour were low across all students, with approximately 25% of students receiving this type of feedback. Quality in terms of specificity and justification, was higher in mid-term feedback than in end-of-term feedback across all measures of quality assessed. This may indicate that students provide more constructive criticism because perceive the mid-term, formative feedback, to be more useful.
4.3.3. Differentiated Strengths and Weaknesses

Strengths and weaknesses in students’ feedback were identified based on the vocabulary used. Strengths were identified as items which were spoken about positively or as contributing to building a good team or a good project. Weaknesses were identified as items which were spoken about negatively, as detracting from creating an effective team environment or inhibiting the project, or as a recommended improvement. Behaviours or course skills which were mentioned but not discussed in either a positive or negative manner were coded as neither strengths nor weaknesses. Some examples of strength and weakness comments for the four most prominently discussed behaviours are included in Table 4-16.

Table 4-16: Example strength and weakness comments for four behaviours from the TEI inventory as discussed in holistic feedback.

<table>
<thead>
<tr>
<th>TEI Behaviour</th>
<th>Strength phrasing</th>
<th>Weakness phrasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2 – Openly Express Ideas and Opinions</td>
<td>&quot;you are able to express yourself really well when we work together and you contribute to team discussions very often which is great.&quot;</td>
<td>“My only advice to you would be to try to interact more with us during the team discussions and not be afraid to express your opinion.”</td>
</tr>
<tr>
<td>C3 – Promote Productive Discussion</td>
<td>“It’s great how you come up with out-of-the-box ideas that help get the team thinking.”</td>
<td>“just try to keep team discussions focused on matters at hand and avoid talking about unrelated matters”</td>
</tr>
<tr>
<td>O2 – Does their Fair Share of the Work</td>
<td>“[Student] is ready to do any work that is needed… [they] did more work than assigned in the [deliverable] because it needed to be done.”</td>
<td>“doesn’t always contribute as much as everyone else in the work shared among the team (for example final revision etc)”</td>
</tr>
<tr>
<td>O3 – Delivers their Work on Time</td>
<td>“[Student] is a respectable person who finishes [their] allotted work on prior to the internal due date allowing it to be more polished by the deadline.”</td>
<td>“On some occasions [they] promised to do a certain part by a certain time. [The parts] were never done and another team member did said part. All team members were working on the project on a certain day [they] did not get on until very late in the evening.”</td>
</tr>
</tbody>
</table>

Most students received comments relating to both strengths and weaknesses in their feedback. In their mid-term feedback, 49 students (15%) received only strengths in their feedback, and 53 students (17%) received only weaknesses. Only two students (1%) received no strengths or weaknesses in their feedback. In their end-of-term feedback, 75 students (24%) received only strengths in their feedback, and 32 students (10%) received only weaknesses. Sixteen (16) students (5%) received no indication of strengths or weaknesses in their feedback.
End-of-term feedback contained more strengths-oriented feedback than the mid-term feedback. This can also be seen in the distribution of strengths and/or weaknesses received by students. As can be seen in Figure 4-4, more students received feedback that was predominantly weakness-oriented in mid-term feedback than in their end-of-term feedback. Also, more students received feedback that was predominantly strengths-oriented in their end-of-term feedback.

![Figure 4-4: Distributions of feedback type received by students, categorized by the majority of the holistic feedback that they received. (n = 317)](a) mid-term (b) end-of-term

Comments about students’ strengths and weaknesses took two forms mirroring the type of content provided by students, team-related and course-related. Weaknesses and strengths identified were predominantly team-related, with less than 10% of students receiving only course-related strengths and weaknesses in either round of feedback. Course-related items were more commonly discussed as strengths rather than weaknesses, with 48% of students receiving course-related items discussing their strengths in either round of feedback, but only 31% receiving course-related items discussing their weaknesses in mid-term feedback, and 13% in end-of-term feedback. As a result, the strengths and weaknesses identified to students in their feedback were predominantly team-related.

In terms of the behaviours identified as students’ strengths and weaknesses, the behaviours identified were fairly common across the study population. Table 4-17 identifies these behaviours. There is significant overlap in students’ strengths and weaknesses with two of the
top three strengths and weaknesses being the same. These strengths and weaknesses correspond
to TEI items that were discussed frequently in student feedback, and have no behaviours in
common with the most frequently identified TEI-based strengths and weaknesses (Table 4-6). It
is possible that these behaviours were seen by the students as the most important to their team’s
success or failure.

Table 4-17: Most frequently discussed, TEI-coded, strengths and weaknesses from students’
holistic feedback. (n = 317)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>O2 – Does their Fair Share of the Work</td>
<td>C2 – Openly Express Ideas and Opinions</td>
</tr>
<tr>
<td>(34%, 36%)</td>
<td>(29%, 25%)</td>
</tr>
<tr>
<td>C2 – Openly Express Ideas and Opinions</td>
<td>C3 – Promote Productive Discussion</td>
</tr>
<tr>
<td>(34%, 31%)</td>
<td>(20%, 28%)</td>
</tr>
<tr>
<td>O3 – Delivers their Work on Time</td>
<td>O2 – Does their Fair Share of the Work</td>
</tr>
<tr>
<td>(34%, 29%)</td>
<td>(19%, 17%)</td>
</tr>
</tbody>
</table>

Note: The first number in parentheses is the percent of students who received the behaviour in their mid-term
feedback, and the second is the percent in their end-of-term feedback

4.3.4. Consistency of Feedback

Consistency in feedback was investigated to determine whether team members were agreeing
or disagreeing on the behaviours a student had as their strengths and weaknesses. Feedback
composition could take four forms: 1) agreement – team members discussed the same behaviours
as either strengths or weaknesses; 2) disagreement - team members discussed the same
behaviour as a strength and a weakness; 3) no agreement or disagreement – team members all
discussed different behaviours; and 4) both agreement and disagreement – team members
discussed the same behaviours, some in agreement and some in disagreement. Consistent
feedback was expected to motivate a students’ improvement by providing a singular perspective
on their performance, whereas inconsistent feedback was expected to confuse a student, and as a
result not motivate them to improve their behaviour.

Team-related behavioural strengths and weaknesses were compared across feedback
providers to determine if there was agreement or disagreement in the feedback received by a
student. The feedback a student received was categorized into one of the four categories for both
mid-term and end-of-term feedback. For example, feedback for a student that discussed two
behaviours in disagreement and multiple other behaviours that only one team member
commented on, would be categorized as disagreement. As can be seen in Figure 4-5, agreement in student feedback increased between the two rounds of feedback and disagreement decreased. Additionally, the number of students whose feedback discussed all different behaviours decreased, meaning that more students received feedback in their end-of-term assessments from multiple team members on the same behaviours. As a result, the consistency in feedback increased between the two rounds of feedback.

![Pie charts showing feedback distribution](image)

(a) Mid-term feedback  
(b) End-of-term feedback

Figure 4-5: Distributions of feedback type received by students, categorized by the type of consistency seen in their feedback in (a) mid-term feedback and (b) end-of-term feedback. (n = 317)

In terms of the extent of agreement identified in the students’ feedback, there was a significant increase in agreement on strengths between the two rounds of feedback. Students received feedback that typically agreed or disagreed on 1 or 2 behaviours in the TEI. Nine students (3%) had agreement on more than 2 weaknesses, and 23 students (7%) had agreement on more than 2 strengths. Table 4-18 describes the number of students who had agreement on their strengths and weaknesses in both rounds of feedback. There was over twice as much total agreement on strengths in end-of-term feedback than there was in mid-term feedback, and a third less disagreement.
Table 4-18: Number (and percent) of students who had agreement and disagreement in their feedback, categorised by quantity of agreement and feedback round. (n = 317)

<table>
<thead>
<tr>
<th></th>
<th>Number of behaviours in mid-term feedback</th>
<th>Number of behaviours in end-of-term feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Agreed upon as</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengths</td>
<td>68</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>(21%)</td>
<td>(5%)</td>
</tr>
<tr>
<td>Agreed upon as</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaknesses</td>
<td>58</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>(18%)</td>
<td>(4%)</td>
</tr>
<tr>
<td>Disagreed upon as</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengths or</td>
<td>64</td>
<td>12</td>
</tr>
<tr>
<td>Weaknesses</td>
<td>(20%)</td>
<td>(4%)</td>
</tr>
</tbody>
</table>

All behaviours from the TEI were discussed with agreement and disagreement in students’ holistic feedback except for R3 – Show respect for Team Members. Student feedback never had any disagreement on whether respect was a strength or a weakness for the student.

4.4. Relationship between TEI and Holistic Feedback

Students’ TEI-based feedback and holistic feedback were compared to determine if there was a relationship between the two types of feedback students were receiving. This section only looks at the team-related, TEI-coded behaviours discussed in students’ holistic feedback. Three types of relationships between these two feedback sources were investigated:

1) Quantity – was there a relationship between TEI-ratings and quantity of holistic feedback received?
2) Consistency – did holistic feedback confirm, complement, or contradict TEI-ranked strengths and weaknesses?
3) Behaviours – which behaviours were present most in confirmatory or contradictory feedback?

To determine if there was a relationship between quantity of holistic feedback items and TEI-ratings, a Kruskal-Wallis test was conducted. Median numbers of TEI-items in holistic feedback were not significantly different between the different TEI quintiles, $\chi^2(4) = 1.43$. That is, students who were rated poorly on the TEI did not receive more or less holistic feedback than higher-rated students.
In terms of consistency, strengths and weaknesses identified in holistic feedback were assessed to determine if they confirmed, complemented, or contradicted TEI-ranked strengths and weaknesses. Feedback that confirmed behaviours identified the same strengths and weaknesses in holistic and TEI-based feedback. Feedback that complemented identified different strengths and weaknesses in TEI-based and holistic feedback with no agreement or disagreement between the two types. Feedback that contradicted behaviours had disagreement between the two types of feedback as to whether a behaviour was a strength or a weakness (i.e. TEI-based strengths discussed as weaknesses in holistic feedback, or vice versa). A students’ feedback was not categorized exclusively into one of the three categories and was placed into multiple categories if some behaviours were confirmed and some were complemented in the two types of feedback. Holistic feedback types are shown for mid-term and end-of-term in the Venn diagrams in Figure 4-6.

![Venn Diagrams](image)

Figure 4-6: Percent of students with holistic feedback that contradicted, confirmed, and complemented their TEI-based feedback in (a) mid-term feedback, and (b) end-of-term feedback. Note: values in the intersection of two circles represent the percent of students who received both types of feedback. (n = 317)

Holistic feedback predominantly complemented TEI-ranked strengths and weakness, with 100% of students receiving complementary items in their mid-term feedback, and 99% in their end-of-term feedback. At least 79% of students received mixed feedback that was comprised of more than one feedback type in both rounds. The percent of students receiving contradictory feedback decreased from 46% to 42% between rounds, as did confirmatory feedback, which
decreased from 80% to 68%. As a result, holistic feedback provided a space for individual students to share their own perspectives regardless of whether they matched the teams’ perspective as determined by the averaged TEI-ratings. This means that if a student discussed what they believed was the recipients strength in their holistic feedback, it would ensure that the strength was communicated to them, regardless of whether it was an algorithm determined strength based on the feedback of all team members. Given that all students received feedback that had confirmatory and complementary components, the holistic feedback was not seen to be inconsistent with TEI-ranked strengths and weaknesses.

The TEI-identified strengths and weaknesses that were confirmed most often in holistic feedback were Organisational and Communication behaviours. These behaviours corresponded to the six most frequently discussed holistic-feedback behaviours, and included the most frequently discussed strengths and weaknesses in Table 4-19.

Table 4-19: TEI-item coded strengths and weaknesses that were most frequently discussed in agreement in students’ holistic feedback.

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>O2 – Does their Fair Share of the Work (23%, 34%)</td>
<td>C2 – Openly Express Ideas and Opinions (24%, 21%)</td>
</tr>
<tr>
<td>C2 – Openly Express Ideas and Opinions (19%, 17%)</td>
<td>C3 – Promote Productive Discussion (17%, 24%)</td>
</tr>
<tr>
<td>O4 – Help to Plan and Organise the Workflow (16%, 15%)</td>
<td>O3 – Delivers their Work on Time (18%)</td>
</tr>
<tr>
<td></td>
<td>C1 – Exchange Information in a Timely Manner (17%)</td>
</tr>
</tbody>
</table>

Note: The first number in parentheses is the percent of all items coded in agreement in mid-term feedback, and the second number is the percent in end-of-term feedback. For columns where there are two distinct behaviours with only one number in parentheses, the behaviour on the left corresponds to mid-term feedback, and the right corresponds to end-of-term feedback.

However there’re are two notable exceptions. First, while C1 – Exchange Information in a Timely Manner was the most frequently TEI-identified weakness, it was one of the least frequently discussed behaviours in holistic feedback, and was not one of the top three holistic-identified weaknesses. This means that when team members chose to discuss C1 in their holistic feedback they did so when they were in agreement that it was a student’s weakness. Second, O4 – Help to Plan and Organise the Workflow was not one of the most frequently identified strengths in either TEI-based or holistic feedback, but was one of the most frequently agreed
upon strengths. This is most likely due to the connection between this behaviour and students in APS112’s discussion of the leadership of their team leaders. Because this behaviour was discussed consistently for any team member whose feedback identified them as a team leader, it is possible that this correlation is due to students rating students on their role and its required behaviours, rather than the individual students’ actual competence.

The TEI-identified strengths and weaknesses that were contradicted the most by holistic feedback across all students (Table 4-20), were some of the same behaviours that were most frequently discussed as strengths or weaknesses in holistic feedback (Table 4-17). These contradicted behaviours shared no behaviours in common with the most frequently identified TEI-based strengths and weaknesses (Table 4-6). It is possible that students within teams perceived these behaviours more differently than they did other behaviours, resulting in greater disagreement of students’ performance along them.

Table 4-20: TEI-item coded behaviours that were most frequently discussed in disagreement in students’ holistic feedback.

<table>
<thead>
<tr>
<th>Behaviours</th>
<th>(Mid-term, End-term)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2 – Openly Express Ideas and Opinions</td>
<td>(13%, 13%)</td>
</tr>
<tr>
<td>C3 – Promote Productive Discussion</td>
<td>(13%, 12%)</td>
</tr>
<tr>
<td>O2 – Does their Fair Share of the Work</td>
<td>(12%, 12%)</td>
</tr>
</tbody>
</table>

Note: The first number in parentheses is the percent of all items coded in agreement in mid-term feedback, and the second number is the percent in end-of-term feedback.

In terms of the relationship between TEI and Holistic Feedback received by students, the relationship appeared to be a positive, complementary one. All students regardless of TEI-ratings received approximately the same amount of holistic feedback which predominantly complemented and confirmed TEI-identified strengths and weaknesses. Behaviours that were commonly contradictory or confirmatory matched behaviours that were most frequently discussed in holistic feedback.
4.5. Student Response to their feedback

Student responses to their mid-term feedback were obtained at the end-of-term through a survey. When students logged on to TELS to provide their end-of-term feedback they were also asked to complete a “Survey on the Use of Peer Evaluations and Feedback”. While 317 students started the survey, only 263 completed the entire survey. A copy of the survey can be found in Appendix L.

Student responses to their feedback were captured along four dimensions:

1) Structure of the feedback – were they able to understand their performance?
2) Tone – how was the feedback phrased?
3) Content – did they receive enough quality feedback to know what to do?
4) Motivation to Improve – how were they motivated to improve their performance?

Survey responses were compared to the type and amount of holistic feedback a student received, TEI-rating quintiles, feedback consistency and how differentiated a students’ strengths and weaknesses were.

4.5.1. Feedback Structure

Students were questioned about the structure of the feedback they received. The report structure can be seen in Appendix K. Reports were structured to identify to students at-a-glance their strengths and weaknesses from the TEI, and any differences in their self and peer ratings.

Overall, the majority of students agreed (slightly or strongly) that their feedback was structured in such a way that they understood it (236 students – 90%), and that it was useful (239 students – 91%). More students agreed (slightly or strongly) that they found out their weaknesses from the feedback than found out their strengths (230 students (87%) to 218 students (83%)). However, overwhelmingly students who agreed that their feedback identified their weaknesses also agreed that it identified their strengths (Cramer’s $V = 0.59$, $p < 0.01$). The ability to identify strengths and weaknesses appeared to be more related to the presentation of the TEI-feedback as opposed to the holistic feedback, as there was no significant relationship between the amount of holistic feedback that contained strengths and weaknesses, and students’ ability to identify them (Cramer’s $V = 0.09$).
Three students provided textual critiques on the presentation of their feedback, all in different areas. One student reported that the number of strengths and weaknesses identified should not be fixed at 3 each. Another student commented that the visuals were “a little bit difficult to do comparison” meaning comparison between self and peer feedback. A third student commented that they wanted every team members’ individual ratings in the summary table instead of simply the minimum, maximum and average.

4.5.2. Tone

Students were asked about the tone of their feedback to determine its influence over how they interpreted their feedback. The majority of students reported that their feedback had a neutral tone (169 students – 64%) with 86 (33%) reporting that it had a positive tone, and 8 (3%) a negative tone. Students who reported their feedback had a negative tone had dense feedback similar to those that reported they received too much feedback. These same students did not report that their feedback was lacking in weaknesses. Students who reported a positive tone had approximately the same characteristics of students that reported a neutral tone.

Students were also asked how the tone of their feedback affected their motivation to improve. Of the 184 students who provided an answer to the question, 119 (65%) reported that it had a positive effect, 46 (25%) reported it had no effect, and 19 (10%) reported that the tone had a negative effect. Students who commented that the tone had a negative effect can be grouped into two categories: 1) they received overly positive feedback that they felt did not provide a route for improvement, or 2) they did not agree with their team members, or felt they were over emphasizing a one-off behaviour. Students who commented that the tone had a positive effect can also be grouped into two categories: 1) their feedback showed they were underperforming and identified areas for them to improve, and 2) their feedback identified how they were contributing well to the team and were encouraged to continue doing so.

4.5.3. Content

Students’ response to the content of their feedback was assessed to determine if any trends in feedback received created specific types of responses. Feedback was assessed along three dimensions: the amount of feedback received, content that students felt was missing from their feedback, and similarly content they felt was unnecessary.
In terms of the amount of feedback students received, the majority of students reported that they received enough feedback (228 students – 87%), with 30 students (11%) reporting that they received too little feedback, and 5 students (2%) reporting that they received too much. All five students who commented that they received too much feedback had dense holistic feedback – over 50% of their feedback discussed specific behavioural strengths and weaknesses. Of the 30 students that reported they received too little feedback, 14 also reported that they felt their holistic feedback was lacking quality comments.

Most students reported that there was nothing missing from their feedback. However, some students felt that their feedback was lacking in specific areas. Eighty-one students (31%) that responded to the question “What information would you have liked to see in feedback to you that wasn’t there? What was provided that was unnecessary?” reported that nothing was missing from their feedback. Forty-seven students (18%) reported that their feedback lacked a description of specific improvements; 16 students reported that their feedback did not discuss their strengths (of which 9 also felt their feedback lacked improvements); and 42 students (16%) expressed that their feedback lacked quality holistic feedback. No students commented on any discrepancies between self and team-member ratings.

The students that reported their feedback lacked weaknesses or areas for improvement, reported that their feedback did not discuss exactly what their weaknesses were nor how to improve them. Of the 47 students in this category, 19 reported their feedback did not discuss how to improve, and 24 reported their feedback lacked specificity in articulating weaknesses. Students in this category discussed their feedback as “vague” or “general”, and that the feedback lacked sufficient information to know what their team members wanted them to do to be a better team member.

Students’ perceptions of a lack of quality stemmed from similar issues to those who felt their feedback lacked weaknesses. Students in this category were not looking so much for specificity as they were for justification or evidence to motivate the feedback they received. Of the 42 students who reported that their feedback lacked quality comments, 15 students reported their feedback was vague or “useless”, 9 felt their feedback lacked honesty, 15 reported their feedback lacked evidence or examples, and 3 students reported their feedback was too short or brief.
Other miscellaneous content areas identified as missing from feedback by a few students were:

- if their team members liked them or their personality,
- if their team members thought they produced high quality work or made valuable contributions,
- how they would have been rated by teaching assistants or instructors,
- how their team members thought their team as-a-whole was doing,
- if their team-mates found their leadership style helpful, and
- how effective they were at running meetings.

Fifteen students reported that there was unnecessary content in their feedback; in all cases related to teamwork behaviours. Ten students commented that there were too many behaviours that they were rated on, 2 reported that there was too much teamwork related content, and 3 reported that their feedback was too detailed. It is possible that these students’ personal models of good teamwork did not align with the framework put forward in the TEI.

A cross-comparison between feedback received, and student-reported responses to the content of their feedback was performed to determine if there were any trends in feedback that motivated these responses from students. There were no significant differences in the length of feedback statements received, or of the amount of teamwork-related content between students who reported that their feedback either lacked weaknesses or quality comments, and those that did not report such things. The majority of students who commented that their feedback lacked weaknesses (28 of 47 students) had more strengths identified in their feedback than weaknesses. All students who commented that their feedback lacked quality comments had low consistency in their holistic feedback. All 42 students had less than 50% of the items in their feedback discussed by more than one individual.

In conclusion, it appears that students want to receive feedback that is specific, includes examples or evidence to justify poor or excellent behaviour, describes the preferred behaviour desired by the team, and that is agreed upon by at least some of their team members.
4.5.4. Motivation to Improve

Students were asked about their motivation to improve their behaviour as well as the source of their motivation in a survey. Motivation sources were assessed to determine whether the feedback a student received generated their motivation to improve, or fueled a pre-existing desire to be a better team-member.

Students were asked four questions about their motivation:

1) The feedback (reports) I received was structured in such a way that it motivated me to want to improve my competence {4 levels of agreement}
2) Were you motivated to improve your performance? Why?
3) How did the tone in which your feedback was phrased affect your motivation to improve your performance?
4) The amount of time I spent planning/practicing to improve my performance after receiving the feedback was: {none, 0-1 hours, 2-3 hours, 4+ hours}

In response to the first question, students predominantly agreed that they were motivated to improve their competence (216 students, 82%), with nine students strongly disagreeing that they were motivated to improve their competence. Student response to the fourth question in terms of how much time they spent working to improve their competence was related to students’ response to the first question, Figure 4-7, (Cramer’s V = 0.182, \( p < 0.01 \)). Students who reported they were more motivated to improve also reported spending more time working to improve their competence.

Students reported motivation to improve was strongly correlated with whether their feedback described them as they perceived themselves. Students who agreed that their feedback described them well reported that they were more motivated to improve (Cramer’s V = 0.239, \( p < 0.01 \)). Additionally, 24 students discussed in their freeform responses that their motivation to improve was because they agreed with their peer feedback. It is important to note that a student agreeing with their feedback does not imply that a student’s self and peer assessments were identical, but that the feedback the student received persuaded them that it was a reasonably accurate description of their performance.
Students motivation to improve their competence as categorised according to the amount of time they spent planning/practicing to improve it.

Students explanations of why they were motivated to improve their competence were grouped into three major categories, with students who did not report a reason being placed in a fourth (Figure 4-8).

1) They cared about their team and felt that they were a valuable and influential member of the team.

Eighty-eight (88) students reported this as the source of their motivation to improve. They typically discussed this in one of three particular ways: i) that they wanted to make their team as a whole better and felt that their individual actions could do that, ii) they felt their feedback acknowledged the effort they had put into their team, and as a result wanted to do more, or iii) they wanted to be a better team member.
Figure 4-8: Distribution of students’ reasons for why they were motivated to improve their performance. (n = 216)

2) They wanted higher grades and saw the team as a vehicle to get them.

Forty-four (44) students reported this as the source of their motivation. This motivation was discussed from the desire to improve one’s own grades as well as the grades of the team. Some students articulated a belief that the team needed to work well together to get high grades, and that was why they were motivated to improve.

3) Personal and/or professional need for self-improvement

Thirty-nine (39) students reported a motivation to improve stemming from having a self-improvement orientation. These students expressed this as a desire to improve their capability to either be a better person or a better engineer. These students expressed a belief that engineers always work to improve their weaknesses, and engineers need to learn to be professional and work in teams.

In terms of what in their feedback motivated them to improve their competence, 40 students reported that it was the strengths and weaknesses in their feedback. Students reported this in one of two ways: i) it identified where they needed to improve and thus they could do that, or ii) because the feedback presented both weaknesses and strengths, it gave them the ability to focus on their weaknesses without feeling incompetent.
In terms of how students were motivated by their feedback to improve their competence, students overwhelmingly indicated that the tone of their feedback had a positive effect. As discussed in Section 4.5.4 the neutral-positive tone perceived by students in their feedback motivated students to improve as it reported their weaknesses without making them feel bad about having weaknesses.

Overall, students’ response to their feedback was predominantly positive in terms of the tone and structure of the feedback. Students provided mixed responses as to whether their feedback articulated specific strengths and weaknesses for them to work on. Students that had less consistent feedback, identified that their feedback lacked such content more frequently than those that had consistent feedback. The majority of students were motivated to improve their performance, and those that were more motivated reported spending more time working to improve. Students motivational sources were varied but the majority were motivated to improve to either make themselves or their teams better. Students were also motivated by feedback that allowed them to see both their strengths and weaknesses.

4.6. Discussion

This section aims to draw conclusions about: i) how students understood the role of feedback in their teams and in their development as team members, ii) what kinds of feedback students require to develop a greater awareness of their competence, and iii) how students think about teamwork and which behaviours are most important when working in a team.

Students approached both mid-term and end-of-term rounds as formative feedback opportunities, but focused more strongly on developmental feedback in the mid-term. Mid-term TEI feedback was more actively completed – the feedback students received had more ratee-oriented and less unconsidered ratings than the end-of-term feedback resulting in more highly differentiated strengths and weaknesses. Mid-term holistic feedback contained more weaknesses, more justification and explanation, and fewer non-specific and brief comments. As a result, the feedback that students received in the mid-term was more focused on identifying opportunities where students could grow and improve as a team member. This may be because students perceived that the feedback they provided in the mid-term would have a greater influence on the
situation at hand; students had a self-serving motivation to provide higher quality feedback in the mid-term.

However, not all students perceived that their feedback contained quality information on their weaknesses for both the TEI and holistic feedback. In the TEI feedback, the number of strengths and weaknesses was fixed at three each, meaning that regardless of how many strengths or weaknesses were numerically determined, the presentation structure would highlight strengths and weaknesses based on the way the feedback was ranked. This resulted in two issues:

1) For students who did not have differentiated strengths and weaknesses (8 students in the mid-term and 24 students in the end-of-term feedback rounds) they may not have perceived the identification of strengths and weaknesses to be credible.

2) For students who had more strengths or weaknesses than the report structure allowed (i.e. 5 equally rated weaknesses with space for only 3 behaviours to be highlighted in the report structure), the presentation of those behaviours in their feedback report would correspond to the question order when completing the TEI. This is because similarly rated items would not be differentiable in the algorithm and would exit the algorithm in the same order as it was entered (order of the questions) – for students with multiple identically ranked behaviours their demarcated strengths and weaknesses may have not shown the whole picture of their performance. This may have strongly influenced the 40% of students who had the same behaviours identified as their strengths. Regardless of this issue, the behaviours that were identified as strengths and weaknesses were significantly different for these students and did indicate areas in which their team members perceived their behaviour to be good versus areas where it could be improved.

A clear picture of the type of feedback students desired to receive emerged from their comments about the feedback they received. They wanted:

- feedback that identified both strengths and weaknesses so that they did not feel incompetent as team members,
- feedback that identified only a few strengths and weaknesses,
- some agreement from their team members on their weaknesses and strengths so they would know which behaviours were preferred by their teams, and
weaknesses justified with recommendations as to how their team members wanted them to improve.

Expanding on the second point, students wanted only a few strengths and weaknesses identified. Students that had feedback that contained many strengths and weaknesses responded poorly, stating that there was either too much feedback, or that it had a negative tone. It is possible that having too many behaviours to improve on made it difficult for students to identify a clear path forward.

Students’ agreement with their feedback emerged as a strong predictor of whether a student would be motivated to improve or not. This countered the initial design framework of TELS which aimed to make students aware of the discrepancies between how they perceived their behaviour and how their team members did. It appears that students who had discrepancies that were within their realm of possibility were motivated to improve. However, students whose feedback described them too differently from how they perceived themselves, disregarded the feedback as wrong or “absolutely untrue”.

It is interesting to note that students’ desire for feedback that contained specific ways of improving their behaviour mirrored how students provided comments to me on the feedback they received. In areas where students responded positively to their feedback they simply stated how they felt, whereas for areas that they responded poorly to, they included suggestions for how the system designers could improve the system or feedback process. This speaks to two particular engineering-student orientations:

1) Students are applying their trained problem-solution mentality to the process of providing feedback. They want their feedback to articulate both the problem and identify how to solve it. Students did this when providing feedback to me about the TELS system. They also noted when it was lacking from their behavioural feedback; students said they did not have sufficient information to improve their behaviour (no weaknesses or specific improvements). It appears that while they want this type of feedback behaviourally, they do not provide suggestions for improvement as readily for behaviours as they do for a technical system or design problem.

2) Engineering students’ positivist epistemology is expressed in their beliefs about their feedback – they believe there is a right answer as to how to behave and that their team
members should have given them the solution so they can execute on it. While there exists the possibility of multiple ways of improving the same weakness, these first-year students wanted a singular approach to be provided to them. It is possible that this effect might be less prominent in upper year students who are more developed as learners.

This work provided new insight into how students think about teamwork. First, four behaviours were particularly salient to students and were each discussed in over 40% of students’ feedback. These behaviours were *O2-* does their fair share of the work, *O3-* delivers their work on time, *C2-* openly expresses ideas and opinions, and *C3-* promotes productive discussion. In previous studies, the students holistic feedback focused primarily on Organisational behaviours (Sheridan, Evans, & Reeve, 2015), but in this study students were split between Organisational and Communication behaviours. This indicates a potential shift in students’ understanding of the role of interacting with each other to engage in teamwork that does not simply look at teamwork as the sum of each team member’s work. Connecting back to engineering students’ orientations to thinking, three of these four (O2, O3, and C2) are behaviours that could possibly be assessed by students quantitatively as the frequency of the behaviour rather than the quality with which it was expressed. Based on holistic feedback it is not possible to parse out which of these two possibilities is most representative.

Second, between mid-term and end-of-term feedback there was a shift in the distribution of behaviours identified. This change in distribution of the other 8 behaviours may be indicative of a shift from an individualistic approach to teamwork (i.e. divide and conquer) to a collaborative approach (i.e. interact with others to build the best result). Two Relational behaviours featured prominently in end-of-term feedback: *R2-* seeks and includes the input of others, and *R4-* listens and pays attention to others. Both of these behaviours are ones that demonstrate valuing the contributions of others and leveraging them in team discussions. This can also be seen in student motivations to improve their behaviour for the betterment of their team.

4.7. Conclusions

Connecting this back to the conceptual framework of student improvement, Figure 1-1, these findings have implications for developing student awareness of how they operate in teams.
This work shows that the TEI provides students a framework with which to understand teamwork. Students discussed more Relational and Communication behaviours in holistic feedback with the TEI present than without an inventory (Sheridan, Evans, & Reeve, 2015). While students may not have adopted the exact wording of the behaviours in the inventory, the behaviours they discussed in their own words in the holistic feedback predominantly mapped on to the behaviours in the inventory. Additionally, end-of-term feedback (once students had used the inventory more than once), had a greater percentage of Relational holistic feedback than students’ mid-term feedback. This may indicate that students developed an awareness of the importance of collaborative behaviours that create quality interactions over the course of their teamwork.

Students’ responses to the end-of-term survey indicated that they had developed an awareness of their capability. Most students were motivated to improve and had an understanding of areas for improvement. Feedback that was not too different from a students’ self-concept facilitated greater awareness and motivated improvement. It was found that feedback that articulated weaknesses for improvement but was phrased in a positive (constructive and encouraging) tone motivated improvement. Students who reported they were more motivated to improve also reported spending more time working to improve their competence.
5. Student Improvement Efforts and Results

This chapter discusses how students used the Team-effectiveness Learning System (TELS) as a method to improve their teamwork behaviour, and the results of those efforts. Whereas Chapter 4 discussed the feedback students received and how it motivated them to want to improve, this chapter looks at what students did to improve their behaviour based on that feedback and how effective it was. This chapter will present student use of improvement methods on TELS (viewing feedback and accessing online lessons), discuss student response to these methods, and will then discuss areas of student improvement and the factors that influenced student improvement.

5.1. Study Design and Research Methods

Understanding student improvement efforts took the form of a sequential explanatory study. Quantitative data from student use of TELS provided an overview of what students were accessing on the system to improve their behaviour. This data was then combined with further quantitative and qualitative data from the end-of-term TELS use survey to understand student choices and rationales for the trends that were visible in the TELS use data.

Student use of TELS was tracked to determine which aspects of the system students accessed, and when they accessed them. Aspects that were tracked included: providing feedback, viewing feedback, and viewing lessons and exercises on the system. Students individually consented to have their use of the system tracked, allowing for system-wide use to be reported on with respect to the full study population (955 students).

TELS access data was combined with mid- and end-of-term feedback, and end-of-term TELS use surveys for students that had full-team consent as outlined in Chapter 4. Combining student use of the TELS system with student feedback content and personal rationales provided information to better understand which students improved their behaviour, how they worked to improve their behaviour and how they chose to use different aspects of TELS.

Mid- and end-of-term feedback characteristics were extracted from the analyses discussed in Chapter 4 to determine which feedback characteristics were most strongly correlated with students that improved their behaviour overall, improved on their weaknesses, and accessed the
learning resources on TELS. Three open-ended questions from the TELS use survey were used to understand how students worked to improve their behaviour and if and why they chose to access the feedback and lessons on TELS. Qualitative questions on the TELS use survey were thematically coded and focused on extracting methods students reported using to improve their performance, and their use of the lessons (did they use them, why did they use them, were they helpful). This data was used to explain student rationale and response to using the system at an individual level.

5.2. Improvement Methods

Two complementary improvement methods were provided to students on the Team-effectiveness Learning System (TELS): reports of feedback from their peers as described in Chapter 2.3.4, and lessons on the behaviours in the Team-effectiveness Inventory as discussed in Chapter 2.3.5. Feedback reports identified discrepancies between their and their team’s perception of their behaviour, as well as areas for improvement. Lessons on TELS were meant to follow up on feedback, and provide students with information on how to improve in the areas identified by their feedback.

Student use of these improvement methods is discussed below with respect to two populations. First, to provide a sense of the uptake of the aspects of TELS by the class, the two improvement methods will be discussed with respect to the entire population of individually consented students (n = 955). Second, to get a sense of individual student’s perceptions of their utility and efficacy, the two improvement methods will be discussed with respect to the full-team consent students who provided feedback in the end-of-term TELS survey (n = 263). It is reported this way to provide a description of TELS use at a class-level, and discuss individual student reaction to the different methods of improvement within TELS.

5.2.1. Reading and Reflecting on Feedback

Reading and reflecting on feedback from student peers was the dominant method of improvement for students. Table 5-1 shows the frequency and number of students accessing their mid- and end-of-term feedback reports.
Table 5-1: Frequency and total number of student feedback reports views based on time period.

<table>
<thead>
<tr>
<th>No. of views per student</th>
<th>Mid-term feedback views</th>
<th>End-of-term feedback views</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Any time after release</td>
<td>Between feedback rounds</td>
</tr>
<tr>
<td>Average</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Max</td>
<td>21</td>
<td>13</td>
</tr>
<tr>
<td>Total no. of Students</td>
<td>863 (90%)</td>
<td>714 (75%)</td>
</tr>
</tbody>
</table>

Of the 955 individually-consented students, 863 (90%) read their mid-term feedback report on TELS. Students typically reviewed their feedback within a day of its release, with a sharp drop-off in views after 4 days. This may indicate that students were curious and/or eager to find out what their team-members thought about them. A majority of students (55%) also viewed their mid-term feedback at the same time as providing their end-of-term feedback.

Of the 263 students that had full-team consent, 253 students (96%) accessed their mid-term feedback (208 (79%) soon after their mid-term feedback, 154 (59%) while providing their end-of-term feedback), and 94 students (36%) accessed their end-of-term feedback. The access trends of these students are not significantly different from those of the whole study population, and thus their comments about the way they used their feedback reports likely do not differ significantly from those of the entire study population.

A series of contingency table analyses were performed among these 263 students to determine if any particular feedback characteristics were significantly associated with the number of times a student reviewed their mid-term feedback. Characteristics investigated included 12-behaviour average rating, magnitude of difference in strengths and weaknesses, magnitude of discrepancy between self and peer ratings, quantity of holistic feedback received (number of sentences), and quality of holistic feedback received. For quality of holistic feedback, the percent of a students’ total holistic feedback received was binned according to the quantity of it that discussed strengths or weaknesses with four levels { [0-25%], (25-50%), (50-75%), (75-
The only characteristic that was statistically significantly associated with reviewing feedback was the percent of holistic feedback that contained strengths and weaknesses. Students who had a greater percent of their feedback discussing strengths and weaknesses reviewed their feedback significantly more than those who did not ($\chi^2 = 24.8$, Cramer’s $V = 0.177$, $p < 0.05$). Thus, higher quality feedback – feedback that discussed strengths and weaknesses as compared to providing generic statements about the team and what work each student completed – motivated students to review their feedback more than those with lower quality feedback.

Of the 263 students, 55 indicated in their end-of-term TELS survey that reflecting on their feedback was the method they used to improve their behaviour. Selected comments from these students are included in Table 5-2.

Table 5-2: Student comments from the end-of-term TELS use survey about using their feedback for improvement.

<table>
<thead>
<tr>
<th>Student comments about the utility of their feedback for improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Considered feedback, related feedback to behaviour through reflection, isolated key behavioural elements that were negatively affecting performance, committed to minimizing these elements in my interaction with team.”</td>
</tr>
<tr>
<td>“In applicable instances, I evaluated my actions and tried to reflect whether I could have improved what I have done using the feedback I received.”</td>
</tr>
<tr>
<td>“Read over the comments and reflected what I have done to cause them commenting me like that. Then, I made a list of things that I need to change to improve my performance in the team.”</td>
</tr>
<tr>
<td>“Through reading the comments I tried to find the areas that weren't explicitly mentioned and reflected on theses areas to see what I could improve.”</td>
</tr>
<tr>
<td>“During my team meetings, the areas I scored low on were always on my mind, putting to the forefront what I should be subconsciously improving while attending to my meeting responsibilities.”</td>
</tr>
<tr>
<td>“Just by reminding myself of the weaknesses and trying not to repeat the same mistake again.”</td>
</tr>
</tbody>
</table>

It appeared that students felt they had enough information to improve their behaviour from the feedback alone. Students who reflected on their feedback reported using it to improve weaknesses, and not to improve or leverage their strengths. Fourteen students stated that they read their feedback more than once, and referred back to it to identify behaviours or mannerisms that needed to be improved. The process they described was: 1) read the feedback, 2) think of what to do better on their own, and 3) try to do that better. Some students commented that they tried to reflect on their feedback during team meetings to correct their behaviour in the moment. However, no students articulated a method to improve their behaviour other than trying not to demonstrate any weaknesses listed in their feedback.
Due to the large percentage of students viewing their mid-term feedback in TELS, and the number of students who articulated that this feedback could identify what they needed to improve, the system can be used to facilitate actionable feedback for students on their behaviour in teams.

5.2.2. Lessons on TELS

Lessons and exercises were provided to students on TELS. These are meant to teach how to best demonstrate the 12 behaviours included in the team-effectiveness inventory. Descriptions of the lesson structure and content is outlined in Chapter 2.3.5, with sample lessons provided in Appendix S. Lessons were provided to give students tools and techniques to improve their behaviour in future team interactions. Students were encouraged to use the lessons both in lectures about TELS, and in email announcements that feedback was available for viewing. For example, email announcements indicating that feedback was ready for viewing also suggested accessing the lessons.

This section will first describe student use of the lessons - which lessons were accessed, when they were accessed, and who accessed them. Then it will discuss students’ response to the lessons in terms of their accessibility, and utility.

5.2.2.1. Lesson Use

Student use of lessons was very limited, and was not widely adopted as a method of improvement. Just reading the feedback and reflecting on it was far more common. Table 5-3 shows the number of unique student accesses for each lesson and for the “Lessons & Exercises” splash page in TELS. This splash page was a page that indexed all of the available lessons on the system.

Of the 955 individually-consented students, only 128 students (13%) accessed any TEI-based lessons, whereas 621 students (65%) viewed the index of lessons available to them. It is unclear as to why this is the case. It is possible that students clicked on the “Lessons & Exercises” button on the dashboard out of curiosity to see what was there. Perhaps the number of lessons on the splash page scared students away, or students were too busy to review them, or they might not have thought there would be value in reviewing them. No data from the end-of-term surveys
answers this question. However, the fact that there were two clicks to access a lesson, instead of just one may have limited student use of the lessons.

Table 5-3: Number of unique student accesses of specific lessons in the TELS system.

<table>
<thead>
<tr>
<th>Pages (Lessons) Accessed</th>
<th>Number of Unique Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lessons &amp; Exercises Splash Page</td>
<td>621</td>
</tr>
<tr>
<td>O4 - Help to Plan and Organise the Workflow</td>
<td>63</td>
</tr>
<tr>
<td>C1 - Exchange Information in a Timely Manner</td>
<td>55</td>
</tr>
<tr>
<td>C4 - Raise Contentious Issues in a Constructive Way</td>
<td>35</td>
</tr>
<tr>
<td>R1 – Demonstrate Accountability</td>
<td>34</td>
</tr>
<tr>
<td>O1 – Attend Team Meetings Prepared</td>
<td>34</td>
</tr>
<tr>
<td>O2 – Does Fair Share of the Work</td>
<td>30</td>
</tr>
<tr>
<td>O3 – Deliver their Work on Time</td>
<td>27</td>
</tr>
<tr>
<td>R4 – Listen and Pays Attention</td>
<td>20</td>
</tr>
<tr>
<td>R2 – Seek and Include the Input of Others</td>
<td>19</td>
</tr>
<tr>
<td>C3 – Promote Productive Discussion</td>
<td>17</td>
</tr>
<tr>
<td>R3 – Show Respect for Team Members</td>
<td>16</td>
</tr>
<tr>
<td>C2 – Openly Express Ideas and Opinions</td>
<td>16</td>
</tr>
</tbody>
</table>

In terms of which lessons were accessed by students, it is interesting to note that the two most frequently accessed lessons were two of the behaviours that had strongest agreement between holistic and TEI-based feedback. O4 – Help to Plan and Organise the Workflow was one of the top three agreed upon strengths, and frequently discussed in conjunction with team leadership in holistic feedback. C1 – Exchange Information in a Timely Manner was one of the top three agreed upon weaknesses, and one of the most frequently identified weaknesses in TEI-based feedback. Similarly, it is interesting to note that two of the most frequently discussed behaviours in holistic feedback, C2 – Openly Express Ideas and Opinions, and C3 – Promote Productive Discussion, were among the three least accessed lessons. Thus, the lessons accessed may correspond to behaviours in which there is agreement between TEI-based and holistic feedback, but do not appear to correspond solely to weaknesses identified for improvement.

In terms of when lessons were accessed by students, the majority of accesses occurred while students were providing feedback. Table 5-4 shows the number of student lesson-accesses categorised by time of access. While students were providing either round of feedback, 105 students accessed the lessons in TELS, compared to 46 students who accessed lessons at other times. Only 27 students accessed lessons immediately after receiving their mid-term feedback,
despite 714 students logging onto the TELS system to review their feedback during the same time period. The hypothesis when designing these lessons and exercises was that students, upon reviewing their feedback, would access the lessons to learn how to improve. The students did not behave in this way. They were not accessing the lessons after receiving their feedback to improve on their weaknesses, but instead were accessing the lessons while on the system to provide feedback.

Table 5-4: Number of student lesson accesses categorised by time of access.

<table>
<thead>
<tr>
<th>Time of Access</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before providing feedback</td>
<td>7</td>
</tr>
<tr>
<td>While providing mid-term feedback</td>
<td>66</td>
</tr>
<tr>
<td>Between mid- and end-of-term feedback</td>
<td>27</td>
</tr>
<tr>
<td>While providing end-of-term feedback</td>
<td>39</td>
</tr>
<tr>
<td>After end-of-term feedback</td>
<td>12</td>
</tr>
</tbody>
</table>

Of the 128 unique students who accessed lessons on TELS, the majority of students accessed only one or two lessons, Figure 5-1. Additionally, very few students (4) accessed all of the lessons on TELS. This number was smaller than I expected; I have seen students read through every course resource provided to them just in case it might be on a test. Of the 27 students who accessed lessons between rounds of feedback, there was full-team consent for 14 students. For these students it could be determined if they accessed lessons which were identified to them as weaknesses. Of the 14 students, 5 students accessed one of their TEI-identified weaknesses, and no students accessed lessons for 2 or more weaknesses. While this sample is a small subset of the total population, it supports the conclusions about which lessons students access; students do not appear to select lessons based on the areas in which their feedback identifies they need to improve.

To better understand who chose to access the lessons, the 263 full-team consent students were analysed to see if there were any characteristics that could distinguish those who did access the lessons from those who did not. Within the 263 students, 55 students (21%) accessed at least one lesson. Contingency table analyses were conducted to determine if students who were: i) in the bottom quintile of the study population; ii) had a large difference between their self and peer ratings (students with either high or low self assessments that had greater than a 1-point difference between their self and peer ratings); or iii) had a greater difference in ratings between
their strengths and weaknesses, accessed the lessons more than those who did not. No characteristics that could differentiate these students from those that who did not access the lessons were found.

Figure 5-1: Number of unique behaviour-lessons accessed by students.

5.2.2.2. Student Response to Lessons

To better understand why so few students adopted the lessons as compared to what was expected, student feedback from the end-of-term survey on TELS use was analysed. Students were asked in this survey if they accessed the lessons, if so which ones they accessed, and what use the lessons were to them. Student responses focused on two key themes: whether students were aware of the lessons, and the utility of the lessons.

Of the 263 students that completed the end-of-term TELS use survey, 194 reported not using the lessons, of which 50 provided a reason as to why. Selected student comments are provided in Table 5-5. Students who provided reasons why they did not access them expressed confusion as to whether there were lessons and where they were located (27 students), and complained that they were not adequately informed that such lessons existed as they would have been useful to them or their team (5 students). Students’ complaints suggested the website for TELS was hard to find, and that they were not reminded about the lessons sufficiently in course announcements. Eight students reported that they were too busy to have time to look at lessons about teamwork, and 12 students reported that they did not need lessons because they or their teams were good
already. While the number of students who provided reasons was small, the reasons connect together to support the belief that teamwork is something that you only spend time on if your team is not effective. In this framing, lessons would be seen as remedial rather than supplementary or informative.

Table 5-5: Student comments from the end-of-term TELS use survey about not using the lessons.

<table>
<thead>
<tr>
<th>Student comments about not using the lessons on TELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I did not... though I think I knew about these lessons (somewhere in the back of my mind), there were not enough friendly reminders for me to remember to try them.”</td>
</tr>
<tr>
<td>“See, the way I see it, this website is quite hard to find.”</td>
</tr>
<tr>
<td>“Wait there are lessons..?”</td>
</tr>
<tr>
<td>“I also think they were more useful for dysfunctional teams and I don't think our team was dysfunctional”</td>
</tr>
<tr>
<td>“We really didn't have any problems so we couldn't really use any lessons.”</td>
</tr>
<tr>
<td>“No, didn't have much time and it didn't seem worth it since I didn't feel I had any areas in major need of improvement.”</td>
</tr>
<tr>
<td>“Unfortunately I did not use them; but I'm pretty sure they would have helped our team, function better.”</td>
</tr>
<tr>
<td>“I didn't try [them] because I have my own plan.”</td>
</tr>
</tbody>
</table>

Of the 55 students that used the lessons, 35 commented on them in the end-of-term TELS-use survey, and three reported which lessons they accessed. Example student comments for these areas are provided in Table 5-6.

Table 5-6: Student comments from the end-of-term TELS use survey about the utility of the lessons.

<table>
<thead>
<tr>
<th>Student comments about the utility of lessons on TELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I read over some of them to give me a better idea of how to act. I might not have made a master plan of change after reading them but they helped show what was expected of me as a team member.”</td>
</tr>
<tr>
<td>“I used them to understand the categories of the team-learning system, and applied it to my understanding of the different aspects of assessing the team members and their work.”</td>
</tr>
<tr>
<td>“I had a chance to read a few of the lessons. Some topics seem redundant. Maybe they are not, but it did not motivate me to read it.”</td>
</tr>
<tr>
<td>“did use some of the lessons such as using an agenda/calendar to improve time management. So far, I have improved in this aspect.”</td>
</tr>
<tr>
<td>“tried to use the lessons from the team-learning system by taking more time to reflect on what I did during team meetings, and trying to get better for the next meeting. I think that it worked out well. I feel that I am a much better team member now than I was in January.”</td>
</tr>
<tr>
<td>“I think I looked at one [lesson] but I only read like two sentences and then I closed it. Probably because there was so much words, and when you see this, all these [list of lessons], I don’t want to read.”</td>
</tr>
</tbody>
</table>
Twenty-three students commented that the lessons were useful. These comments ranged from the lessons helping them provide feedback more effectively by explaining the behaviours, to specific behavioural improvements that they adopted and felt improved their team dynamics. Five students reported that the lessons were vague, redundant, or things they knew already. Four students commented that they were not useful but did not provide a reason why, and three students commented that they used them and that the lessons provided no additional information. A critique from students who did use the lessons was that they were too long and wordy. Students expressed the need for pictures or videos, and that the number of lessons and amount of words was intimidating. The two greatest barriers to adoption of the lessons appeared to be: a lack of awareness that they existed, and the fact that they were all text lessons.

5.2.3. Other Modes of Improvement

Four other modes of improvement were listed in the end-of-term TELS use survey by 22 students. The most common ‘other’ mode of improvement was meeting with team members to plan how to operate better based on their feedback (13 students). This was discussed as an improvement method for both the individual and the team. The processes described by students mimicked an unstructured brainstorming process that students were taught in their design courses where students collaborated to determine a solution to improve the team’s or an individual’s behaviour. Five students described performing an internet search to find out what to do to improve, two students said that they asked people involved with the course or those who had more experience in teams about how to improve, and two discussed getting to know their team members more to better understand what the team needed. No comments were provided on how useful these approaches were.

To summarise the key findings around how students worked to improve their behaviour:

- Reviewing feedback was the most commonly reported method of improvement, which is confirmed by the frequency and quantity of students viewing feedback on TELS
- Few students used the lessons on the online system, however those that did reported that they were useful
- Methods of improvement that were simple to access (few clicks) and were made highly visible to students were used more.

5.3. Student Improvement between Mid- and End-of-Term Feedback

To determine the effectiveness of TELS in the courses studied, student mid-term and end-of-term feedback was compared to determine if there were differences in students’ performance across the two rounds of feedback. While the previous section investigated how student worked to improve, this section discusses whether students did improve. This section describes areas of improvement seen in end-of-term feedback, which students improved the most, and what factors in TELS were most strongly correlated with student improvement.

5.3.1. Improvement seen in student feedback

Improvement in student behaviour was assessed through changes in TEI-ratings between mid- and end-of-term feedback, and through comments received in end-of-term holistic feedback. In terms of TEI-ratings, four dimensions of student improvement were assessed: mid-term identified weaknesses, mid-term identified strengths, differences in self and peer ratings and overall average rating, Table 5-7.

Table 5-7: Median values of mid-term and end-of-term TEI-ratings across four dimensions of potential student improvement.

<table>
<thead>
<tr>
<th></th>
<th>Mid-term</th>
<th>End-of-term</th>
<th>Difference</th>
<th>Standard score (Z)</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weaknesses (^a)</td>
<td>3.22</td>
<td>3.44</td>
<td>0.22</td>
<td>5.42**</td>
<td>0.31</td>
</tr>
<tr>
<td>Strengths (^a)</td>
<td>3.88</td>
<td>3.66</td>
<td>-0.22</td>
<td>-9.98**</td>
<td>0.57</td>
</tr>
<tr>
<td>Overall Average Rating (^b)</td>
<td>3.61</td>
<td>3.53</td>
<td>-0.06</td>
<td>-4.56**</td>
<td>0.26</td>
</tr>
<tr>
<td>Difference in Self and Peer Ratings (^c)</td>
<td>0.14</td>
<td>0.08</td>
<td>0.00</td>
<td>-0.73</td>
<td>0.04</td>
</tr>
</tbody>
</table>

\(^a\) Average of the 3 TEI-behaviours identified as strengths or weaknesses in TEI-feedback reports, \(^b\) Average of all self and peer ratings across all 12 behaviours, \(^c\) Average difference between self and peer ratings across all 12 behaviours. ** \(p \leq 0.01\).

To determine if students improved on their mid-term identified weaknesses, the average mid-term ratings of those weaknesses were compared to their average ratings in end-of-term feedback. A paired Wilcoxon signed-rank test determined that there was a statistically significant difference in average rating of mid-term identified weaknesses of 0.22 between mid-term and
end-of-term feedback ($Z = 5.42$), with a moderate effect size. Thus, an improvement in mid-term TEI-identified weaknesses was seen in students’ end-of-term feedback.

A similar test was run to see if students also improved on their mid-term identified strengths in their end-of-term feedback. A paired Wilcoxon signed-rank test determined that there was a statistically significant difference in average rating of mid-term identified strengths of -0.22 between mid-term and end-of-term feedback ($Z = -9.98$), with a moderate effect size. Thus, a significant decrease in performance of mid-term TEI-identified strengths was seen in students’ end-of-term feedback.

Students’ average self and peer rating (overall average rating) was compared between mid-term and end-of-term feedback to determine if students experienced an overall improvement in TEI-ratings. A paired Wilcoxon signed-rank test determined that there was a statistically significant difference in overall average of -0.06 between mid-term and end-of-term feedback, with a small effect size. Thus, there was a significant decrease in average ratings between mid-term and end-of-term feedback.

Finally, the difference between students’ self and peer ratings was compared between mid-term and end-of-term feedback to see if the ratings team members provided became more aligned with each other over the term. A lower self-peer difference was seen to indicate that the student and their team members had developed a similar understanding of their performance. A paired Wilcoxon signed-rank test determined that there was no significant difference, meaning that while the discrepancy in self and peer ratings did decrease between assessments, it did not decrease significantly.

Improvement in holistic feedback was assessed through the presence of comments acknowledging improvements in specific areas in students’ end-of-term feedback. Twenty percent (20%) of students received an acknowledgement that they had improved their performance along a mid-term identified weakness in their end-of-term feedback. Selected comments from students that articulate these improvements are included in Table 5-8.

Thus, students improved on their weaknesses, decreased on their strengths, and experienced a slight decrease in 12-behaviour-average ratings between mid-term and end-of-term feedback. Some students additionally received feedback that acknowledged their improvements in their
end-of-term holistic feedback. However, the percent of students that received these acknowledgments is small in comparison to the number of students who demonstrated improvement.

Table 5-8: Holistic feedback comments received in end-of-term feedback acknowledging student improvement.

<table>
<thead>
<tr>
<th>Feedback Received by Improving Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Your team mates have noticed that you are participating more and appreciate the respect that it shows.”</td>
</tr>
<tr>
<td>“I think you improved a lot throughout the term in handing your work on time and becoming more engaged as a team member.”</td>
</tr>
<tr>
<td>“You have been putting a lot of effort during the whole process and I can tell you did think of how to improve your attitude. You've become a much nicer person! In the early stage you just edited whatever your wanted but in the [final deliverable] you tried to convince us and seek our agreement (for the test plan thing)!”</td>
</tr>
<tr>
<td>“You have also taken my previous recommendation to heart and begun participating much more in team discussions.”</td>
</tr>
<tr>
<td>“Showed improvement in attending team meetings and involvement in group discussions”</td>
</tr>
</tbody>
</table>

5.3.2. Factors that differentiated student improvement

A series of analyses were completed to determine if there were any factors that enhanced or impeded student improvement. These analyses were conducted with respect to students’ improvement in their TEI-based feedback. Factors of interest included: overall average rating, difference in average between strengths and weaknesses, quantity of holistic feedback that discussed strengths and weaknesses, reviewing feedback on TELS, and use of TELS’ lessons.

To determine if high and low performing students improved equally, full-team consent students were divided into quintiles based on their overall average rating. Table 5-9 shows the difference in improvement scores of student weaknesses and overall average rating between the top 20% and bottom 20% of students.

Two Mann-Whitney U tests were run to determine if there were differences in improvement in student weaknesses and in their overall average rating between the top and bottom quintiles. Distributions of the weakness improvement scores for both groups were similar, as assessed by visual inspection. Median weakness improvement score was statistically significantly higher for the bottom 20% of the class than for the top 20% of the class. Median overall improvement score was statistically significantly higher for the bottom 20% of the class than for the top 20% of the class, with a moderate effect size. Therefore, students that received the lowest mid-term ratings
improved more overall and on their identified weaknesses, than did students that received the highest mid-term assessments.

Table 5-9: Difference in Improvement of student weaknesses and overall rating between the top 20% and bottom 20% of the study population.

<table>
<thead>
<tr>
<th></th>
<th>Bottom 20%</th>
<th>Top 20%</th>
<th>U-score</th>
<th>Standard score (Z)</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weakness Improvement</td>
<td>0.75</td>
<td>-0.22</td>
<td>412</td>
<td>-7.68**</td>
<td>0.75</td>
</tr>
<tr>
<td>Overall Improvement</td>
<td>0.05</td>
<td>-0.10</td>
<td>1,119</td>
<td>-3.79**</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Note: ** $p \leq 0.01$, n = 105

To determine if there was a difference in improvement for students who had more differentiated strengths and weaknesses than those who did not, student improvement was compared to the difference in average ratings between mid-term identified strengths and weaknesses, Table 5-10.

Table 5-10: Amount of difference between strengths and weaknesses in mid-term TEI-ratings between students that did and did not improve on their weaknesses.

<table>
<thead>
<tr>
<th>Strength-Weakness Difference</th>
<th>Student Improved</th>
<th>Student did not Improve</th>
<th>U-score</th>
<th>Standard score (Z)</th>
<th>Effect size (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.78</td>
<td>0.44</td>
<td>13,578</td>
<td>8.89**</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Note: ** $p \leq 0.01$, n = 263

A Mann-Whitney U test was run to determine if there were differences in the magnitude of difference between mid-term identified strengths and weaknesses in students that did or did not improve on their mid-term identified weaknesses. Median difference between mid-term identified strengths and weaknesses was statistically significantly higher for the students that did improve on their weaknesses than for students that did not, with a moderate effect size.

To determine if there was a difference in improvement for students based on the quality of holistic feedback they received, a contingency table analysis was performed. The same metric for holistic feedback quality that was used in Section 5.2.1 (percentage of holistic feedback that discussed strengths and weaknesses) was used here. As can be seen from the response distributions in Figure 5-2, students that improved had a greater percent of holistic feedback that was strengths or weaknesses. This difference is significant, Table 5-11.
Contingency table analyses were also performed to determine if there was a significant difference in improvement for students based on either the number of times they accessed their mid-term feedback, or the number of lessons they accessed on TELS. As can be seen in Table 5-11, neither of these factors were related to student improvement between the two rounds of feedback.

As a result of these analyses, the factors that differentiated student improvement were:

- overall TEI-rating in mid-term feedback
- the magnitude of difference between strengths and weaknesses in mid-term feedback
- the percent of holistic mid-term feedback that was strengths and weaknesses

While it is good to see that students who performed in the bottom quintile of the study population improved the most, it is important to note the factors that affected the entire class. Both the differentiation of strengths and weaknesses and percent of holistic feedback that discusses strengths and weaknesses are measures of high-quality feedback. Thus, the factors that differentiated student improvement were mid-term ratings and the quality of feedback a student received from their team members.

![Figure 5-2: Distribution of student improvement seen in end-of-term feedback compared to the type of holistic mid-term feedback received.](image-url)
Table 5-11: Contingency table analysis comparing student improvement to holistic feedback composition, lesson accesses, and mid-term feedback accesses.

<table>
<thead>
<tr>
<th>Factor Investigated</th>
<th>Pearson’s $\chi^2$</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of holistic feedback that was strengths or weaknesses</td>
<td>11.6</td>
<td>0.21**</td>
</tr>
<tr>
<td>Number of Mid-term Feedback Accesses</td>
<td>3.33</td>
<td>0.11</td>
</tr>
<tr>
<td>Number of Lessons Accessed</td>
<td>1.25</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Note: ** $p \leq 0.01$

5.4. Discussion

In terms of understanding how students used the Team-effectiveness Learning System to improve their behaviour in teams, three key themes emerged from this analysis:

1. The quality of feedback a student receives is the greatest influencing factor in their improvement
2. Students may utilise online lessons (or other resources) more if they are highly visible and easily accessible with their feedback
3. Improving teamwork behaviour is viewed as a remedial activity

Given that students’ primary improvement method is reviewing their feedback, the quality of feedback a student receives has the greatest influence on whether they improve their behaviour or not. This conclusion is supported by the fact that students who received highly differentiated strengths and weaknesses, and holistic feedback that was predominantly strengths or weaknesses were not only more motivated to improve their behaviour (Section 4.5.4) but also actually improved their behaviour. It is also possible that students who received low ratings in their mid-term TEI-based feedback, received ratings that were more reflective of the quality of feedback provided by their team members rather than their absolute ability as team members. In these cases, the low ratings could have served to push students towards a specific area for improvement. High quality holistic feedback appeared to be even more influential than TEI-based feedback in terms of motivating student improvement as feedback that contained more strengths and weaknesses was correlated with a greater number of views of feedback on TELS.

However, high-quality feedback is highly dependent on the students within a team, and how much they engage in the process and in effective teamwork. Without convincing students to utilise other methods of improvement as well, student access to improving their behaviour in teams will not be distributed equitably across a class. Thus, instruction around how to provide
high-quality feedback would provide a high return on student learning about teamwork, but it is not enough to ensure improvement.

Making online lessons better connected to student feedback and more publicized to students, may help to ensure more equitable access to learning across a class. Two factors impeded students access to these lessons: i) the fact that they did not know that there were lessons on TELS, and ii) that accessing the lessons required more than one link (or one-click). As can be seen in the analysis of TELS use data, students clicked on links that were readily visible to them, and engaged with content that was primarily “one-click” to access. This was most evident in the number of students who accessed the lessons splash page (one click - 621 students) compared to the number of students who accessed a lesson (two clicks – 128 students). To encourage students to leverage these resources more, they need to be more explicitly integrated with student feedback. To include a link to lessons that directly correspond to weaknesses may address these issues as well as the students’ concerns from Section 4.5.3 that the feedback they received lacked sufficient information to be actionable.

The students that did utilise the lessons reported that they were useful. However, they contained too much text. Text-based lessons appeared to deter students from reading them and using them. While access data can describe that students opened a lesson in TELS, it cannot describe whether they actually read it or not. Thus, to increase uptake and utility of the lessons for students, they need to be moved to a format that is utilised in online learning systems – video format. Doing so may increase student use of the lessons.

It is important to note that students did not use the lessons as anticipated, i.e. to learn how to improve their behaviour upon reading their feedback. Instead they looked at them when they were on the system to provide feedback. It is possible in this case that students were using the lessons to better understand or concretize the behaviours they were assessing – student comments on the end-of term survey articulated that the lessons helped explain the behaviours and helped students provide better feedback. In this case, the lessons appear to have predominantly helped students provide more accurate assessments of their team members, or to better provide feedback on a behaviour they observed but did not quite know how to describe. Overall, for those who did access them, the lessons supported student learning of teamwork through concretizing the vocabulary of the assessment framework (the TEI).
Students’ lesson access patterns speak to a set of beliefs about how and when to engage in learning about teamwork. The first belief that emerged was that learning about teamwork and explicitly working to improve teamwork may be seen of as a remedial activity. Only if a team, or a student on a team, is doing poorly would it be worthwhile to access the lessons. The second belief was that improving on teamwork is a common-sense activity. To learn to engage or stop engaging in specific behaviours is simply a matter of will and students deciding either to do, or not do it. To increase uptake and use of TELS these beliefs need to be directly challenged. This could be accomplished through a better designed integration of TELS into courses. Students need to see gradations of effectiveness for teams rather than simply functional and dysfunctional.

5.5. Conclusions

Connecting back to the conceptual framework of student improvement, Figure 1-1, the following findings are evident in student use of TELS:

- In terms of providing a framework for effective teamwork: students do use the lessons to better understand and concretise the vocabulary of the team-effectiveness inventory (TEI)
- In terms of developing awareness: students do access and review their mid-term and end-of-term feedback to learn about how they are operating in their teams.
- In terms of efforts to improve: the most common approach was reviewing and analysing feedback. Student uptake of the lessons in TELS was minimal. Students who received high quality feedback reviewed their feedback more.
- In terms of student improvement: a significant improvement in weaknesses was seen across the full-consent study population, with greater improvement observed in the lowest performing students. High quality mid-term feedback was the greatest predictor of student improvement.
6. Conclusions and Recommendations

This thesis presents the development and testing of an online Team-effectiveness Learning System (TELS) and the resultant effects on student behaviour with respect to teamwork in the context of first-year engineering-design courses. TELS provides a novel scaffolded learning experience for engineering students through:

1. Articulating a vocabulary and framework of teamwork behaviours that responds to engineering students task-privileging orientation by highlighting the interpersonal nature of teamwork (Chapter 3);
2. Leveraging self and peer feedback to identify areas needing improvement in student behaviour (Chapter 4); and
3. Integrating online lessons that explain the importance of the behaviours in the framework and provide students with tools and techniques to practice developing each behaviour (Chapter 5).

This educational technology has been tested with 955 first-year engineering students to determine its ability to affect improvement in student teamwork behaviours. From this testing, both the efficacy of the approach and an understanding of student beliefs on learning about teamwork were developed.

6.1. Novelty of TELS as Compared to Existing Tools

The Team-effectiveness Learning System (TELS) provides students with a more detailed understanding of their team-member effectiveness than the existing tools on the market. TELS provides a different approach to assessment and opportunities for improvement, by focusing on the behaviours of team-member effectiveness and providing students with strategies to better demonstrate each of these behaviours in the future. A comparison of the functions of TELS to two other technologies (CATME and ITP Metrics) is provided in Table 6-1. Three key differences are of note between TELS and the other two systems.

1. The framework of team-member effectiveness in TELS is provided to students at a behaviour level instead of at a dimension or aspect level as in CATME and ITP Metrics. As described in Section 1.2.4, the two other systems provide students a framework that
articulates and asks them to assess their capability along five dimensions of teamwork which each comprise multiple behaviours. TELS’ framework of team-member effectiveness (the TEI) provides students with 12 behaviours which act as the specific criteria with which students’ self and peer assess their capability. As a result, students receiving feedback from TELS will know exactly which behaviour they demonstrated well or poorly. Students using CATME or ITP Metrics which amalgamate behaviours into a dimensional assessment will not be able to identify which exact behaviours influenced the assessments they received.

2. TELS provides students an opportunity to provide holistic textual feedback to their team-mates that will allow them to clarify, justify, or expand on the ratings they provided in their behavioural assessments. This differentiates TELS from CATME which currently does not provide such an opportunity.

3. Scaffolded learning in TELS provides students with detailed descriptions of the behaviours, the actions that comprise them, and strategies to demonstrate the behaviours assessed in the system more effectively. Both CATME and ITP Metrics do not provide such detailed information to students to improve their behaviour – they simply articulate what the positive version of the behaviour is with no information on how to achieve demonstrating it or why it might be important.

As a result, TELS provides a more in-depth assessment and feedback opportunity for students that allows them to both understand their performance as well as how to improve it.

Table 6-1: Comparison of the functions of TELS to CATME and ITP Metrics.

<table>
<thead>
<tr>
<th>Tool</th>
<th>Assessment Level</th>
<th>Feedback types</th>
<th>Self and Peer Comparison in Feedback</th>
<th>Scaffolded Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Specific</td>
<td>Holistic</td>
<td></td>
</tr>
<tr>
<td>TELS</td>
<td>Behaviours</td>
<td>Behaviours</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>CATME</td>
<td>Dimensions</td>
<td>Dimensions</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>ITP Metrics</td>
<td>Dimensions</td>
<td>Dimensions</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Lessons that comprise tools and techniques to develop each behaviour
List of positive behaviours in each dimension
List of positive behaviours in each dimension and student self-reflection on how to improve
6.2. Efficacy of TELS in Facilitating Student Improvement in Teamwork

Student improvement in teamwork was supported through three approaches that correspond to the initial hypotheses of this thesis, that student competency in teamwork can be improved through:

Hypothesis 1: *providing students a framework (TEI) to self and peer assess team-member effectiveness that highlights the interpersonal nature of teamwork* (Study 1 – Chapter 3)

Hypothesis 2: *using self and peer feedback with this framework to facilitate student awareness of their behaviour* (Study 2 – Chapter 4)

Hypothesis 3: *providing scaffolding and resources to facilitate student improvement based on feedback received.* (Study 3 – Chapter 5)

Hypotheses one and two were accepted and hypothesis three was rejected.

One of the significant contributions of this work is the development of a Team-effectiveness Inventory. The final TEI for self and peer assessment, the final 12-item inventory has better construct validity, first-use reliability, and ease of understanding than the initial 27-item inventory. The behaviours in the inventory were reported by students as being useful in articulating a model of effective teamwork.

Utilising the inventory to guide the feedback process caused students to think beyond the Organisational behaviours that they traditionally use to describe teamwork. Providing holistic feedback with the inventory resulted in students discussing more Relational and Communication behaviours in feedback to their team members. Additionally, end-of-term feedback, had a greater percentage of Relational holistic feedback items than students’ mid-term feedback. The distribution of behaviours discussed in holistic feedback between mid- and end-of-term feedback indicated a shift from an individualistic approach to teamwork (divide and conquer) to a collaborative approach (interact with others to build the best result). Two Relational behaviours were more prominent in end-of-term feedback: *R2 – seeks and includes the input of others*, and *R4 – listens and pays attention to others*. Both of these behaviours are ones that demonstrate valuing the contributions of others and leveraging them in team discussions. This indicated that
students developed an understanding of the importance of collaborative behaviours that create quality interactions with team members.

The system facilitated improvement through developing student awareness of their behaviour. The feedback students received was the dominant predictor and self-reported cause of students working to improve their behaviour. This meant that the feedback they received provided them with an awareness of what to improve. Ninety-five percent of students logged on to TELS to access and review their mid-term and end-of-term feedback. Students’ responses to the end-of-term survey indicated that most students were motivated to improve and had areas of improvement identified in their feedback. The feedback from students’ team-members was as reliable as the ratings from teaching assistants or observers trained in teamwork observation meaning that students’ team members were able to provide feedback that was a representative and useful description of the recipient student’s behaviour. Students provided feedback that was formative in nature, focusing more heavily on developmental feedback in the mid-term round, and acknowledging improvement in the end-of-term round. Students’ agreement with their feedback also emerged as a strong predictor of whether a student would be motivated to improve their behaviour or not. Students’ TEI-based ratings improved between the two rounds of feedback, and improved significantly in the areas of weakness identified in mid-term feedback, demonstrating conclusively that the self and peer assessments provided through TELS do promote improvement through making students aware of the areas in which they need to improve.

Facilitating improvement through on-line lessons within TELS was not as successful. This method was not effective and was only taken up by 13% of students. Lessons were used predominantly by students when providing feedback as opposed to once they had received feedback. Some students reported that they used the lessons to better understand and concretise the vocabulary of the team-effectiveness inventory (TEI). It is possible that the providing students’ use of the lessons enhanced their ability to provide high quality feedback which in turn led to the recipient student’s improvement, but this cannot be proven. Reviewing the lessons could also have exposed students to new ideas about teamwork that they did not know previously. For students that did utilise the lessons, students reported that they were useful, however they contained too much text. Text-based lessons appeared to deter students from
reading them and using them. No association was evident between lesson accesses and improvement in student behaviour. However, given the small percentage of students who accessed them it is not clear if there would have been an association had more students used them.

6.3. Findings about Student Learning of Teamwork

This section addresses the second research question:

*What does student use of and response to the online team-effectiveness learning system tell us about how they understand teamwork?*

From student use of and response to TELS, three findings about how engineering students understand teamwork were apparent:

1) Students see teamwork as predominantly a work-product production environment
2) Teamwork is seen of as ‘common-sense’ and therefore working to improve at teamwork is a remedial activity
3) Engineering students apply their positivist epistemology to providing and reading feedback

Students see teamwork as a predominantly work-product production environment; this was seen in students’ privileging of the Organisational behaviours when providing holistic feedback and in their responses to the items in the TEI. When asked to provide feedback in the absence of a framework of effective behaviours, students overwhelmingly discussed work-product development items which would be categorised as Organisational behaviours based on the TEI. In students’ responses to what was missing from the feedback they received, students reported that their feedback lacked a discussion of their ability to produce good technical work for their team – they wanted to know if their team members were “happy with their work.” Students’ focus on the work-products of their teamwork when thinking of effective teamwork may be limiting for student development. From the external raters’ assessment of team-level performance using the TEI as assessment criteria, the behaviours in the Relational aspect of the inventory were the more visible predictors of team effectiveness. As a result, while using the TEI
expands students’ understanding of teamwork beyond work-production behaviours, more intentional instruction to complement the TEI in the classroom is still needed.

The second theme that emerged was that teamwork is a common-sense activity. When asked to describe how students improved their team-member effectiveness they reported thinking about the behaviour and remembering to do it more. It appeared as though students believed that learning to engage or stop engaging in specific behaviours was simply a matter of will and either deciding to do, or not to do it. As a result, students may not see gradations of effectiveness for teams and instead simply see functional and dysfunctional. This could be seen in students’ response to the use of lessons, where students reported not using them because their teams were good and they did not need help. Without breaking down this belief in students, teamwork may be viewed as an innate quality that one is either good or bad at, instead of a skill that can be developed with practice. Encouraging students to develop a mastery mindset around teamwork and team-member effectiveness behaviours may be one approach to addressing this issue.

It is important to note that TELS is the only system that has analysed how students worked to improve their team-member effectiveness based on feedback received. In TELS this was completed through tracking student use of the system and through collecting student feedback about how TELS supported their development. Both CATME and ITP Metrics have not yet published about how students use their systems to enhance their performance.

The third theme that emerged, was that engineering students’ positivist epistemology was present in their beliefs about their feedback; they believed there was a right way to behave and that their team members should have given this information to them so they could simply execute on it. While there exists the possibility of multiple ways of improving the same weakness, this particular response to the feedback they received does not acknowledge this multiplicity. Ironically, one possibility for this ‘truth’ was presented in the tools and techniques available through TELS lessons and in the TEI, but students did not readily take this up. Students wanted their holistic feedback to read in problem-solution form - they wanted the feedback they received to articulate both the problem as well as identify for them the desired solution. When providing feedback to me about the TELS system, students used this problem-solution approach, but appeared to struggle with doing so when articulating feedback about behaviours. Thus, while
students may be able to identify what is not working effectively in their teams, they may not
know how to articulate the desired behavioural change they want to see.

6.4. Implications for Teaching Teamwork

Based on student use of TELS, and the findings about how they understand teamwork, three
strategies for teaching teamwork more effectively can be inferred. These strategies will be most
useful in situations where students’ beliefs that teamwork is common sense, and either functional
or dysfunctional, have been broken down so that a mastery mindset can be present in student
learning.

First, teaching teamwork needs to be synonymous with teaching students how to provide
high quality feedback. Since the quality of holistic feedback a student received was the greatest
influencing factor in their improvement, training students in how to provide this type of feedback
effectively is needed. The TEI provides a framework for the behaviours to be discussed that
expands the scope of students understanding of teamwork, and as a result the scope of feedback
one student gives another student. However, it does not influence the quality of the textual
feedback. Modelling for students how to provide constructive textual feedback that is specific
and actionable for both strengths and weaknesses would enhance the ability of students receiving
feedback to improve their behaviour.

Second, students need to be reminded of the resources that are available to them. Despite
students being informed about the existence of the lessons both in lecture in advance of
providing feedback, and with the email announcing that their feedback reports were available,
students still forgot that there were lessons on TELS. Students may utilise online lessons (or
other resources) more if they are highly visible and easily accessible with their feedback.
Integrating messaging about lessons into feedback reports, or facilitating a class-level debrief on
the most frequently identified weaknesses that showcases the lessons may promote greater
student uptake.

Third, to increase the uptake and utility of the lessons, they need to be moved to a format that
is easier to assimilate than text – possibly video format. Making short (possibly humourous)
videos of the behaviours demonstrating how the tools and techniques available can enhance a
student’s performance may increase student use of the lessons. While student use of the lessons
was not predictive of behavioural improvement, changing the format of them to make them more accessible may create such an association.

### 6.5. Recommendations for Future Research

Based on the findings of this Thesis, there are four areas for future research that would enhance student learning of teamwork, and the efficacy of TELS in the engineering student classroom.

1. **Identifying engineering students’ beliefs about teamwork**

   This thesis explored engineering students’ orientations to teamwork through the use of secondary data: my experience in the classroom, literature on engineering students, and inferences about their beliefs from their feedback on TELS and learning about teamwork. To confirm that the TEI is indeed designed to encourage students to see ‘who’ their team members are and to encourage them to privilege the interpersonal nature of teamwork, students’ beliefs about teamwork and their task-orientation towards it need to be confirmed through primary data. Gathering and analysing students’ beliefs about teamwork and learning teamwork in engineering students’ own vocabulary will contribute to the literature (which currently lacks such an understanding) and to TELS through confirming and/or improving the inventory to meet engineering students’ needs. This information can then be used to develop ways to unseat the beliefs exposed in this thesis that teamwork is common sense, with one right answer, and only to be studied by those who are bad at it.

2. **Explore student use of multimedia lessons**

   As discussed in Chapter 5, student uptake of the learning objects provided to them within TELS was limited. Students reported both that they contained too much text and were unaware of the lessons. Converting these lessons to a multi-media format (such as videos) that could demonstrate what the behaviours look like and how they affect team members may enhance uptake and adoption of behavioural improvement techniques. Exploring this will extend the understanding of student improvement approaches developed in this thesis and facilitate a more effective TELS system.
3. Explore other implementations of TELS

As discussed in Section 2.4, only one use-case for TELS was tested in this thesis – a two round feedback process approximately 6 weeks apart. While this use case followed the course deliverables and term timing well, exploring whether this is the ideal frequency for facilitating student improvement should be investigated. Additionally, TELS was only tested in engineering design classrooms while it may be effective in broader pedagogical contexts. Testing TELS in different types of team projects with different frequencies of use would extend the efficacy of TELS through being able to articulate the ideal use cases for different scopes and types of teamwork projects.

4. Longitudinal teamwork behaviour development with a cohort of students

The implementation of TELS explored in this thesis only investigated first-year engineering students’ improvement in teamwork in one course; longitudinal effects of the system to assess transferability of a student’s teamwork behaviours between teams, and across years, was not investigated. TELS should be tested with a cohort of students to track their learning and improvement across multiple teams and multiple years. Exploring this will extend the applicability of TELS as a pedagogical approach to learning teamwork through confirming that the behaviours in the TEI are applicable to upper year teamwork and that TELS can scaffold learning across multiple courses and multiple years.
References


Information redacted to preserve blind review. (n.d.).


Appendix A. 12-item Team-effectiveness Inventory

<table>
<thead>
<tr>
<th>ORGANISATIONAL</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attend team meetings prepared</strong></td>
<td>Did not attempt to prepare anything or complete tasks in advance of meetings</td>
<td>Meeting preparation done hastily within minutes of the meeting commencing, or while other aspects of the meeting were underway</td>
<td>Preparation was completed but its presentation at the meeting was not well thought out in terms of delivery or team response</td>
<td>Prepared meeting information in a thoughtful manner that accounted for expected team response</td>
</tr>
<tr>
<td><strong>Do their fair share of the work</strong></td>
<td>Did not complete their fair share of the work</td>
<td>Completed their fair share of the work only when requested/reminded</td>
<td>Completed all their allocated work</td>
<td>Completed their allocated work and assisted other team members whenever necessary with theirs</td>
</tr>
<tr>
<td><strong>Deliver their work on time</strong></td>
<td>Did not complete their work on time</td>
<td>Completed some of their work on time; or only completed their work when requested</td>
<td>Completed all their work on time</td>
<td>Completed all their work on time and assisted other team members in meeting deadlines when needed</td>
</tr>
<tr>
<td><strong>Help to plan and organize workflow</strong></td>
<td>Did not assist in developing goals, deadlines, or timelines</td>
<td>Tried to organize/plan work solely for their benefit</td>
<td>Helped to organize/plan work for the benefit of the whole team</td>
<td>Helped to organize/plan work for the benefit of the whole team and adapted their workflow when needed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>RELATIONAL</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demonstrate Accountability</strong></td>
<td>Did not follow through on commitments and did not admit when they had not completed work</td>
<td>Followed through on some commitments when reminded and admitted when something was not completed if there was little repercussion to the admission</td>
<td>Followed through on commitments and admitted when something was not done</td>
<td>Followed through on commitments and if something was not done, presented an alternate plan for success</td>
</tr>
<tr>
<td><strong>Show respect for team members</strong></td>
<td>Did not show respect for other team members</td>
<td>Showed respect for other team members infrequently</td>
<td>Showed respect for other team members at all times</td>
<td>Showed respect for all team members, and encouraged others to respect them through their actions towards the team</td>
</tr>
<tr>
<td><strong>Listen and pay attention to team members</strong></td>
<td>Did not pay attention to team activity, did not listen to team members.</td>
<td>Appeared distracted at times and occasionally demonstrated an interest in team activity or discussion</td>
<td>Paid attention to other team members when talking, listened to them and did not interrupt them</td>
<td>Maintained focus on team activity, listened to others and demonstrated engagement with what was being said</td>
</tr>
<tr>
<td>COMMUNICATION</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Exchange information in a timely manner</strong></td>
<td>Did not exchange information unless requested repeatedly</td>
<td>Exchanged information when prompted</td>
<td>Exchanged information in a timely manner, rarely needing prompting</td>
<td>Exchanged all information and encouraged other team members to do so as well</td>
</tr>
<tr>
<td><strong>Openly express ideas and opinions</strong></td>
<td>Did not express ideas or opinions</td>
<td>Expressed ideas and opinions in a manner which detracted from the team’s productivity</td>
<td>Expressed ideas and opinions in an open and constructive manner</td>
<td>Expressed ideas and opinions in an open and unbiased manner that welcomed input from others</td>
</tr>
<tr>
<td><strong>Promote productive discussion</strong></td>
<td>Did not engage in discussion with team members</td>
<td>Engaged in discussion that did not focus the team toward decision making</td>
<td>Engaged in focused discussion that moved the team towards making decisions</td>
<td>Engaged in focused discussion that moved the team towards decisions and ensured the whole team contributed to the discussion</td>
</tr>
<tr>
<td><strong>Raise contentious issues in a constructive way</strong></td>
<td>Avoided contentious issues</td>
<td>Raised contentious issues in a biased or destructive manner</td>
<td>Raised contentious issues constructively in a manner that focused on the benefit to self</td>
<td>Raised contentious issues in a manner that focused on team improvement</td>
</tr>
</tbody>
</table>
Appendix B. Behavioural Sorting Algorithm on TELS

To surface the top three strengths and bottom three weaknesses, sort the behaviours according to the following heuristic. This will bring the strengths that the student is unaware of to the top and the weaknesses that the student is unaware of to the bottom.

Sort the competencies sequentially by:

1. Average Peer Assessment from smallest to largest
2. Difference between Self and Average Peer Assessment from smallest to largest
3. Peer Assessment Standard Deviation from largest to smallest
4. Average Self and Peer Assessment from smallest to largest
Appendix C. 27-item Team-effectiveness Inventory

Please provide feedback on <Name of Teammate 1>’s competency as an effective team member. Please select one competency level along each of the behaviours listed below, using intermediate levels when a team member’s competency falls in between the described levels.

<table>
<thead>
<tr>
<th>ORGANIZATIONAL ASPECTS</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support team rules</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Did not contribute to the development or team rules, nor did they abide by them during the project</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Supported only those rules which were convenient or they felt were appropriate</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Contributed to the development of the rules and supported most of the rules, most of the time</td>
<td></td>
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<tr>
<td>Contributed to the development of the rules, and not only supported them but assisted other teammates in supporting them</td>
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</tr>
<tr>
<td>Attend team meetings prepared</td>
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<td></td>
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</tr>
<tr>
<td>Did not attempt to prepare anything in advance of meetings</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Meeting preparation done hastily within minutes of the meeting commencing, or while other aspects of the meeting underway</td>
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<tr>
<td>Preparation was sparse and not well thought out in terms of delivery or team response</td>
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<tr>
<td>Prepared meeting information in a thoughtful manner that accounted for expected team response</td>
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<tr>
<td>Contribute to making meetings effective</td>
<td></td>
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<tr>
<td>Did not engage in discussion or participate in collaborative work; appeared to be “off in another world”</td>
<td></td>
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<tr>
<td>Engaged in the areas of the meeting that were within their individual work scope only; engaged superficially in other aspects of the meeting</td>
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<tr>
<td>Engaged in all aspects of the meeting; assisted in guiding the conversation towards important decisions</td>
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<tr>
<td>Contributed to shaping the decisions made in all areas of the meeting; ensured everyone was ‘on the same page’ at all times; engaged less responsive team members</td>
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<tr>
<td>Do their fair share of the work</td>
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<tr>
<td>Did not complete their fair share of the work</td>
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</tr>
<tr>
<td>Completed their fair share of the work only when requested</td>
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</tr>
<tr>
<td>Completed their allocated work</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Completed their allocated work and assisted other team members whenever necessary with theirs</td>
<td></td>
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</tr>
<tr>
<td>Deliver their work on time</td>
<td>Did not complete their work on time</td>
<td>Completed some of their work on time; or only completed their work when requested</td>
<td>Completed all their work on time</td>
<td>Completed all their work on time and assisted other team members in meeting deadlines as well</td>
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<td>-------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Produce high-quality work</td>
<td>Produced work below the expectations of the team and was not open to improving their work</td>
<td>Produced work at an acceptable level when assisted by the team, or when given specific areas to improve</td>
<td>Produced high quality work</td>
<td>Produced high quality work and assisted in ensuring other team members did similarly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Help to plan, set goals and organize work</td>
<td>Did not help in developing goals or ways to attain</td>
<td>Helped plan goals and work around their needs only</td>
<td>Helped to organize/plan work for the benefit of the whole team once goals were set by other team members</td>
<td>Solicited team members other obligations and used them to assist in developing attainable goals and organizing work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Track team progress vs. project timeline</td>
<td>Did not track team progress</td>
<td>Tracked team progress in areas that were relevant to their aspects of the work</td>
<td>Tracked whole team’s progress as a means of ensuring everyone was on task</td>
<td>Tracked whole team’s progress as a means of providing support to those who were behind</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encourage progress to meet goals and deadlines</td>
<td>Focused solely on meeting their individual goals and deadlines; was not concerned with team progress towards goals</td>
<td>Encouraged progress towards deadlines when the team fell behind, or when deadlines were looming</td>
<td>Encouraged progress towards goals and deadlines that presented a challenge to the team</td>
<td>Encouraged progress towards all goals and deadlines and ensured all team members were progressing accordingly</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Display dedication and determination</td>
<td>Did not display any concern about meeting team goals</td>
<td>Displayed dedication and determination with respect to their own work</td>
<td>Displayed dedication and determination most of the time</td>
<td>Displayed dedication and determination at all times as a means of motivating others towards reaching team goals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RELATIONAL ASPECTS</td>
<td>Build the trust of team members</td>
<td>Expected to be trusted by others without demonstrating trust in others</td>
<td>Worked in a manner in which trust was implied, but was not consciously developed or discussed</td>
<td>Engaged in non-work related activities to consciously build trust between team members</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivate others on the team to do their best</td>
<td>Did not demonstrate interest in the motivation of anyone on the team, including self</td>
<td>Did not demonstrate interest in the motivation of others on the team</td>
<td>Attempted to motivate others when it was beneficial to self, or was not too time consuming</td>
<td>Motivated others on the team to do their best at all times during the project</td>
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</tr>
<tr>
<td>Raise contentious issues in a constructive way</td>
<td>Raised contentious issues in a destructive manner</td>
<td>Avoided contentious issues</td>
<td>Raised contentious issues constructively in a manner that clearly focused on the benefit to self only</td>
<td>Raised contentious issues in a manner that focused on team improvement and no person in particular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solicit input before proceeding</td>
<td>Proceeded without asking for others’ opinions</td>
<td>Solicited input before proceeding on areas that were contentious only</td>
<td>Solicited others for input before proceeding in all tasks</td>
<td>Solicited others for input before proceeding in all tasks, and encouraged all team members to provide input</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Adopt suggestions from other members</td>
<td>Did not adopt others’ suggestions about their work/work habits</td>
<td>Adopted suggestions they felt were appropriate only or in areas that were easy</td>
<td>Adopted suggestions from others without soliciting input on how they were adopted</td>
<td>Adopted suggestions from others and solicited input from the team on how they were adopted</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accept feedback about strengths and weaknesses</td>
<td>Disregard all feedback as incorrect or irrelevant</td>
<td>Accept feedback about some strengths and weaknesses, but only those they agree with</td>
<td>Accepts feedback about strengths and weaknesses but does not attempt to improve based on it</td>
<td>Accepts feedback about strengths and weakness and attempts to improve through soliciting additional feedback on their attempted improvements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Show respect for other team members</td>
<td>Did not show respect for other team members</td>
<td>Showed respect for other team members only when they agreed with them or were working well together</td>
<td>Showed respect for all other team members</td>
<td>Showed respect for all team members, and encouraged others to respect them through their actions towards the team</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrate accountability</td>
<td>Did not admit when they were wrong or had not completed work</td>
<td>Admitted when they were wrong if there was little repercussion to the admission</td>
<td>Admitted when they were wrong or if something was not done regardless of the possible repercussions</td>
<td>Admitted when they were wrong or if something was not done and presented an alternate plan for success; encouraged others to demonstrate accountability</td>
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</tr>
<tr>
<td>Collaborate effectively</td>
<td>Did not attempt to engage with the team on any aspect of the work</td>
<td>Collaborated with others when it was beneficial to the work they were assigned only</td>
<td>Collaborated with others in a manner which promoted openness and understanding among team members</td>
<td>Collaborated with, and supported where needed, other team members in any manner that was beneficial to team objectives or dynamics</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**COMMUNICATION ASPECTS**

<table>
<thead>
<tr>
<th>Exchange information in a timely manner</th>
<th>Did not exchange information in a timely manner, and only exchanged information when requested repeatedly</th>
<th>Exchanged information when prompted, but needed at least one reminder</th>
<th>Exchanged information in a timely manner most of the time and rarely needed prompting</th>
<th>Exchanged all information before it was necessary and ensured that all other teammates exchanged their information on time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduce new ideas</td>
<td>Did not introduce new ideas</td>
<td>Introduced new ideas only when prompted by other team members</td>
<td>Introduced new ideas often</td>
<td>Introduced new ideas, and encouraged others to do similarly</td>
</tr>
<tr>
<td>Openly express opinions</td>
<td>Did not express opinions</td>
<td>Expressed opinions in a manner which demonstrated hesitation or reservation</td>
<td>Expressed opinions in an open manner</td>
<td>Expressed opinions in an open and unbiased manner that solicited input from others</td>
</tr>
<tr>
<td>Promote constructive brainstorming</td>
<td>Did not contribute to brainstorming</td>
<td>Presented few ideas; judged ideas as they were presented</td>
<td>Presented ideas and did not judge others’ ideas</td>
<td>Presented ideas and did not judge others’ ideas; encouraged those less active to participate and all to be non-judgmental</td>
</tr>
<tr>
<td><strong>Actively listen to team members</strong></td>
<td>Did not listen to team members</td>
<td>Listened to others, but appeared distracted and did not demonstrate an interest in what was being said</td>
<td>Listened to others and demonstrated interest in what was being said</td>
<td>Listened to others, and demonstrated interest and understanding of what was being said through demonstrating engagement with what was being said</td>
</tr>
<tr>
<td><strong>Provide constructive feedback</strong></td>
<td>Did not provide feedback</td>
<td>Provided feedback in a manner that demonstrated criticism rather than critique</td>
<td>Provided unbiased and relevant feedback to team members that did not attack the person they were critiquing</td>
<td>Provided unbiased and relevant feedback, and identified opportunities within where the team member could improve</td>
</tr>
<tr>
<td><strong>Make sure that team members understand important information and instructions</strong></td>
<td>Did not care if team members understood information or instructions</td>
<td>Made sure team members understood information that was relevant to their tasks OR responded forcefully if team members did not understand information/instructions</td>
<td>Ensured team members understood important information/instructions</td>
<td>Ensured team members understood important information/instructions through openly soliciting questions on information and providing clarification when possible</td>
</tr>
<tr>
<td><strong>Help the team build consensus</strong></td>
<td>Detracted from the team’s ability to build consensus</td>
<td>Helped build consensus in areas that were relevant to their tasks only</td>
<td>Helped the team build consensus in either task or team related areas</td>
<td>Helped the team build consensus in task and team related areas</td>
</tr>
</tbody>
</table>
Appendix D. Feedback from the 27-item TEI

360° Team Effectiveness Evaluation for Student 157

You have received the following assessments from your team members based on your performance in your ESC102 team project.

<table>
<thead>
<tr>
<th>Behaviours</th>
<th>Self</th>
<th>Feedback from Teammates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support team rules</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Attend team meetings prepared</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Contribute to making meetings effective</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Do their fair share of the work</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Deliver their work on time</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Produce high quality work</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Help to plan, set goals, and organize work</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Track team progress vs. your timeline</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Encourage progress to meet goals and deadlines</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Display dedication and determination</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Build the trust of teammates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivate others on the team to do their best</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Raise contentious issues in a constructive way</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Solicit input before proceeding</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Adopt suggestions from other members</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Accept feedback about strengths and weaknesses</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Show respect for other teammates</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Demonstrate accountability</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Collaborated effectively</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Exchange information in a timely manner</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Introduce new ideas</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Openly express opinions</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Promote constructive brainstorming</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Actively listen to teammates</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Provide constructive feedback</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Make sure that teammates understood important information and instructions</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Help the team build consensus</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

What does this mean to me?
The behaviours highlighted in green are your areas of greatest strength, those in yellow are areas where you are competent, and in red are your opportunities for greatest improvement. To improve your effectiveness as a team member, it is recommended that you work on the areas highlighted in red first, as they will create the greatest change in your effectiveness.
Appendix E. Unstructured Feedback from Study 1 Phase 1

Team-effectiveness Feedback

Student 50

You have received the following feedback from your team members based on your performance in your ESC102 team project. To improve your effectiveness as a team member, it is recommended that you work on the areas outlined as weaknesses as they will create the greatest change in your effectiveness.

-----------------------------------------------------------------------------------------------------------------------------

Over the course of the Topic Precis and RFP I believe that I was very effective while working with my team since we divided work fairly, I completed my allotted work, and I helped other complete their parts by helping them with small things they were having difficulty with. I was also open to the ideas of my teammates and helped them develop these ideas where necessary. However, I could have been a little more open to their ideas and should try to do this to a greater extent during the design phase. My communication skills were excellent and there were few to no problems in terms of clarity when discussing ideas or the work that needed to get done. Additionally, I believe my team and I were organized throughout the process, given that we would share the work that we completed with our group members so that we could assess our progress. In addition, we also set deadlines for when work had to be done, and we met most of these deadlines so that we were never rushing to meet a submission deadline.

-----------------------------------------------------------------------------------------------------------------------------

It was a great experience being [their] team member. [they] was a great leader in the group, set up team meetings, always offered to add more to the project (ie. formatting and editing the final document) and [they] produced quality work on time with our set deadlines.

-----------------------------------------------------------------------------------------------------------------------------

[they] always does [their] research in great details, and doesn't mind to take on works which [they] is good at, such as document's format editing. [they] also gives this team lots of insights during the research phase. [their] willingness to go beyond the requirements really makes a huge difference. I value [them] as a teammate.

-----------------------------------------------------------------------------------------------------------------------------

Great job done on bringing all parts together and master editing the RFP itself. Put in a great amount of work and time into the RFP so as to ensure it was up to standards. Helped with all the formatting issues and revision work as well.
Appendix F. Study 1 Phase 1 End-of-term Survey

Please complete the following survey, reflecting solely on your experiences in this course, and on the feedback you received on your team-effectiveness performance at the midpoint.

1) The amount of feedback I received was: (select one)
   - Too little
   - Enough
   - Too much

2) The feedback I received was structured in such a way that:
   - I understood the feedback
   - I found out what my strengths are
   - I found out what my weaknesses are
   - It motivated me to want to improve my competence
   - It was useful

3) I received feedback on:
   - A broad range of topics
   - Specific areas of team effectiveness
   - My ability to organize a team’s tasks effectively
   - My ability to relate to other team members effectively
   - On the way I communicated with other team members
   - On my ability to resolve conflict
   - On my ability to appreciate differences
   - On my overall contribution to the team

4) The feedback I received described me exactly how I perceived myself

If the feedback described you differently you had perceived yourself, please explain how it was different:

_________________________________________________________________
_________________________________________________________________
_________________________________________________________________
_________________________________________________________________

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5) Were you motivated to improve your performance? If so, what did you do to improve it?

______________________________

______________________________

6) Feedback to me was phrased in a:
   - Positive tone
   - Neutral tone
   - Negative tone

7) How did the tone in which your feedback was phrased affect your motivation to improve your performance?

______________________________

______________________________

8) The amount of time I spent initially planning/practicing to improve my performance after receiving the feedback was:
   - None
   - 0 – 1 hour
   - 2 – 3 hours
   - 4 – 5 hours
   - 6 – 7 hours
   - > 7 hours

9) What information would you have liked to see in feedback to you that wasn’t there? What was provided that was unnecessary?

______________________________

______________________________

10) Based on the feedback, I was better able to determine my competency level during future teamwork?

   Strongly Disagree
   Disagree
   Slightly Disagree
   Neutral
   Slightly Agree
Appendix G. Study 1 Phase 1 Focus Group Questions

Note: For the TA focus group, the word “teammates” was replaced with “students.”

**Usability:**
How user-friendly was the tool to use? What would you do to make it more user-friendly?
Did you understand all of the terminology in the framework?
Were there aspects of completing the framework you found difficult to work with? If so, describe.
Were there aspects of submitting/receiving feedback that you found difficult to work with? If so, describe.
How did the framework map to your personal perceptions of what team-effectiveness is?
Were you able to provide all the feedback you wanted to using the framework? Is there any content that should be added to or removed from the framework?
Could you easily rank the competency of your team-mates using the scale provided? Which competency levels were easy to understand, and which were complicated?
Was there a benefit to categorizing the competencies? Did this affect your ability to assess your teammates effectively?

**Web-based Tool:**
How long would you be willing to spend filling out such a framework per teammate?
How did you perceive the layout of the tool?

**Open Questions:**
Are there any other comments you would like to provide the designers about using the framework?
## Appendix H. 18-item Team-effectiveness Inventory

<table>
<thead>
<tr>
<th>ORGANISATIONAL</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attend team meetings prepared</strong></td>
<td>Did not attempt to prepare anything or complete tasks in advance of meetings</td>
<td>Meeting preparation done hastily within minutes of the meeting commencing, or while other aspects of the meeting were underway</td>
<td>Preparation was completed but its presentation at the meeting was not well thought out in terms of delivery or team response</td>
<td>Prepared meeting information in a thoughtful manner that accounted for expected team response</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Do their fair share of the work</strong></td>
<td>Did not complete their fair share of the work</td>
<td>Completed their fair share of the work only when requested/reminded</td>
<td>Completed all their work on time</td>
<td>Completed all their work on time and assisted other team members in meeting deadlines as well</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Deliver their work on time</strong></td>
<td>Did not complete their work on time</td>
<td>Completed some of their work on time; or only completed their work when requested</td>
<td>Completed all their work on time</td>
<td>Completed all their work on time and assisted other team members in meeting deadlines as well</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Produce high quality work</strong></td>
<td>Produced work below the expectations of the team and was not open to improving their work</td>
<td>Produced work at an acceptable level when assisted by the team, or when given specific areas to improve</td>
<td>Produced high quality work</td>
<td>Produced high quality work and assisted in ensuring other team members did similarly</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Help to plan and organize workflow</strong></td>
<td>Did not assist in developing goals, deadlines, or timelines</td>
<td>Tried to organize/plan work solely for their benefit</td>
<td>Helped to organize/plan work for the benefit of the whole team</td>
<td>Helped to organize/plan work for the benefit of the whole team and readjusted their workflow when needed by the team</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Encourage progress to meet goals and deadlines</strong></td>
<td>Focused solely on meeting their individual goals and deadlines; was not concerned with team progress towards goals</td>
<td>Encouraged progress towards deadlines when the team fell behind, or when deadlines were looming</td>
<td>Encouraged progress towards goals and deadlines at all times, including times when deadlines were far away</td>
<td>Encouraged progress towards goals and deadlines and ensured all team members were supported to meet them</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RELATIONAL</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
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</tr>
<tr>
<td>Build the trust of team members</td>
<td>Did not attempt to build trust with team members</td>
<td>Expected to be trusted by others without demonstrating trust in others</td>
<td>Worked in a manner in which trust was implied, but was not consciously developed or discussed</td>
<td>Engaged in activities to consciously build trust between team members</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivate others on the team to do their best</td>
<td>Did not demonstrate interest in the motivation of anyone on the team, including self</td>
<td>Did not demonstrate interest in the motivation of others on the team</td>
<td>Attempted to motivate others when it was beneficial to self, or was not too time consuming</td>
<td>Motivated others on the team to do their best at all times during the project</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adopt suggestions from other members</td>
<td>Did not adopt others’ suggestions/feedback about their work/work-habits</td>
<td>Adopted suggestions/feedback they felt were appropriate only or in areas that were easy</td>
<td>Adopted suggestions/feedback from others but did not solicit further guidance</td>
<td>Adopted suggestions/feedback from others and actively solicited further guidance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Show respect for other team members</td>
<td>Did not show respect for other team members</td>
<td>Showed respect for other team members only when they agreed with them or were working well together</td>
<td>Showed respect for other team members at all times</td>
<td>Showed respect for all team members, and encouraged others to respect them through their actions towards the team</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demonstrate accountability</td>
<td>Did not admit when they were wrong or had not completed work</td>
<td>Admitted when they were wrong if there was little repercussion to the admission</td>
<td>Admitted when they were wrong or if something was not done regardless of the possible repercussions</td>
<td>Admitted when they were wrong or if something was not done and presented an alternate plan for success</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Help the team build consensus</td>
<td>Detracted from the team’s ability to build consensus</td>
<td>Helped build consensus in areas they demonstrated interest in</td>
<td>Helped the team build consensus</td>
<td>Helped the team build consensus and presented alternate methods of finding consensus when the team was deadlocked</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMUNICATION</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
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<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------</td>
</tr>
<tr>
<td>Exchange information in a timely manner</td>
<td>Did not exchange information in a timely manner, or only exchanged information when requested repeatedly</td>
<td>Exchanged information when prompted, but needed at least one reminder</td>
<td>Exchanged information in a timely manner most of the time and rarely needed prompting</td>
<td>Exchanged all information before it was necessary and ensured that all other teammates exchanged their information on time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Openly express ideas and opinions</td>
<td>Did not express ideas or opinions</td>
<td>Expressed ideas and opinions in a manner which demonstrated hesitation or reservation</td>
<td>Expressed ideas and opinions in an open and constructive manner</td>
<td>Expressed ideas and opinions in an open and unbiased manner that solicited input from others</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Promote productive discussion</td>
<td>Did not engage in discussion with team members</td>
<td>Engaged in discussion that did not focus the team on the topics</td>
<td>Engaged in focused discussion that moved the team towards decisions</td>
<td>Engaged in focused discussion that moved the team towards decisions and ensured the whole team contributed to the discussion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actively listen to team members</td>
<td>Did not listen to team members</td>
<td>Appeared distracted and did not demonstrate an interest in what was being said</td>
<td>Listened to others and did not interrupt them</td>
<td>Listened to others and demonstrated engagement with what was being said</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Raise contentious issues in a constructive way</td>
<td>Avoided contentious issues</td>
<td>Raised contentious issues in a biased or destructive manner</td>
<td>Raised contentious issues constructively in a manner that clearly focused on the benefit to self</td>
<td>Raised contentious issues in a manner that focused on team improvement and no person in particular</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solicit input before proceeding</td>
<td>Proceeded without asking for others’ input</td>
<td>Solicited input before proceeding on areas that were contentious only</td>
<td>Solicited others for input before proceeding in critical areas</td>
<td>Solicited others for input before proceeding in all tasks, and encouraged all team members to provide input</td>
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Appendix I. Feedback from the 18-item TEI

You have received the following assessments from your team members based on your performance in your <course> team project. The behaviours highlighted in green are your areas of greatest strength, those in yellow are areas where you are competent, and in red are your opportunities for greatest improvement. A value of zero in either a self- or peer-feedback column means that no feedback was provided. To improve your effectiveness as a team member, it is recommended that you work on the areas highlighted in red first as they will create the greatest change in your effectiveness.

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<td><strong>Attend team meetings prepared</strong></td>
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<td><strong>Do their fair share of the work</strong></td>
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<td><strong>Deliver their work on time</strong></td>
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<td><strong>Produce high quality work</strong></td>
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<td><strong>Help to plan and organize workflow</strong></td>
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<td><strong>Encourage progress to meet goals and deadlines</strong></td>
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<td>Expected to be trusted by others without demonstrating trust in others</td>
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<td>Worked in a manner in which trust was implied, but was not consciously developed or discussed</td>
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<td>Engaged in activities to consciously build trust between team members</td>
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<td><strong>Motivate others on the team to do their best</strong></td>
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<td>Did not demonstrate interest in the motivation of anyone on the team, including self</td>
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<td>Attempted to motivate others when it was beneficial to self, or was not too time consuming</td>
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<td>Did not adopt others’ suggestions/feedback about their work/ work-habits</td>
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<td>Adjusted suggestions/feedback they felt were appropriate only or in areas that were easy</td>
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<td>Adopted suggestions/feedback from others and actively solicited further guidance</td>
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<td>Showed respect for other team members only when they agreed with them or were working well together</td>
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<td>Showed respect for other team members at all times</td>
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<td>Showed respect for all team members, and encouraged others to respect them through their actions towards the team</td>
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<td>Did not follow through on commitments and did not admit when they had not completed work</td>
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<td>Followed through on some commitments when reminded and admitted when something was not completed if there was little repercussion to the admission</td>
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<td>Followed through on commitments and admitted when something was not done</td>
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<td>Followed through on commitments and if something was not done, presented an alternate plan for success</td>
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<td><strong>Help the team build consensus</strong></td>
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<td>Detracted from the team’s ability to build consensus</td>
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<td>Helped build consensus in areas they demonstrated interest in</td>
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<td>Helped the team build consensus and presented alternate methods of finding consensus when the team was deadlocked</td>
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<td><strong>Exchange information in a timely manner</strong></td>
<td>Did not exchange information in a timely manner, or only exchanged information when requested repeatedly</td>
<td>Exchanged information when prompted, but needed at least one reminder</td>
<td>Exchanged information in a timely manner most of the time and rarely needed prompting</td>
<td>Exchanged all information before it was necessary and ensured that all other teammates exchanged their information on time</td>
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<tr>
<td><strong>Openly express ideas and opinions</strong></td>
<td>Did not express ideas or opinions</td>
<td>Expressed ideas and opinions in a manner which demonstrated hesitation or reservation</td>
<td>Expressed ideas and opinions in an open and constructive manner</td>
<td>Expressed ideas and opinions in an open and unbiased manner that solicited input from others</td>
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<tr>
<td><strong>Promote productive discussion</strong></td>
<td>Did not engage in discussion with team members</td>
<td>Engaged in discussion that did not focus the team on the topics</td>
<td>Engaged in focused discussion that moved the team towards decisions</td>
<td>Engaged in focused discussion that moved the team towards decisions and ensured the whole team contributed to the discussion</td>
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<td><strong>Actively listen to team members</strong></td>
<td>Did not listen to team members</td>
<td>Appeared distracted and did not demonstrate an interest in what was being said</td>
<td>Listened to others and did not interrupt them</td>
<td>Listened to others and demonstrated engagement with what was being said</td>
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<tr>
<td><strong>Raise contentious issues in a constructive way</strong></td>
<td>Avoided contentious issues</td>
<td>Raised contentious issues in a biased or destructive manner</td>
<td>Raised contentious issues constructively in a manner that clearly focused on the benefit to self</td>
<td>Raised contentious issues in a manner that focused on team improvement and no person in particular</td>
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<td><strong>Solicit input before proceeding</strong></td>
<td>Proceeded without asking for others’ input</td>
<td>Solicited input before proceeding on areas that were contentious only</td>
<td>Solicited others for input before proceeding in critical areas</td>
<td>Solicited others for input before proceeding in all tasks, and encouraged all team members to provide input</td>
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Appendix J.  Study 1 Phase 2 End-of-term Survey

Reflecting solely on your experience in this course, and on the feedback you received on your team-effectiveness performance at the midpoint.

1) The amount of feedback I received was: (select one)
   - Too little
   - Enough
   - Too much

2) The feedback I received was structured in such a way that:
   - I understood the feedback
   - I found out what my strengths are
   - I found out what my weaknesses are
   - It motivated me to want to improve my competence
   - It was useful

3) The feedback I received described me exactly how I perceived myself

If the feedback described you differently you had perceived yourself, please explain how it was different:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

4) Were you motivated to improve your performance? If so, what did you do to improve it?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
5) Feedback to me was phrased in a:
   - Positive tone
   - Neutral tone
   - Negative tone

6) How did the tone in which your feedback was phrased affect your motivation to improve your performance?

7) The amount of time I spent initially planning/practicing to improve my performance after receiving the feedback was:
   - None
   - 0 – 1 hour
   - 2 – 3 hours
   - 4 – 5 hours
   - 6 – 7 hours
   - > 7 hours

8) What information would you have liked to see in feedback to you that wasn’t there? What was provided that was unnecessary?

9) Based on the feedback, I was better able to determine my competency level during future teamwork?
10) Did you learn about how to be an effective team-member through this project? If yes, what did you learn, and how?

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

11) Did you find there was any difference in the way you and your team-mates approached the team project? What were these differences and how did your team resolve them?

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

12) What was the most important thing you learned about being an effective team-member through this project?

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

A) USABILITY
Did you understand all of the terminology in the inventory?

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________

Were there aspects of completing the inventory you found difficult? If so, describe.

__________________________________________________________________________________________

__________________________________________________________________________________________

__________________________________________________________________________________________
How did the framework map to your personal perceptions of what team-effectiveness is?


Were you able to provide all the feedback you wanted to using the framework? Is there any content that you believe should be added to or removed from the framework?


Are there any other comments you would like to provide the designers about this learning process?


Appendix K. Feedback from the 12-item TEI

Screenshot of the feedback interface demonstrating how the self- and peer-assessments from the Team-effectiveness Inventory are displayed for students using radar plots and a table of sorted competencies. Holistic feedback was provided immediately below the table.
Appendix L. Study 1 Phase 3 End-of-term Survey

Reflecting solely on your experiences this year, and on the feedback you received through this on-line system, please answer the following questions.

1) The amount of feedback I received was: (select one)
   - Too little
   - Enough
   - Too much

2) The feedback I received was structured in such a way that:
   - I understood the feedback
   - I found out what my strengths are
   - I found out what my weaknesses are
   - It motivated me to want to improve my competence
   - It was useful

3) The feedback I received described me exactly how I perceived myself
   - If the feedback described you differently you had perceived yourself, please explain how it was different:

   ____________________________________________________
   ____________________________________________________
   ____________________________________________________

4) Were you motivated to improve your performance? If so, what did you do to improve it?

   ____________________________________________________
   ____________________________________________________
   ____________________________________________________
   ____________________________________________________
5) Feedback to me was phrased in a:
   - Positive tone
   - Neutral tone
   - Negative tone

6) How did the tone in which your feedback was phrased affect your motivation to improve your performance?

7) The amount of time I spent initially planning/practicing to improve my performance after receiving the feedback was:
   - None
   - 0 – 1 hour
   - 2 – 3 hours
   - 4 – 5 hours
   - 6 – 7 hours
   - > 7 hours

   If yes, how did you try to improve your performance?

8) What information would you have liked to see in feedback to you that wasn’t there?
   What was provided that was unnecessary?

9) Did you find there was any difference in the way you and your team-mates approached the team project? What were these differences and how did your team resolve them?
10) What was the most important thing you learned about being an effective team-member through this project?

11) Did you understand all of the questions in the survey? Were there aspects of providing feedback you found difficult? If so, please describe.

12) Did you use the lessons in the online team-learning system? What did you use? How did it work out?

13) Are there any other comments you would like to provide the designers about this learning process?
Appendix M. Study 1 Phase 3 Stimulated Recall Interview Protocol

**INTERVIEW PROTOCOL:**

**OBJECTIVES:**
The purpose of the interview is to attain qualitative data on how the student understood, responded to, and learned from critical incidents in their teamwork and communication practices in their first-year team experience. Examples of possible incidents include: a contentious discussion occurred, team decision making occurred, a specific team strategy is employed, a student is misunderstood, a student does not understand the objective of a discussion, work distribution and completion is discussed, etc.

Data obtained from this interview will be used to develop a better understanding of how students engage in teamwork and meaning making in their team experiences and how well the team-effectiveness inventory and on-line learning system map to the situation in which they are learning about teamwork.

**WHO**
3 teams of students each in APS112 (21 students) and ESC102 (12 students).

**WHEN**
Students will have three team meetings (~2 hours in length) video-recorded during the Winter 2014 term. The first recording will happen during the first 2-3 weeks of the term, the second recording around reading week, and the third immediately before submission of their final deliverable in April. This will allow the researchers to take chronological snapshots of the team development throughout the project.

Student stimulated recall interviews will happen after submission of the team’s final deliverable in April, and will be conducted individually with each student requiring 1 hour of their time.

**HOW**
In advance of the interviews Patricia Sheridan and Dr. Penny Kinnear will review the video-recordings of the team meetings and identify 3-5 critical incidents to discuss with each
student. The interview will be facilitated, and recorded, by Patricia Sheridan and Penny Kinnear and will be transcribed by a contractor external to the course situations. The interviewers will remind the students that they have the option to withdraw from the interview at any point during the discussion and should not feel obligated to answer each question.

At the start of the interview Patricia and Penny will review the research project, outline the objectives of the interview, and ask the interviewee to verbally provide consent to participate in the interview and have their answers recorded. The student will then view the first critical incident with the interviewers. The recording will be stopped at previously identified points in order to ask the student relevant questions from the list below. The list is not inclusive as the specific prompt will be dependent upon the incident and the actions of the student being interviewed. However, none of the questions will deviate from the objectives of the stimulated recall as stated above. The interviewers will proceed through the selected incidents in order, stopping at the end of one hour, regardless if all of the incidents have been discussed or not. Students will be asked if they would like to schedule a second session but assured that it is not necessary.

**STIMULATED RECALL INTERVIEW PROMPTS:**

(Prompts will be made more specific before the interviews based on review of the video recordings.)

What were you thinking at this point? Why?
What did you want to happen when you said/asked that? Why?
What strategy did you try to use to accomplish this? Why? What might you do differently now?

We noticed that you appeared confused by what a A said. What did you think you understood? Why was this confusing to you? What strategy did you use to try and clear this confusion? Why? What might you do differently now?

We noticed that A seemed confused or unsure of what you were trying to say at this point. Did you notice this? If so, what did you do to try and clear up this confusion? If not, why didn’t you? How did you interpret A’s response? What might you do differently now?

What did you hope others would understand when you said/asked that? Why?
What strategy did you try to use to accomplish this? Why? What might you do differently now?

What action did you hope others would take when you said/asked that? Why?
What strategy did you try to use to accomplish this? Why? What might you do differently now?

What strategy did you try to use to accomplish this? Why? Where did you learn about this strategy? What might you do differently now?

We noticed you used the Team Strategy tools x times. How did you use these in your team meetings? If not, why? What might you do differently now?

What else can you tell us about this incident?
What have you noticed?
Appendix N. “Teaching Team-effectiveness in Large Classes”


**Teaching Team-effectiveness in Large Classes**

A report submitted to the Higher Education Quality Council of Ontario in response to

EOI-RFP-002-02

prepared by

Patricia K. Sheridan, Greg J. Evans and Doug Reeve
Institute for Leadership Education in Engineering and Dept. of Chemical Engineering and Applied Chemistry
University of Toronto
Executive Summary

Instruction of team skills is quickly emerging as an important and missing dimension of engineering education. This project evaluated a new framework for guiding students in providing self and peer assessments of their effectiveness in teamwork. This framework is the foundation for a new web-based tool that offers students structured feedback from teammates, along with personalized exercises and actionable strategies that guide targeted learning in the areas thereby identified. Specifically, the study documented in this report investigated whether the feedback framework, when used for intra-team self and peer feedback, increased students’ abilities to learn about and improve their team-effectiveness in executing design projects.

The framework consisted of 27 competencies across three aspects of team-effectiveness: organizational, relational and communication competencies. The framework was tested in a randomized controlled experiment in a first-year engineering design class of 280 students against an unstructured feedback prompt. Students were asked to provide feedback at the mid-point of the course and to provide their thoughts on the utility of the feedback they received in an end-of-term survey. Student assessments were also compared to teaching assistant assessments.

Students using the framework found the feedback they received to be more actionable than unstructured feedback, and found that it motivated them more to improve their performance than did the students receiving unstructured feedback. Students in the unstructured group received feedback on fewer and less diverse team-effectiveness competencies than those in the framework group. Students in the unstructured group received feedback on approximately 10 competencies on average, and approximately half of that feedback was on organizational competencies; students in the unstructured group received little feedback on relational competencies. The unstructured feedback also primarily identified the students’ strengths, which were phrased as praise of their performance, with minimal discussion of the students’ weaknesses.

Students in the framework group were able to peer-assess their team members accurately when using the framework but were less able to self-assess accurately. When compared to the assessments of their teaching assistants, students’ peer assessments correlated significantly with teaching assistants’ assessments across all three aspects of team-effectiveness. However, only students’ self-assessments along the organizational aspect correlated significantly with teaching assistants’ assessments.

While students in the unstructured group did not receive this more comprehensive feedback, they did comment that the textual feedback made them feel more committed to their team, as it demonstrated that their team members had an interest in them and in the team as a whole. Based on this benefit and on students in the feedback group’s requests for examples and comments in their feedback, we believe that a hybrid of the feedback framework along with some textual feedback would be the best method for providing feedback moving forward.
1. Introduction

Intentional instruction of team skills is quickly emerging as an important and missing dimension of engineering education. This project investigated and evaluated a new intervention that supports personalized learning of team effectiveness in large undergraduate courses. Specifically, we evaluated the effectiveness of a new web-based tool to provide students with structured feedback from teammates, along with personalized exercises and actionable strategies that guide targeted learning in the areas thereby identified. This intervention aimed to provide students with a safe, virtual environment in which they could: i) learn about their team-effectiveness and team issues, and ii) identify methods to improve their areas of weakness before trying them with their team members. A fundamental component of this intervention is the feedback framework that forms the basis of the tool. The feedback framework grounds the assessments students provide and the feedback they receive along specific competencies, guiding students to recognize and reflect on necessary teamwork skills. This study aimed to investigate whether the feedback framework, when used for intra-team self and peer feedback, would increase a student’s ability to learn about and improve their team-effectiveness in their project teams.

2. Background and Motivation

Engineering is a team-based profession that requires students to be both technically proficient and effective at teamwork. The Canadian Engineering Accreditation Board mandates that all students who graduate from engineering programs be capable of working effectively alone as well as in teams (Canadian Engineering Accreditation Board, 2010). Upon graduation, when students transition to working in industry, they will work on large-scale, complex problems that require multiple individuals working effectively in teams to design appropriate solutions. In endeavouring to prepare students for this environment, most undergraduate engineering programs have students work on team-based projects that model what the students will experience in industry. The projects endeavour to instill in students the skills necessary to work effectively in these teams as well as in their future careers. However, students have traditionally been expected to develop teamwork skills implicitly simply by participating in the team project.

At the University of Toronto, engineering students are introduced to teamwork in their first-year engineering design courses. First-year classes, in which students learn the foundational skills they need for the remainder of their degrees and for their careers, are traditionally the largest. For example, class size in the engineering program at the University of Toronto ranges from 100 to 1,000 students, with the two first-year engineering design classes being the largest at approximately 280 and 1,000 students. In these courses, students have been grouped into teams to simulate industry working conditions. However, the sizes of these teams (ranging from three to seven students) are mainly constrained by facilities and instructor/teaching assistant time, especially grading time. In these large classes, providing feedback on student performance in a timely manner is always a challenge. As a result, these students have traditionally received feedback on the quality of their team’s deliverables (e.g., design reports, presentations and
prototypes) from their teaching assistants, but rarely receive feedback on how they as individuals are performing as team members. Courses have traditionally informed students that the teaching assistants are available to support but not assess their team-effectiveness.

The team-based project environment in first-year engineering design courses is a high-stakes environment. The projects are too complex for one person to address on their own and require some level of collaboration between team members. The students do not always work effectively together but are still graded together – the whole team receives whatever grade the deliverable receives, regardless of how effectively they worked together. When students in the project teams do not pull their weight, the remainder of the students in the team learn not to like teamwork and not to trust their team members. They see teamwork as an undesirable experience being forced on them that jeopardizes the thing they value: their grades.

Our belief is that many of these issues could be mitigated by providing students with personalized support in the development of their teamwork skills. The first part of this support is providing students with an awareness of what is happening in their teams. In small classes, an instructor can do this thanks to the personal nature of teacher-student interactions resulting from a significantly decreased assessment load. However, even here, the instructor may only see part of what is occurring within a team. Thus, due to the way in which student teams work, we believe that the best people to provide this feedback, both in large and small classes, are the students themselves. They see their team members for the entire duration of the project, in particular in team meetings outside of class or tutorial time when instructors are not present. Our objective is to use self and peer assessment within the student project teams to provide personalized feedback to each of the team members on their effectiveness as a team member during the project.

Approaches to conducting self and peer assessments of teamwork skills in engineers have been a popular focus of research over the last five to 10 years. Web-based tools have been developed in the US, most notably the Comprehensive Assessment of Team-member Effectiveness (Loughry, Ohland & Moore, 2007), and in the UK, the WebPA (Loughborough University, 2009). These tools originated to ensure that instructors have sufficient information to know if they need to modify individual students’ grades based on their relative contributions to a team deliverable. As these tools have expanded to become web-based resources to facilitate the learning of team-effectiveness, they have approached teamwork from a strong task-focused orientation. Students in engineering are already traditionally more oriented towards the task side of teamwork than to the people side, so there exists a greater need to facilitate their development of the relational and communication skills of teamwork. As a result, rather than adopting one of the existing frameworks, we developed our own that pushes students to think about relational skills in addition to task skills when providing and receiving feedback. We sought with this study to assess the effectiveness of this self and peer assessment feedback framework.
This report documents the assessment of our team member effectiveness feedback framework as a foundation to facilitate student development of their competency as team members. Feedback originating from the use of the feedback framework was compared to feedback developed from an unstructured feedback prompt to assess the usefulness and effectiveness of the feedback framework. This report first presents the framework in Section 3, outlines the study design and research questions in Section 4, responds to these research questions individually in Sections 5-8, and finally concludes with our findings around the utility of the feedback framework. A discussion of planned future work is outlined in Section 9.

3. Feedback Framework

The team-effectiveness feedback framework that was used in this intervention is presented in Table 3-1.

Table 3-1: The 27 competencies of the feedback framework divided into three aspects of team member effectiveness. The competency numbers preceding each competency will be used to reference the competencies in the analysis.

<table>
<thead>
<tr>
<th>Organizational Aspects</th>
<th>Relational Aspects</th>
<th>Communication Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1. Support team rules</td>
<td>R11. Build the trust of teammates</td>
<td>C20. Exchange information in a timely manner</td>
</tr>
<tr>
<td>O2. Attend team meetings prepared</td>
<td>R12. Motivate others on the team to do their best</td>
<td>C21. Introduce new ideas</td>
</tr>
<tr>
<td>O3. Contribute to making meetings effective</td>
<td>R13. Raise contentious issues in a constructive way</td>
<td>C22. Openly express opinions</td>
</tr>
<tr>
<td>O4. Do their fair share of the work</td>
<td>R14. Solicit input before proceeding</td>
<td>C23. Promote constructive brainstorming</td>
</tr>
<tr>
<td>O5. Deliver their work on time</td>
<td>R15. Adopt suggestions from other members</td>
<td>C24. Actively listen to teammates</td>
</tr>
<tr>
<td>O6. Produce high quality work</td>
<td>R16. Accept feedback about strengths and weaknesses</td>
<td>C25. Provide constructive feedback</td>
</tr>
<tr>
<td>O7. Help to plan, set goals, and organize work</td>
<td>R17. Show respect for other teammates</td>
<td>C26. Make sure that teammates understand important information and instructions</td>
</tr>
<tr>
<td>O8. Track team progress vs. your timeline</td>
<td>R18. Demonstrate accountability</td>
<td>C27. Help the team build consensus</td>
</tr>
<tr>
<td>O9. Encourage progress to meet goals and deadlines</td>
<td>R19. Collaborate effectively</td>
<td></td>
</tr>
<tr>
<td>O10. Display dedication and determination</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: This framework has been analyzed in other studies as well. See Sheridan et al. (2013) and (2014).
This framework was developed from four existing inventories and designed to include a greater focus on non-task-related competencies (Bushe & Coetzer, 1995; Lingard, 2010; Moore, Diefes-Dux & Imbrie, 2006; Maxwell, 2011). A synthesis of these inventories was developed and redundancy between behaviours was eliminated. Competencies were categorized according to three aspects of team member effectiveness (Table 3-1): organizational competencies, which focus on the project management and task completion aspect of effective teamwork; relational competencies, which focus on how students build effective means of collaborating together and trust in each other; and communication competencies, which focus on how students leverage their interactions to exchange information and promote productive discussions.

For each competency, there is a behaviorally anchored rating scale that describes a student’s level of engagement in utilizing that competency to improve team performance. Students assess themselves and their teammates according to a 7-point descriptive Likert scale, where an assessment of 1-2 represents an unengaged team member, 3-5 a self-focused team member, and 6-7 a team-focused team member. To obtain a team-focused assessment along each competency, the student has to demonstrate an ability to exhibit and promote the behaviours of the competency in their team members. The behaviourally anchored rating scale for all competencies is available in Appendix C. By structuring the assessments using a behaviourally anchored rating scale for each competency, students should: i) be able to assess according to a common scale, increasing the consistency in assessments received by a student, and ii) be able to provide feedback that is specific enough that a teammate can identify their performance level and how they need to improve from it.

4. Study Design and Research Methods

The objective of the study was to understand how students perceive, interpret and use our feedback framework to promote learning about team member effectiveness behaviours in their project teams through the use of self and peer assessment. Our goal was to design an effective framework to guide students to provide feedback in order to facilitate the learning of teamwork within student project teams in large classes, with minimal need for additional contact-hour resources. Our hypothesis was that:

Students can be guided to provide useful personalized feedback on team-effectiveness to their teammates using our team-effectiveness framework.

A study to assess the utility of the framework in facilitating feedback was tested in the Winter 2012 term of Praxis II, a 280-student cornerstone design course in first-year engineering at the University of Toronto. This course previously had students provide some unstructured comments about their team members to the teaching team as a means of expressing concern in cases where team members did not complete equitable shares of the project work. As providing unstructured comments about each team member was already a mode of reflection about team-effectiveness in the course, we wanted to compare our framework to the pre-existing unstructured feedback method to determine whether our framework could be more useful in guiding students to
improve their team-effectiveness behaviours. To assess this, we used the following four research questions to guide our inquiry:

1. Does the framework guide students to provide a greater breadth, quantity or accuracy of feedback?
2. Do students perceive the peer feedback from the framework to be more useful than unstructured feedback?
3. Can students provide feedback similar to that of a trained observer (course teaching assistant) when using the framework?
4. Is the framework accessible (e.g., jargon, descriptions, levels of competency) to students and trained observers?

The theoretical orientation taken to learning in this study is that of social constructivism. This is because the team acts as a learning community in which to develop a greater understanding of one’s own team member effectiveness behaviours, as well as a greater understanding of team member effectiveness in general. Self and peer assessments of team member effectiveness act as scaffolding to support students in observing and thereby developing a better understanding of team member effectiveness behaviours. Improvement in behaviour is believed to be motivated both intrinsically and extrinsically through the desire to be a better team member and to create a better team, respectively.

4.1. Course Context

Praxis II is a first-year engineering design course in the first-year Engineering Science program at the University of Toronto. Praxis II is a 280-student course that takes place in the second term of the school year and builds on the introductory design, communication and teamwork principles covered in their first-term course, Praxis I. The course follows the pedagogies of Kolb, Perry and Vygotsky in the design and execution of its course lectures, tutorials and assignments. Specifically related to this study, the class (students and teaching assistants) attended three half-hour lectures on team-effectiveness, where they were introduced to Tuckman’s (1965) and Lencioni’s (2002) models of effective teamwork, the aspects and competencies of our feedback framework (Table 3-1), and how these behaviours manifest in highly effective, high-performance teams.

The course is designed as a service-, project- and team-based learning course in which students spend the first half of the 13-week term interacting with communities around the City of Toronto to identify engineering design opportunities they can address, and the second half of the term addressing a group of opportunities selected by the teaching team and based on those identified in the first half of the term. The projects take place in self-selected teams of three to four students for the entire 13 weeks of the course. Students can select their team from the 22 to 27 students in their tutorial section; students may not be able to select to work with their friends if they are not in the same tutorial section. As a result of working with the same team for the 13 weeks of the course, students have sufficient time to determine how they and their team members work in
teams, as well as improve their teamwork skills and behaviours based on feedback during the course.

The course has a teaching team of nine members: two course instructors, one of whom is a design expert and the other a communication expert, and seven teaching assistants, whose areas of expertise straddle engineering, the arts and the humanities. Students are grouped into tutorials of 22 to 27 students and are paired with two teaching assistants of complementary backgrounds. The role of the teaching assistants is to challenge the ideas of the students, instill good design and communication practices, model constructive and collegial disagreement, and demonstrate effective collaboration in their teaching style.

4.2. Study Design

The study looked at the effectiveness of the feedback framework by comparing it to unstructured feedback in a randomized controlled experiment within the same class. An overview of the study demonstrating which participants completed which components is provided in Figure 4-1.

Figure 4-1: Overview of the study design demonstrating which participants complete which assessments, surveys and attend focus groups

4.3. Student Participation

The entire class’ teams were divided randomly and approximately equally into the unstructured and framework feedback groups. Individual students were then able to consent to letting us use their feedback for research purposes. Student teams were used to separate students into the experiment groups in order to ensure that all students within a team were using one type of feedback mechanism, and that students only received feedback of one type.
Immediately after the student teams submitted their first major deliverable in week 7, students were asked to provide self- and peer assessments of their effectiveness as team members. Students provided peer assessments within their project teams only for their team members.

Forty-eight percent of the class was grouped into the framework group and completed this assessment using our feedback framework (Appendix C). These students completed their assessments by selecting the descriptor that matched their team member’s behaviour for each question. The remaining 52% were grouped into the unstructured group and completed this assessment by providing unstructured feedback that responded to the prompt: “Please provide feedback to yourself and your team members based on your/their team-effectiveness over the course of this project.”

Students in both groups were asked to provide feedback for their team members online on sequential pages of a survey. Students completed these surveys on LimeSurvey, an open-source surveying software that was implemented on a secure server on campus. Students were provided a link to complete their survey, and depending on whether they were in the framework or unstructured feedback group, they saw and completed a different survey.

One week after completing the assessment, students received their self and peer feedback online for review. Students in the framework group received numerical feedback from their team members that corresponded to the descriptors the students used to provide their assessments (Appendix A). Feedback in the framework group identified for each student their lowest-ranked competencies as weaknesses (by highlighting their feedback along these competencies in red) and their highest-ranked competencies as their strengths (by highlighting their feedback along these competencies in green). The ranking of these competencies was determined according to a sorting algorithm that took into account the values of the self-assessment, peer assessments, and the difference between the two.

The algorithm worked to identify three strengths and three weaknesses for the students. However, in the case of competencies with tied rankings, the minimum number of ranks that resulted in three or more competencies being highlighted were coloured as strengths or weaknesses, respectively. For example, if four competencies all had the same ranking that was higher than all other competencies, only that rank (those four competencies) would be highlighted. Including all students who had tied rankings, the maximum number of competencies that was ever highlighted as a student’s strengths or weaknesses based on the sorting algorithm was five.

Students in the unstructured group received unedited textual feedback, with no strengths and weaknesses intentionally highlighted.

Students in both groups also received a list of tools and techniques that they could use to enhance their effectiveness for each of the competencies outlined in the framework. An example of
framework feedback is provided in Appendix D, and an example of unstructured feedback is provided in Appendix E.

At the end of the course, students in both groups completed the same end-of-term survey on the usefulness of the feedback they received (Appendix F). Questions in the survey analyzed the quantity, depth and breadth of the feedback, as well as its ability to motivate students to improve their effectiveness in teams based on the feedback.

Focus groups with students who used the framework were conducted after the end-of-term survey to assess the framework’s utility, capture data on how participants perceived and used it, and their perceptions of the utility of the feedback it generated. The focus groups were conducted by an experienced focus group facilitator from outside of engineering and asked the questions outlined in Appendix G.

4.4. Teaching Assistant Participation

Teaching assistants (TAs) participated in the study by using the framework to provide assessments for all students in their tutorial sections. Teaching assistants were used as trained observers to assess the concurrent validity of the framework. TAs are typically the individuals who have identified and addressed team dysfunction situations and who students in the course approach when they have questions or issues with their teamwork. Additionally, with a class of 280 students, these were the only individuals who had sufficient one-on-one contact with the students in their teams, and were already scheduled to be supporting, and therefore observing, them in tutorials. The demographic information of the seven TAs is shown in Table 4-1. These TAs supported nine tutorial sections in pairs, with each TA staffing at least two tutorials and some staffing three. The pairing of TAs in tutorials provided a fortuitous opportunity to acquire two observations of each student with which to compare the students’ self- and peer assessments. This allowed us to assess whether students provided similar feedback to their tutorial TAs, as well as the ability of the TAs as trained observers.

Teaching assistants were trained before providing feedback about their students according to the process shown Figure 4-2. After attending the same lectures on team-effectiveness as the students, the TAs met with the designers of the framework for 1.5 hours to discuss how they would be using the framework to assess their students. As almost all TAs had previously been TAs in the course, the group elected to use the previous year’s teams that they and the framework designer were familiar with as the case studies to calibrate their assessments. These exemplar teams were described to the two new TAs in front of the framework designer by the other five TAs, so that they could all assess the teams based on the provided descriptions. Using these case studies, the TAs negotiated what high and low performance looked like for each framework competency until their assessments of performance were in agreement. Finally, the TAs asked the framework designer any questions of clarification about what different behaviours in the framework could look like outside of the teams discussed.
Table 4-1: Demographic information of the teaching assistants (TAs) who participated in the study, their backgrounds and their respective previous affiliations with the course

<table>
<thead>
<tr>
<th>Background</th>
<th>TA1</th>
<th>TA2</th>
<th>TA3</th>
<th>TA4</th>
<th>TA5</th>
<th>TA6</th>
<th>TA7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Eng</td>
<td>Eng</td>
<td>Eng</td>
<td>Eng</td>
<td>Eng</td>
<td>Arts</td>
<td>Humanities</td>
</tr>
<tr>
<td>Previous experience with the course</td>
<td>Student</td>
<td>Student</td>
<td>Student and TA</td>
<td>Student and TA</td>
<td>TA</td>
<td>TA</td>
<td>TA</td>
</tr>
<tr>
<td>Native English Speaker</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: For background, Eng represents engineering

Figure 4-2: Training sequence in which the teaching assistants participated prior to providing any assessments of student performance

TAs were asked to complete their assessments differently than were the students in two respects. First, teaching assistants completed the assessments two weeks after the students. As students provided their feedback immediately after submitting their first major team deliverable, TAs were grading at that time. Approximately two weeks after the students provided feedback, the TAs were asked to independently provide feedback for every student in their tutorial sections using the framework. As this meant that each TA had between 54 and 81 students to assess, they were given more time to complete the framework than the student teams who only had to assess three or four team members. The TAs were given two weeks to complete these assessments, meaning that some TA assessments were completed up to a month from the time when the students completed them. Second, at the training session TAs requested a ‘do not know’ option for each of the competencies. The TAs commented that they would prefer not to be forced to provide an incorrect assessment for a student when they felt that they were not able to assess the student along that competency.

A focus group with the TAs was conducted after the end of term to assess the framework’s utility, capture data on how they perceived and used it, and their perceptions of the utility of the feedback it generated. The focus group was conducted by an experienced focus group facilitator from outside of engineering and asked the same questions as the student focus group, outlined in Appendix G.
4.5. Participation Rates

The rate of students’ consent to participate in the research study was high at 77.5%, totalling 218 students from the class – 112 from the unstructured group and 106 from the framework group. Since the students had to complete the assessments of their team members for course purposes, as part of a 2% completed/not completed deliverable, there was no additional effort on the part of the students to participate in the study. Students were incentivized to allow us to use their data in the study through the opportunity to win one $100 gift card.

Of the 112 students in the unstructured group who agreed to participate in the study, the data from 105 students were used in this analysis. One team of three students was completely dysfunctional and as a result, they used their unstructured feedback as a place to vent their anger rather than provide feedback. These data were removed, as we felt that they had the potential to significantly skew the results of the depth and breadth of the unstructured feedback content. Four other students were removed, as each of them had only one other team member who consented to participate in the study, therefore eliminating the ability to complete any feedback comparisons between peers. All 105 students provided feedback and responded to the end-of-term survey.

Of the 106 students in the framework group who agreed to participate in the study, the data from 105 students were used. One student’s feedback was removed, as they were the only person in their team to consent, providing no peer feedback for this individual. Only 95 of these students responded to the end-of-term survey.

All teaching assistants in the course agreed to provide feedback on their students, as well as participate in a focus group on their use of the feedback framework. As this was additional work on top of the teaching assistants’ normal course duties, teaching assistants were compensated at the university’s teaching assistant pay rate for the additional hours required to complete the framework for their students. While data were obtained from the teaching assistants for 100% of the students, only the data for the 77.5% who consented to participate were used for the analysis.

Either due to the lack of grade-based incentives or to the timing after exams, student participation in the focus groups was significantly lower than expected at three students, making all findings from the student focus group informative but not significant.

4.6. Research Methods

The study was conducted as a control-condition experiment within the same class, thus allowing us to compare the effects of both modes of providing feedback within the same context. The study was approved by the University of Toronto’s Research Ethics Board for Social Sciences, Humanities, and Education. This study followed a mixed methods approach that used both qualitative and quantitative inquiry. All qualitative analysis was completed in NVivo, with quantitative analyses completed in SPSS and Microsoft Excel.
Feedback that students received in response to the unstructured feedback prompt was coded according to the feedback framework (Table 3-1) to identify which competencies were discussed in common between the unstructured feedback and the framework feedback. Codes were set up for the 27 competencies, as well as for four other competency themes that emerged in the unstructured feedback but did not map directly onto the framework’s competencies. A discussion of these themes is included [at the end of this Appendix]. The number of occurrences of each of the competency codes was then calculated for comparison with the framework feedback and overlaps between codes investigated. Additionally, the type of feedback provided to a student (individual or team-level) as well as the content of the feedback (design related, teamwork related, etc.) was also coded.

Feedback that students received from the framework was analyzed using intra-class correlations to understand how students were using the framework for self- and peer assessments. Trends in assessment patterns were determined and compared to those of the unstructured feedback. As TAs also used the framework, TA assessments were analyzed similarly.

The end-of-term survey contained a combination of both qualitative and quantitative questions and was completed by students in both the unstructured and framework feedback groups. Qualitative questions were coded thematically and a comparison of comments across the two groups was performed. Coding themes focused on motivation (if students tried to improve, why did they do it), action (what students did to improve) and impact (what response did the feedback evoke in the students in terms of belief or commitment). Quantitative questions measured students’ level of agreement with different statements regarding the feedback and were compared to identify statistically significant differences between the two groups’ perceptions of their feedback.

The focus groups were audio recorded and transcribed. The transcriptions were then coded thematically to identify similarities and differences in student and TA responses, and were analyzed to determine similarities and differences.

5. Differences in the Quantity, Breadth and Accuracy of Student Feedback

This section responds to the first research question – does the framework guide students to provide a greater quantity, breadth or accuracy of feedback than the unstructured prompt – by comparing the types of feedback received by students in the two groups.

5.1. Quantity of Team Member Effectiveness Content

Quantity was measured by the number of different team member effectiveness competencies a student received in their feedback that matched those in our feedback framework. All students in the unstructured group received feedback on at least three competencies, with a few students receiving feedback on up to 20 competencies (Figure 5-1) discussed in our framework.
Figure 5-1: Number of framework competencies discussed in feedback received by students in the unstructured feedback group in response to the prompt “Please provide feedback to yourself and your team members based on your/their team-effectiveness over the course of this project”

On average, students in the unstructured group received feedback on nine to 10 competencies. All students received feedback on at least one organizational competency, 97% of students received feedback on a communication competency, but only 88% of students received feedback on a relational competency.

Four students in the unstructured group, including three from the same team, chose to structure their feedback based on the framework’s competencies presented to students during the three half-hour lectures on team-effectiveness. Even though these students chose to use the framework’s competency-language to provide feedback, they did not provide feedback on all 27 competencies but primarily used the terminology of the competencies to frame their feedback.

By comparison, all students in the framework group received feedback on 27 competencies, as students were required to provide feedback on all competencies included in the framework.

Therefore, students in the framework group received a greater quantity of team member effectiveness feedback.
5.2. Breadth of Team Member Effectiveness Content

Breadth was evaluated based on whether students received feedback covering a range of competencies or whether the comments provided feedback on few similar competencies. Competencies discussed in the feedback were grouped into the three aspects of team member effectiveness in the framework to assess the breadth of the feedback a student received.

Students in the unstructured group generally received significantly more feedback on their organizational competencies than on the other two aspects’ competencies. Students in the unstructured group on average received feedback on five organizational behaviours ($SD=1.7$), two relational behaviours ($SD=1.6$) and three communication behaviours ($SD=1.4$). This corresponds to approximately 50% of a student’s feedback being on organizational competencies, 22% on relational, and 28% on communication competencies. While the amount of organizational and communication content by percent was fairly stable regardless of the number of competencies a student received feedback on, students who received feedback on few competencies received little to no feedback on relational competencies, see Figure 5-2. Competencies that were discussed the most in feedback (over 60% of students) included produces high quality work, does their fair share of the work, delivers their work on time and introduces new ideas. Competencies that were discussed the least in feedback (less than 10% of students) included support team rules and build the trust of teammates.

Figure 5-2: Percent of relational content in an unstructured group’s student’s feedback based on the total amount of feedback received.

Students in the framework group received feedback on 10 organizational behaviours, nine relational behaviours and eight communication behaviours. On average, students in the
unstructured group received feedback on less than half as many competencies as students in the framework group.

A two-way contingency table analysis was conducted to evaluate whether there were differences between the unstructured and the framework group’s perceptions of the breadth of their feedback in response to the same question on the end-of-term survey, “I received feedback on: a broad range of topics” (Table 5-1). The two variables used in each of these analyses were the experimental condition with two levels (unstructured, framework), and student response to the question on a Likert scale (strongly disagree, disagree, slightly disagree, neutral, slightly agree, agree and strongly agree).

Table 5-1: Contingency table analysis comparing group agreement on receiving a broad range of topics in their feedback.

<table>
<thead>
<tr>
<th>Question</th>
<th>Pearson’s $\chi^2$</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td>I received feedback on: a broad range of topics</td>
<td>20.4</td>
<td>.32**</td>
</tr>
</tbody>
</table>

Note: ** $p \leq .01$

As can be seen from Table 5-1, there was a significant difference in students’ perceptions of the breadth of their feedback across the two groups. Looking at the graph of the student responses to this question, it can be seen that students in the unstructured feedback group perceived that they did not receive feedback on as broad a range of topics as the framework group (Figure 5-3).

Figure 5-3: Distribution of responses to the statement “I received feedback on: a broad range of topics” by group.
5.3. Other Types of Information in the Feedback

In addition to the feedback discussed above on students’ team member effectiveness, a number of other items were presented in the unstructured feedback that did not support student awareness of their team member effectiveness. Two types of feedback fit this description: unrelated feedback and team-level feedback.

5.3.1. Unrelated Feedback

Some students in the unstructured group received feedback on their course-related knowledge/skills (17 students) or were provided with a description of what work their teammates perceived they contributed to the project (34 students, of which 11 received no team member effectiveness-related feedback). Non-feedback statements, generic statements (e.g., “good job”) that provided no information about the students’ team-effectiveness competencies or course skills, were received by nine students and provided them with no information that they could use as either a point of reference or guidance about their performance.

No students in the framework group received unrelated feedback due to the nature of the feedback framework.

5.3.2. Team-level feedback

Self-assessments in particular were not used effectively by students in the unstructured group. When students were asked to provide feedback on themselves, they often reflected on their whole team’s effectiveness rather than on their own individual effectiveness. Twenty-four percent (24%) of students in the group did this, providing no specific reflection on their own performance as a team member. No students provided team-level assessments as peer feedback without discussing how the receiver contributed to the team’s effectiveness – a key component that was missing from the self-assessments.

No students in the framework group received team-level feedback due to the nature of the feedback framework. As a result, no students in the framework group missed out on this opportunity to compare their self- and peer assessments.

5.4. Accuracy – Agreement between Self- and Peer Assessments

Accuracy was measured by examining the amount of unconsidered assessments provided by each group, the agreement between self- and peer assessments, as well as through student perceptions of the accuracy of their feedback as reported in their end-of-term surveys. Assessments that demonstrated no considered reflection on the part of the provider were unlikely to provide accurate assessments of the receiver’s performance. Agreement in the unstructured group was measured in terms of the number of competencies discussed in common across multiple team members. Agreement in the framework group looked at correlation between self- and peer assessments using intra-class correlation and Spearman’s rank correlation.
5.4.1. Unconsidered Assessments

Unconsidered assessments for the unstructured group consisted of non-teamwork-related comments, non-feedback statements such as generic performance statements, and descriptions (rather than assessments) of a student’s contribution to team deliverables. Forty-seven individual assessments were judged to be unconsidered, of which the majority were provided by eight students to each of their team members. This resulted in 45% of students in the unstructured group receiving at least one unconsidered assessment, out of a total of three or four assessments from their whole team.

Unconsidered assessments in the framework group were those in which a student gave themselves and/or their peers the same numeric assessment across all 27 competencies. Twelve assessments met these criteria, with seven of them coming from two individuals. One student provided the same assessment for all team members across all competencies, and a second student provided their peers with the same assessment across all competencies but demonstrated consideration in their own assessment. It was unclear whether the other five assessments were considered, as their assessment value did not differ substantially from the considered assessments of their other team members. Thus, seven out of 94 individuals in the framework group received unconsidered assessments (approximately 7.5%), substantially less than the 45% in the unstructured group.

The unconsidered assessments – 12 from the unstructured group and seven from the framework group – were removed before completing the analyses discussed below.

5.4.2. Agreement in the Unstructured Feedback

Students in the unstructured group received limited feedback that demonstrated agreement or disagreement on their performance, as their feedback contained few competencies that were discussed in common by more than one assessor. Thus, the ability to assess agreement is limited to the cases in which either the student’s peers discussed at least one competency in common, or in which a student and at least one of their peers discussed at least one competency in common.

Using the 27 competencies that were coded based on the feedback framework, 14% of all competency-coded feedback in the unstructured group addressed competencies that were discussed in common by two or more peers. This resulted in 83 students receiving feedback that discussed at least one competency in common, with an agreement on the student’s performance on that competency. On average, 24% of a student’s feedback discussed competencies in common. The maximum percentage of feedback discussing competencies in common was 63%.

Competencies discussed in common were grouped according to whether the peers agreed on the performance level of the student, whether the peers disagreed on the performance level, or whether it was unclear whether there was agreement or disagreement between the peer assessments. The distributions of these performance-level agreements on a per student basis can be seen below in Figure 5-4. Across the 83 students who received feedback in common, 60
students received feedback that, on average, agreed on the performance level of the student, 4 received feedback that disagreed on the performance level of the student, and 6 students received feedback that agreed on the performance level of at least one competency and disagreed on at least one other. For the remaining 13 students’ competencies discussed in common, it was unclear whether there was agreement or disagreement between assessments.

Figure 5-4: Distribution of performance agreement in student feedback for competencies that were discussed in common by peer assessors

5.4.3. Agreement in the Framework Feedback

To assess the agreement of the feedback a student received in the framework group, the inter-rater reliability between peer assessors and the correlation between students’ self- and peer assessments were determined. Inter-rater reliability was determined using the intra-class correlation coefficients (ICCs) for peer assessments, using a two-way random effects model for consistency. Ninety-one of the 95 students had at least two peer assessors and were considered in this analysis. Peer ICCs were then grouped according to their level of agreement between the peer assessors (Table 5-2). Thirty-one percent of the feedback showed no agreement between the peer assessors, and 8.8% showed substantial agreement between the peer assessors. The majority of assessments showed limited agreement, ranging from slight to moderate agreement. Therefore, it is likely that the feedback showed differing levels of agreement along the different aspects of the framework.
As a result of the limited agreement among peers, the level of agreement between self- and peer assessments was determined. Looking specifically into our hypothesis that the limited agreement may be aspect-specific, accuracy was determined by comparing the average self-assessments to the peer assessments across the three aspects of the framework. Using a Spearman’s rank correlation (Table 5-3), we see a significant correlation between the students’ self- and peer assessments in the organizational aspect. However, there is no significant correlation between students’ self- and peer assessments in the relational and communication aspects. This strong correlation in self- and peer assessments along only the organizational aspect may explain the variance in agreement seen in the peer agreement discussed above.

Table 5-2: Distribution of agreement between peer assessments of a student as measured using ICCs in a two-way random effects model for consistency

<table>
<thead>
<tr>
<th>Level of Agreement</th>
<th>Number of Students</th>
<th>ICC value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>No agreement</td>
<td>28</td>
<td>&lt; 0</td>
</tr>
<tr>
<td>Slight agreement</td>
<td>18</td>
<td>0 - 0.2</td>
</tr>
<tr>
<td>Fair agreement</td>
<td>20</td>
<td>0.21 - 0.4</td>
</tr>
<tr>
<td>Moderate agreement</td>
<td>17</td>
<td>0.41 - 0.6</td>
</tr>
<tr>
<td>Substantial agreement</td>
<td>8</td>
<td>0.61 - 0.8</td>
</tr>
<tr>
<td>Perfect agreement</td>
<td>0</td>
<td>0.81 - 1</td>
</tr>
</tbody>
</table>

Table 5-3: Spearman’s rank correlation between students’ self- and peer assessments for each aspect of the framework

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational</td>
<td>.45**</td>
</tr>
<tr>
<td>Relational</td>
<td>.19</td>
</tr>
<tr>
<td>Communication</td>
<td>.16</td>
</tr>
</tbody>
</table>

Note: Students’ self-assessments (n = number of competencies) and peer assessments (n = number of competencies x number of peers) were averaged separately to determine each student’s self-assessed and peer-assessed level of competency for the aspect. These averages for each aspect were then correlated over all the students. ** - p ≤ .01.

5.4.4. Perceived Accuracy

Using a two-way contingency table analysis, there was no significant difference across the two groups in their agreement with the statement “The feedback I received described me exactly how I perceived myself” from their end-of-term surveys.

This similarity in terms of how students perceived the accuracy of the feedback extended into students responses to the open-ended questions on the end-of-term survey. Four students from the unstructured feedback group and five students from the framework feedback group
commented that they felt their feedback was fake and that it was not accurate. As this accounted for the same percentage of students in either group (5%), neither group on average perceived the feedback they received to be more or less fake than the other group. Additionally, an equal number of students (8) from each group challenged their feedback from their peers, stating that they felt that it did not reflect how they behaved in their team, or that their assessments were based on one incident and not their average behaviour.

One difference between the groups, however, was in terms of the perceived consistency of the feedback. Seven students in the framework group claimed that their feedback presented two differing perspectives on their performance and that it thus became hard to know how they were actually performing in their team. No such comments were provided by students in the unstructured feedback group.

5.5. Discussion

In addition to the differences in feedback around quantity, breadth and accuracy of team member effectiveness competencies, three other notable trends emerged in the analysis. First, students, primarily those in the unstructured feedback group, did not always receive enough feedback to provide them with a clear assessment of their effectiveness as a team member, limiting the usefulness of the feedback they received. Second, students in both groups strongly privileged organizational competencies in their feedback. Third, students in the unstructured feedback group did not always use the self-assessment prompt correctly.

5.5.1. Limited Quantity of Unstructured Feedback

Within the unstructured feedback group, students’ limited ability to find agreement among their peer assessments prevented them from getting a clear picture of how they were performing as a team member. Few students had competencies discussed in common, which was limited further by the amount of unrelated feedback students generated due to the unstructured nature of the prompt. This limited quantity affected the ability of the feedback to provide the receiver with a consistent message about their performance. While there was a fair amount of agreement within the peers about students’ performance when they discussed competencies in common (66% of all feedback discussed in common), there was not sufficient total feedback in common (14% of total feedback) to provide students with a sense of consistency in peer feedback. This resulted in only 9.24% of the unstructured feedback discussing competencies in common with agreement about performance. Essentially, an unstructured prompt (and how students choose to interpret it) will most likely produce peer feedback that raises few aspects in common. Students may thus perceive this feedback as random bits of information without a consistent message, making it easier to dismiss as not accurately describing them.

5.5.2. Student Privileging of Organizational Competencies

Student feedback in both the unstructured and framework groups demonstrated a strong identification with and privileging of organizational competencies. This is not surprising, as
anecdotally students in engineering have a tendency to privilege work-contribution-related competencies.

This privileging was evident in the distribution of competencies discussed in the unstructured group’s feedback through the strong prevalence of organizational items in the unstructured feedback (approx. 50% of all feedback was organizational). Additionally, students who received little feedback received almost all of their feedback on organizational competencies. As a result, unstructured feedback may perpetuate student privileging of organizational competencies and limit their ability to grow as effective team members by not broadening student understanding of team member effectiveness.

When looking at which items were discussed in the unstructured feedback, we find the same organizational predominance, with the exception of two competencies. The top five most discussed competencies in the unstructured feedback were predominantly organizational, with one exception. Given the privileging by engineering students of work-contribution-related competencies, the high level of response relating to the introduce new ideas competency (third most discussed) is likely a product of the team’s project work. Students who came up with the idea that was selected to address the design project were lauded extensively for doing so in their feedback. One organizational competency that was very minimally discussed was support team rules. This is not alarming as in the course context, team rules were discussed as norms of practice but were not codified. As a result, students in the course would not be predisposed to reflecting on a student’s role with respect to team rules.

This privileging can also be seen in the framework feedback in the correlation between student self- and peer assessments. The only significantly correlated assessments were those along the organizational aspect. While this does not affect the feedback a student receives, it does imply that students may perceive the feedback provided along the organizational aspect to be more accurate than the feedback along the other two aspects as they agree more closely with their self-assessments.

5.5.3. Limited Utility of Self-assessments in the Unstructured Group

Student self-assessments in the unstructured group were not used effectively, as many students used it as a space to reflect on their team’s effectiveness rather than their effectiveness as a team member. The self-assessment was meant to act as a point of comparison for the student when receiving feedback to see how differently they, as compared to their peer team members, perceived their effectiveness. Without an individual-level self-assessment, this comparison is less effective and the feedback therefore less useful. Additionally, it does not provide the receiver with any guidance on how to improve their behaviour, as what is needed to improve the team as a whole might be different from what they need to improve as a team member. Thus, not having any self-assessment of team member effectiveness limited the usefulness of the feedback in creating a greater awareness of how the students were performing for this 23% of the unstructured group.
5.6. Conclusion and Response to Research Question

Comparing holistically the feedback received between the two groups, students in the unstructured group received feedback on substantially fewer teamwork competencies than did those in the framework group, and received their feedback primarily on organizational competencies. Students in the unstructured feedback group received significantly less feedback on relational competencies than did those in the framework group – an area known to be underprivileged in engineering students. Students in this group also received a substantial amount of their feedback on non-teamwork-related issues/skills. In terms of the accuracy of the feedback received by students in either group, the framework group received less feedback that appeared to have no considered reflection on the part of the provider than did the unstructured group. Consistency in the feedback provided by students was greater in the framework group, in part due to the set competencies on which all students had to provide feedback, but it did not appear to limit the ability to receive a diversity of feedback, as seen in students’ comments on receiving different assessments from their peers.

Therefore, in response to the research question, the framework provides greater breadth, quantity and accuracy of feedback than the unstructured feedback prompt.

6. Differences in Student Perceptions of the Usefulness of their Feedback

This section responds to the second research question – *do students perceive the feedback from the framework to be more useful than unstructured feedback?* – by comparing students’ received feedback and their comments on the end-of-term surveys. As students in both groups answered the same questions on the end-of-term survey, comparative analyses are possible. Three notable differences surfaced in the analysis: i) identification of strengths and weaknesses in the feedback, ii) perceived amount of actionable feedback, and iii) improvement based on feedback.

6.1. Identification of a Student’s Strengths and Weaknesses

Feedback with clear strengths and weaknesses is more useful to students, as it identifies what they are good at and what they need to improve. This allows students to focus their efforts on improving certain key areas. Feedback from both groups was compared to determine which more readily identified strengths and weaknesses in feedback.

6.1.1. Unstructured Feedback

The feedback from the unstructured group was significantly less granular in terms of performance than the framework feedback. Students were either lauded on what they did well, critiqued on what they did poorly, or informed of what they did or did not do. As a result the
unstructured feedback, which had already been coded to identify team member effectiveness competencies, was coded again according to these three types of feedback.

The unstructured feedback received by students discussed the strengths of the students more commonly than it did weaknesses. Twenty-five students (24%) in the unstructured group did not receive any feedback on weaknesses or critique of their behaviour, and six students (6%) received no praise or identified strengths in their evaluations. Students within both of these groups also received neutral feedback which simply stated what they contributed to the project. To determine the prevalence of strengths in the feedback received by students, the feedback was binned into five categories according to the percent of the feedback that discussed strengths. As can be seen in Figure 6-1 below, 75% of the students in the unstructured group received feedback that primarily discussed their strengths as opposed to their weaknesses (opportunities for improvement).

Figure 6-1: Percent of peer-feedback received by students in the unstructured feedback group that discussed their strengths.

6.1.2. Framework Feedback

All students in the framework group had a similar number of identified strengths and weaknesses. This was a result of the sorting algorithm ranking student framework feedback, such that students’ strengths and weaknesses were determined and highlighted for them. All students
in the framework group had three to five competencies identified in their feedback as strengths, and three to five competencies identified as areas for improvement. This corresponded to students having at least 11% of their feedback identifying strengths and at least another 11% identifying their areas for improvement.

To ensure that the strengths and weaknesses were not just arbitrarily identified but actually flagged competencies with which the receiver had a distinct difference in their level of performance, a Related-Samples Wilcoxon signed rank test was conducted on the difference between the average ratings of the competencies identified as strengths and the average ratings of the competencies identified as weaknesses. There was a significant difference \( p = .01 \) in the averages of the strengths and weaknesses identified for the students, meaning that on average students were receiving feedback that demonstrated distinct differences in their performance level across the competencies.

### 6.1.3. Student Perception of the Strengths and Weaknesses Identified

There was a significant difference in the perception of the identification of strengths and weaknesses across the unstructured and feedback groups. While there was no significant difference between the groups as to their perception of their strengths, there was a significant difference across the two groups in terms of the identification of their weaknesses. A two-way contingency table analysis was conducted to evaluate whether there were differences between the unstructured and the framework group’s perceptions of the content of their feedback in response to the same question on their end-of-term survey (Table 6-1). The two variables used in each of these analyses were the experimental condition with two levels (unstructured, framework), and student response to the question on a Likert scale (strongly disagree, disagree, slightly disagree, neutral, slightly agree, agree and strongly agree).

<table>
<thead>
<tr>
<th>Question</th>
<th>Pearson’s ( \chi^2 )</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td>The feedback I received was structured in such a way that I found out what my weaknesses are</td>
<td>12.4</td>
<td>.25 *</td>
</tr>
</tbody>
</table>

Note: * \( p \leq .05 \)

As can be seen from the response distributions in Figure 6-2, the framework group demonstrated more overall agreement with the statement than the unstructured group, indicating that students in the unstructured group noticed the distinct lack of weaknesses provided in their feedback.

The students in the unstructured group remarked on this lack of critique of their behaviour in the open-ended questions on their end-of-term surveys. The strongest theme (greatest number of students commenting on it) among responses from students who received unstructured feedback was that they did not receive feedback on areas in which they could improve. Thirty-one students (30%) in the unstructured group commented that they wanted more critique in their feedback,
compared with seven students (7%) from the framework group. The strongest theme among the students who received framework feedback was that they wanted more justification, comments or examples for the assessments they received (23%).

Therefore, students in the framework group received and perceived that they received more identifiable weaknesses on which to improve, while both groups perceived a similar number of identified strengths.

Figure 6-2: Distribution of responses to the statement “the feedback I received was structured in such a way that I found out what my weaknesses are” by group

6.2. Improvement based on Feedback

Improvement based on feedback was different across the two groups. Motivation to improve performance appeared stronger for the unstructured feedback group, due to the tone of their feedback. However, self-reported improvement along specific weaknesses identified in the feedback was higher for the framework feedback group.

The tone of the feedback appeared to have a large influence on students’ motivation to improve and develop a sense of team cohesion. A two-way contingency table analysis was conducted to
evaluate whether there were differences between the unstructured and the framework group’s perceptions of the tone of their feedback in response to the same question on their end-of-term survey (Table 6-2). The two variables used in the analysis were the experimental condition (unstructured, framework) and student response to the question on a three-point scale (Positive, Neutral, Negative).

Table 6-2: Contingency table analysis comparing the tone of the feedback received by the two groups

<table>
<thead>
<tr>
<th>Question</th>
<th>Pearson’s $\chi^2$</th>
<th>Cramer’s V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback to me was phrased in a {positive, neutral, negative} tone</td>
<td>8.5</td>
<td>.21**</td>
</tr>
</tbody>
</table>

Note: ** $p \leq .01$

There was a significant difference in the perception of the tone of the feedback. Students in the unstructured group felt that their feedback was phrased more positively, whereas students in the framework group were mostly split as to whether their feedback was presented in a neutral or a positive tone.

Twenty-three students in the unstructured group, compared to 12 students in the framework group, commented that the feedback they received increased their commitment to their team or made them feel that their team members valued their contributions. Comments from students in the framework group seemed to be looking for this personal connection in their feedback. Students in the framework group commented that they wanted more justification, comments or examples for the assessments they received (23 students) (i.e., some textual feedback from their peers).

One difference, however, between the two groups was in the behaviours they indicated that they worked on improving during the period between receiving their initial feedback and completing the end-of-term survey. Students from the framework group cited more weaknesses that were identified in their feedback than did students in the unstructured feedback group (Figure 6-3). Both groups cited working on other improvements that were not indicated in their feedback but that they thought were equally important.

6.3. Discussion

While the tone of the textual feedback provided by students in the unstructured prompt increased student commitment to improving, the lack of identified weaknesses limited the usefulness of the feedback as a means to promote improvement and learning. Since the unstructured feedback group received feedback that was phrased in the words of their team members and mostly focused on strengths instead of weaknesses, it makes sense that students would perceive this feedback as more positive than the framework feedback received by that group. However, in a few cases where students were provided constructive criticism, the context for the feedback was provided to explain the assessment. This aspect of the unstructured feedback strengthened the utility of the feedback for these few students.
This lack of identified weaknesses may also explain why the number of weaknesses on which students identified improving was the same across both groups, but the feedback-identified weaknesses improved on was less for the unstructured group. Having fewer identified weaknesses could inhibit students’ ability to recall and/or consciously improve. Additionally, since the amount of competency-specific feedback was minimal (14%) for the unstructured feedback group, it is likely that even when a weakness was identified, it was written off as an anomaly if it was not also discussed by other peers.

Figure 6-3: Number of weaknesses identified in students’ end-of-term surveys that they commented as improving on based on their feedback, by group

6.4. Conclusion and Response to Research Question

In response to the research question – *do students perceive the peer feedback from the framework to be more useful than unstructured feedback?* – the findings above indicate that students do find the framework feedback to be more useful.

From these analyses, it was clear that the framework guided students to identify strengths and weaknesses more clearly than the unstructured feedback prompt, as students had a prescribed set of competencies to assess in the framework. Students in the unstructured group had significantly less agreement with the statement that their feedback identified their weaknesses, and also vocalised this issue in their open-ended responses in the end-of-term survey. As a result, students
receiving feedback from the framework receive a greater amount of critique and therefore were able to identify their weaknesses so that they could improve on them. This was confirmed when students in the framework group cited that they worked on improving aspects of their team-effectiveness that were identified as weaknesses in their feedback more frequently than did students in the unstructured group.

Therefore, because the framework feedback indicates the potential to create more of the desired behavioural change articulated by team members in their peer feedback, it makes the framework feedback more useful. However, based on the impact of the unstructured feedback’s tone on team cohesion, a hybrid of the framework and unstructured feedback should be investigated in the future to allow for the inclusion of textual comments in the framework.

7. **Difference between Student and TA Assessments**

This section responds to the third research question – *can students provide feedback similar to that of a trained observer (course teaching assistant) when using the framework?* – by comparing the assessments provided by the teaching assistants (using the framework) with the students assessments in both the unstructured and framework groups. Teaching assistants were used as trained observers because of the quantity and quality of their interaction with the students in weekly tutorial sessions. In endeavouring to assess the concurrent validity of the framework, it was not enough for students to be able to provide similar ratings to their peers using the framework. In a more absolute sense, they needed to provide ratings that were in fact a representation of the assessed student’s team member effectiveness.

An investigation of teaching assistants’ ability to provide feedback using the framework was provided by Sheridan et al. (2014). The key findings around how TAs used the framework were:

1. TAs provided assessments that were on average lower than those of the students.
2. The average number of competencies on which a TA provided feedback was 16 (minimum 2, maximum 27), due to their use of the ‘do not know’ option.
3. TAs provided a similar amount of feedback across the three aspects.

Two notable differences surfaced in this comparison of teaching assistant to student assessments: i) similarity of strengths and weaknesses identification, and ii) correlation between teaching assistant, and self- and peer assessments.

7.1. **Similarity in Identification of a Student’s Strengths and Weaknesses**

The same algorithm used on students’ framework assessments was applied to the TAs’ assessments to sort out the three to five top ranked strengths and three to five bottom ranked weaknesses for each student. These TA-identified strengths and weaknesses were then compared to the strengths and weaknesses identified by students in the framework feedback group, and to the competency-coded strengths and weaknesses discussed in feedback for the unstructured feedback group.
When looking at the percentage of students in each group, the agreement between student and TA feedback in terms of identifying at least one strength or weakness in common was higher for the framework group (86%) than for the unstructured group (69%) (Table 7-1). Additionally, while TAs and students rarely agreed on both a strength and a weakness for any given student in both groups, this occurred more frequently in the framework group (18%) than in the unstructured group (7%).

Table 7-1: Frequency of agreement between student and TA identified the same strengths and weaknesses in the unstructured and framework feedback groups

<table>
<thead>
<tr>
<th>Type of Agreement</th>
<th>Percent of Students in Feedback Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 strength OR 1 weakness</td>
<td>Unstructured: 69%  Framework: 86%</td>
</tr>
<tr>
<td>1 strength AND 1 weakness</td>
<td>Unstructured: 7%  Framework: 18%</td>
</tr>
</tbody>
</table>

### 7.2. Correlation between TA and Student Framework Assessments

To determine whether the students provided similar feedback to the TAs when given the framework, the correlations between student self- and peer assessments and TA assessments were computed. As the number of competencies was substantial, and given that a number of the within-aspect competencies are highly correlated, correlation between student and TA assessments to determine the similarity of their assessments was done at the aspect-level of the framework. Correlations were computed across students’ and TAs’ average organizational, relational and communication assessments. These self averages and peer averages for each aspect were then compared to the TAs’ average assessment of the student’s competency by correlating over all the students.

A Spearman’s rank correlation was conducted between the aspect-level TA and peer assessments (Table 7-2) and TA and self-assessments (Table 7-3) for all students in the framework group. When using the framework, the peer assessments and TA assessments of individual students were significantly correlated across all aspects. However, the self-assessments were only significantly correlated with the TA assessments for the organizational aspect – the aspect that students in both the framework and unstructured group were more comfortable assessing. This is the same trend that we saw in Table 5-3, where student self- and peer assessments were only significantly correlated along the organizational aspect as well.
Table 7-2: Spearman’s rank correlation between students’ peer assessments and TAs’ assessments of each student along the three aspects of the framework

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Spearman’s Rank Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational</td>
<td>.35**</td>
</tr>
<tr>
<td>Relational</td>
<td>.27**</td>
</tr>
<tr>
<td>Communication</td>
<td>.24*</td>
</tr>
</tbody>
</table>

Note: Students’ peer assessments (n = number of competencies x number of peers) were averaged separately to determine each student’s peer-assessed level of competency for the aspect. *p ≤ .05, **p ≤ .01

Table 7-3: Spearman’s rank correlation between students’ self-assessments and TAs’ assessments of each student along the three aspects of the framework

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Spearman’s Rank Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational</td>
<td>.26**</td>
</tr>
<tr>
<td>Relational</td>
<td>.00</td>
</tr>
<tr>
<td>Communication</td>
<td>.16</td>
</tr>
</tbody>
</table>

Note: Students’ self-assessments (n = number of competencies) were averaged separately to determine each student’s self-assessed level of competency for the aspect. **p ≤ .01

7.3. Discussion

In addition to the differences in teaching assistant and student assessments, three other notable trends emerged in the analysis. First, teaching assistants were hesitant about the assessment context. Second, the quantity of unstructured feedback limits the applicability of the findings around agreement. Third, student self-assessments by aspect demonstrate a different privileging than does peer assessments.

7.3.1. Teaching Assistant Hesitancy around the Assessment Context

The objective of this part of the study was initially to use TAs as the gold standard against which to compare students’ feedback to determine accuracy. While the results of the assessments provided corroboration that students can provide peer assessments that are similar to those of their TAs, the teaching assistants were hesitant to be considered a gold standard. TAs are the front-line support for team issues and guidance, which requires them to be attuned to how the teams are functioning. However, they commented that they were more tuned in to the teams than to the individuals within the teams themselves. As a result, they were more comfortable and more confident assessing the teams than the individual students.

Part of the TAs’ hesitation may be related to the size of the feedback framework (27 competencies), but based on TA comments from the focus groups we hypothesize that most of the discomfort is due to the cognitive load on the teaching assistants during tutorials. Since the TAs need to provide different scaffolding to each of the teams to support the development of their design and communication skills, their primary mode of observation is during these interactions. In these conversations, the TAs need to assess the current state of the team’s design
work and what scaffolding (in the form of advice, resources or coaching) is necessary to move the team’s design work forward. As a result, this substantially limits their ability simply to observe the students as they work in their teams and biases their assessments against those students with whom they do not frequently interact in the teams. However, given the significant correlations between peer and TA assessments at the aspect level, reducing the TA feedback framework to substantially fewer competencies or to an aspect-level framework may strengthen these correlations, as TAs would then be able to provide more confident and hopefully more accurate assessments of their students.

7.3.2. Limitations on the Agreement for Unstructured Assessments

As discussed in Table 7-1, strengths and weaknesses identified by TAs agreed strongly with students assessments from the framework group. However, it must be noted that this finding is limited by the quantity of unstructured team member effectiveness feedback. As the quantity of unstructured feedback was substantially less than that of the framework feedback, there was a lower likelihood of a student having chosen to discuss a strength or weakness identified by the TA. Since all students in the framework group commented on all framework competencies, there was a greater likelihood of agreement between this group and the TAs. Therefore, while the agreement of the TAs’ assessments with the framework group is greater, there are not sufficient data from the unstructured group to claim any difference in agreement between the two groups.

7.3.3. Aspect-level Discrepancies in Assessment

As discussed in Table 3-8, TA-peer assessments were significantly correlated along all aspects of the framework, while self-assessments were only correlated with TA assessments along the organizational aspect. This finding supports the discussion in Section 5.5.2 that students in this class privilege organizational competencies and are able to self-assess them more accurately than those in the other aspects.

TA-self-assessment correlation for the relational aspect was .00, which demonstrated no correlation between TA and self-assessments at all. This may be a product of the teaching assistants’ lack of comfort with the relational competencies as well. The teaching assistants commented in their focus group that the relational aspect was the hardest to assess. However, there were no clear trends across the three aspects with respect to the number of competencies on which they provided feedback (due to the ‘do not know’ option). This may also be a product of the previously discussed privileging, as students in engineering are not traditionally comfortable with relational competencies. This was seen also in the unstructured feedback, in which less than 20% of the competencies discussed were relational.

Therefore, while the framework does provide a substantial basis for students to give feedback to their team members that is similar to that of their TAs, students had difficulty self-assessing their abilities in regards to relational and communication competencies. This inability to self-assess
accurately speaks further to the value of using peer feedback as a teaching tool to help students develop their self-awareness of and competency in team member effectiveness.

7.4. Conclusion and Response to Research Question

Comparing the feedback received between the two groups and the teaching assistants, we can claim that student peer assessors can be used for intra-team evaluations more effectively than teaching assistants. Agreement between teaching assistant and student feedback in terms of the usefulness of the feedback (identified strengths and weaknesses) is greater when students use the framework than when they use an unstructured prompt. Additionally, student peer assessments are significantly correlated with teaching assistant assessments across all three aspects of the framework. Student peers can provide feedback similar to that of trained TA observers. The same discrepancy between self- and peer assessments was seen with self- and TA assessments, further corroborating that peer assessments provide similar information with which students can broaden their awareness of their teamwork skills.

Therefore, in response to the research question, the framework guides students (as peers) to provide feedback similar to that of trained observers (teaching assistants).

8. Student and TA Feedback on the Usability of the Framework

This section responds to the fourth research question – *is the framework accessible (e.g., jargon, descriptions, levels of competency) to students and trained observers?* – by discussing four prominent themes around the usability of the framework, as discussed by students and TAs in their end-of-term focus groups. These four themes are: i) accessibility of the competencies, ii) accessibility of the rating scale, iii) presentation of the feedback, and iv) missing content.

8.1. Holistic Assessment of Framework Accessibility

The language of the feedback framework received no complaints or comments from either the students or the teaching assistants. Students were particularly happy that there was no “engineering jargon” in the framework, which they felt enhanced its accessibility. Students in the focus group thought that the framework was “thorough.” They described the framework as “pertinent” and “relevant,” and said that it “touched on more detailed elements of teams than [surveys] usually touch on.” Students also commented that the framework was an effective learning tool in and of itself, and remarked that completing the framework at the mid-point of their team projects allowed them to reflect on where they were or were not doing well and reminded them of what competencies effective teamwork required.

Both students and TAs liked that the assessments were grouped into the three aspects of team-effectiveness. Both groups commented that they found this helped them get into a certain headspace and evaluate a specific aspect of the experience. This simplified thinking and helped to clarify any sources of confusion in the questions. One student commented that they would have preferred the competencies to have been presented as questions rather than statements, as it
would “allow [the student] to focus more on what [they are] grading [their team member] on.” They did not elaborate on why they thought this would be the case.

Students commented that instead of rating each team member along the competencies sequentially, they wanted to provide feedback for each team member along the competencies simultaneously – the students wanted to complete relative rankings of their team members. The students felt that if they were rating all their team members at once, they would be able to provide more accurate assessments, and as a result of having fewer (perceived) questions to complete they would provide more accurate assessments. Students commented that completing the entire framework for each team member sequentially resulted in fatigue by the end of the survey, such that they were not fully reading the competency or rating scale and may not have been as accurate for the last team member assessed.

### 8.2. Accessibility of the Framework’s Competencies

Students in the focus group did not comment specifically on the list of competencies, but the TAs did feel that some competencies could not be assessed at an individual level. For competencies like *produce high quality work*, the TAs would only be familiar with team performance and could not rate team members individually. TAs also felt that the competencies *display dedication and determination, track team progress vs. project timeline, demonstrate accountability, exchange information in a timely manner, raise contentious issues in a constructive way and solicit input before proceeding* were all poorly worded, as they were not able to assess these competencies through observation during the tutorials. The TAs saw these competencies as the product of a series or sequence of behaviours that combine together. Given that they were not participating in the teams or observing them all the time, they were only able to see some of the behaviours, not all of the sequence, that combine to create the competency. They commented that they would have preferred to mark off specific individual behaviours they saw rather than trying to deduce the students’ performance along the competency.

### 8.3. Accessibility of the Competencies’ Behaviourally Anchored Rating Scales

Comments regarding the accessibility of the behaviourally anchored rating scales (BARS) for each competency centred around three different aspects of the BARS: their descriptions, their sequencing and the number of rating points.

#### 8.3.1. BARS Descriptions

Students found the BARS descriptions long. Given that they had to provide feedback to each team member individually, they mentioned that they would stop reading them after a while. The students proposed having a longer description of the competency and a few words briefly describing each of the different rating points. However, this would not provide enough information to distinguish clearly the different levels of performance for the students.
TAs felt that the descriptions for the BARS did not outline behaviours that they could clearly observe in tutorials without being a member of the team. TAs felt that in their assessment context, the BARS required deduction rather than observation, which made them uncomfortable when answering. In particular, they felt that the descriptions were not representative of the personality types of their students. TAs perceived that the descriptions privileged extroversion to the detriment of introverted students, especially with respect to the communication aspect, as the only way they could assess students introducing new ideas or openly expressing opinions in tutorials was verbally. Additionally, TAs felt that when they completed the framework for teams they perceived as strong, they found them only to be performing satisfactorily based on the BARS descriptions. TAs found in these cases that the BARS descriptions did not map to their perceptions of the team’s functioning.

8.3.2. Sequencing of the BARS

Students did not express any concerns around the sequencing of the descriptions along the BARS, but the TAs were unsure of the continuums along which the BARS were developed for each competency. For competency R12 – “motivate others on the team to do their best” – TAs found that the examples that were provided in the descriptions of the BARS in place of the word “motivate” sometimes caused there to appear as though there were two continuums along which the competency was being assessed. TAs found this dual continuum to occur most prominently in the relational aspect, where they would agree with one half of a description but not the other half. In this situation, TAs were unsure of how to rate the student and would most frequently pick the lower rating option. For the relational aspect, the TAs commented that they found the in-between options to be largely irrelevant, as the scale was more nominal than ordinal.

TAs felt that the low end of the BARS was not sequenced appropriately, as they felt that it was better to do something wrong than to avoid doing anything at all. In particular, with respect to competency R13 – “raise contentious issues in a constructive way” – they felt that the descriptions for levels 1 and 3 on the scale should be flipped, so that “avoided contentious issues” would be the description for level 1 and “raised contentious issues in a destructive manner” would be the description for level 3, as this organization would show a progression of engagement with the team that better maps to the conceptual framework of the BARS. On the low end of the scale as well, the TAs commented that they felt that the language used often implied that the students would be acting maliciously or demonstrating a “self-interest in the destruction of the team,” which did not map on to their understanding of the students. This was not the intention of the framework designers, who meant to communicate lack of engagement on the lowest end of the scale and self-centredness at the mid-range of the scale. TAs found that the language around doing something to “serve one’s own purposes” appeared malicious, whereas the framework designers did not intend it that way.

Students found the high end of the BARS to have vague and over-arching competency wording, instead of the collaborative orientation intended by the framework designers. The students
commented that language such as that in R19 – “Collaborated with others in a manner which promoted openness and understanding among team members” – was open to interpretation and therefore would be assessed differently by everyone. The students in the focus group commented that a description that “narrows the answer more” and specifies a manner of promoting openness would ensure that the framework had a single interpretation.

8.3.3. Number of Points along the BARS

Two students in the focus group and the TAs believed that there were too many rating options for each competency. Having descriptions on only four of the seven points on the scale created additional confusion, as they were not sure how to interpret the middle options. The majority of focus group participants recommended eliminating these undescribed rating points as a way of reducing the number of points along the scale and making the rating scale clearer.

8.4. Presentation of Feedback

Students in the focus group were asked about the presentation of the feedback (see example provided in Appendix D) to determine if there were ways to make the feedback easier to read and understand. No markedly negative comments were provided about the presentation of the feedback, nor any comments suggesting that students were unable to interpret the feedback or identify their strengths and weaknesses from it. Students in the focus group commented that they liked the colour coding, which allowed them to know “on instant glance” what their strengths and weaknesses were. However, while having the strengths and weaknesses visually separable from the other competencies was a plus, a different set of colours was recommended by a colour-blind student, who commented that it was difficult to distinguish between the green and yellow that demarcated strengths from average competencies.

8.5. Missing Content

Finally, to ensure that the framework addressed students’ feedback needs, students were asked if there was anything they perceived as missing from their feedback. Comments from the focus group participants were combined with students’ responses to question 9 of the end-of-term survey. The strongest theme among the responses was that of a desire for comments or examples from the feedback providers – something that could guide the receiver to know exactly how or why they received the numeric assessments on the framework and how their team members wish them to improve their performance. Students in the focus group saw this as a way to justify high or low assessments, which was also a theme discussed by the TAs. The TAs were more inclined to have an optional justification box after each question in order to justify their assessment and/or their confidence in their assessment when they felt it was necessary.

Students, on the other hand, simply commented that they wanted some justification but indicated no preference between it being per competency or per student. This idea was supported by all students at the focus group as well as by 23% of the students in the framework group, who commented on this in their end-of-term survey. They wanted to know where they excelled, with
specific examples, and to be able to learn by knowing why they were assessed the way they were.

8.6. Discussion

The most common theme that surfaced unintentionally in the focus groups was how the feedback could be leveraged differently in future classes to better facilitate student improvement. Students suggested some other ways to represent the feedback, including as an average of team members’ assessments, by showing their performance relative to their team’s or their class’ average performance, or by integrating the performance level descriptions into the feedback instead of providing it as a separate handout with the feedback. Given engineering students’ competitive nature, this might appeal to their desire to be the best in the class.

By comparison, TAs provided more feedback about the accessibility of the framework as an assessment instrument. This is likely due to their familiarity with grading rubrics as a result of their teaching work.

One recommendation for improving the effectiveness of the feedback from the focus groups, and something that was commented on by some students on their end-of-term surveys, was to add a debrief on the feedback during tutorial time with the team as a whole. This student recommended the inclusion of a structured discussion with the team about their weaknesses to encourage everyone to work more effectively together. This could be designed as a walk-through or scripted exercise that the students run themselves, with the TAs available for support as needed. This would allow each team to receive its own personalized feedback within the structure of the large class. This activity could guide the students through specific exercises or activities for the team to explore areas where they all are weak, or to look at new ways in which they can leverage the strengths of the team members. Having the different resources listed separately from the feedback online did not appear to be a detriment, though it was not commented on positively in the survey or focus groups either. A more intentional way to integrate the feedback and methods of improvement – either in person or online – needs to be conceived.

8.7. Conclusion and Response to Research Question

Combining student feedback about the accessibility of the framework from their end-of-term survey, and student and TA feedback from the focus groups at the end of the term, we conclude that the framework is accessible as a feedback guide for intra-team use. For the TAs, the framework is too long and difficult to complete given their interactions with the students and the cognitive load of their teaching responsibilities. Both groups identified a number of ways in which the framework could be made more relevant and intuitive.

9. Conclusions and Future Work

This project evaluated the effectiveness of a feedback framework as a foundation for a new web-based tool that provides students with structured feedback from teammates, along with
personalized exercises and actionable strategies that guide targeted learning in the areas thereby identified. Specifically, the study investigated whether the feedback framework, when used for intra-team self and peer feedback, would increase a student’s ability to learn about and improve their team-effectiveness.

When feedback from the framework is compared to feedback gathered using an unstructured prompt, we find that feedback from the framework has a greater ability to increase student self-awareness and provide them with information that can guide them in developing team-effectiveness competencies. Students who used the framework had significantly different strengths and weaknesses reliably identified for them, and they received consistent assessments of their performance from their team members. Students in the unstructured feedback group had less consistent feedback that more often discussed strengths alone than both strengths and weaknesses. Additionally, as students in the unstructured feedback group discussed whichever competencies they felt were important, the feedback is less targeted and focuses on how the team perceived the student’s performance.

Students in the feedback group had significantly greater agreement with the statements that they received feedback on a broader range of topics and on their weaknesses than did students in the unstructured group. While students in the unstructured group did not have these same benefits, they did comment that the textual feedback made them feel more committed to their team, as it demonstrated that their team members had an interest in their development and in that of the team as a whole. Based on this benefit and on requests from students in the feedback group for examples and comments in their feedback, we believe that a hybrid combining the feedback framework and some textual feedback would be ideal.

This document addresses an important component of a larger, ongoing project looking at the effectiveness of our feedback framework to facilitate feedback that guides students to learn about and develop their competence as effective team members. We have already incorporated much of the learning achieved through this study into our web-based tool. For example, the number of competencies being addressed has been substantially reduced and an option for holistic freeform feedback incorporated into the framework. Further, as students often work in diverse teams, we are in the process of investigating how diversity of personality characteristics in teams affects the feedback a student receives from their team. This investigation is currently in analysis and will be published at a later date.

References


Appendix: Other Competencies that emerged from the Unstructured Feedback

In addition to the codes for the framework, four other competencies surfaced in the unstructured feedback. Each competency discussed below was seen in over 10% of the total student feedback.

1. Support Other Team Members

Following the framework of team member effectiveness used in the framework group, supporting other team members would constitute a ranking of high competence within a specific aspect. However, when discussed in the unstructured feedback, students described someone who was willing to help and support others as though it were a competency unto itself. While this theme represents students with a team-focused orientation, it is important to note that students may not intuitively see all the different ways one can support a team member. Some samples of student feedback that fit this theme include:
[they] picked up tasks that other members could not do (due to time constraints or similar reasons) and effectively accomplished those tasks. I feel that this is such an important role in any team and that this role perhaps contributes to team-effectiveness the most.

I always help my teammates with their responsibilities when I have completed mine or when they ask for assistance.

[they] worked very hard and was always willing to help on whatever task needed to get done.

2. **Focused/Paid Attention**

The ability of a student to remain focused on a conversation or a specific task was discussed by students in both a negative and positive light, with the majority of feedback related to this theme being negative. Over 20% of students received feedback on this theme, with a number of students receiving feedback on this theme from more than one team member. While this theme may be similar to the competency show respect for other team members, it encapsulates more than just respect for others as it demonstrates a lack of interest in engaging in the work of the team.

Some samples of student feedback that fit this theme include:

- *sometimes becomes easily distracted and loses focus*

- *[they] did not concentrate on [their] task in meetings. For examples, *[they] checked [their] cell phone many times and did non-work related things.*

- *I am usually the person who keep the discussion on the topic and this helped maintain work efficiency.*

- *Requires constant attention to prevent using Facebook.*

3. **Energy/Enthusiasm**

Students who had an enthusiastic or energetic demeanor were also commented on in the unstructured feedback. While this feedback may not directly correspond to an individual competency that can be developed in students, it is important to note that this surfaced as a character trait that students value in their teammates. All examples of this trait demonstrated it as a positive trait whether the feedback commented on the amount a student had, or that the student should demonstrate it more. Some samples of student feedback that fit this theme include:

- *More enthusiasm about the project from [them] would greatly improve the project experience.*
In group discussions [their] comments and interjections are always on point, relevant and concise along with a healthy bit of wit to increase the enjoyment of the whole group.

In addition I would say from personal opinion that [their] positivity encouraged us to continue learning more about our community and working with them the entire time.

4. Leader

While the students were working in self-selected and self-managed teams, many students referred to a leader who emerged within their groups. The majority of leader comments that fit this theme described an individual with high competence in help to plan, set goals, and organize work, who coordinated work distribution among teammates and ensured that the work was completed. The majority of comments described a leader that engaged in collaborative leadership and sought the input of others, however some comments described the leader of the team as an authoritarian person as described through the terms “assigned work to me” and “delegated the tasks.” Some samples of student feedback that fit this theme include:

Furthermore, [they] has valuable leadership skills that drives the team forward.

- leader: takes charge, organizing the work of others

[they] has been a good leader because [they] communicated very well with the team and gave us updates on what he's been up to through email
Appendix O. “A Team-effectiveness Inventory for Guided Reflection and Feedback”


This paper presents the development and refinement of the Team-effectiveness Inventory (TEI) used to facilitate student self- and peer-assessments of individual team-effectiveness in team-based project courses. The objective of the TEI is to create a common language by which guided reflection and feedback can be provided based on visible behaviour competencies as a means to engage students in learning about and improving their individual team-effectiveness. An initial version of the TEI was developed with three aspects (organizational, relational and communication) and 27 competencies. This TEI was studied through responses collected in a first year engineering design class of 250 students in Winter 2012. Correlation analysis was applied to student assessments and combined with the qualitative analyses of survey and focus group feedback from the teaching assistants and students to develop an understanding of how students perceive and use the inventory. Based on this analysis, the 27 competencies were reduced to 18. Student perceptions of the inventory as well as details of the modifications made to the TEI are presented herein.

1. Introduction

Team-based projects have become a common teaching practice in engineering courses as a means to simulate real-world environments. In these courses, students are often instructed on the technical aspects of the project material explicitly, but are expected to learn how to function effectively as a team implicitly.¹ Team-based projects offer students rich learning opportunities to absorb course material while simultaneously developing important teamwork skills - provided student learning in both areas is addressed. 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. Given the focus of current engineering curricula on developing technical competencies, students are implicitly taught to undervalue the need for leadership and interpersonal skills, such as effective teamwork, even though these are desired by the profession.¹ Thus, a web-based tool is being developed at the University of Toronto in response to the required graduate attributes to create an explicit method of facilitating students to learn about and engage in improving their individual team-effectiveness through team-based projects in design courses.

The effectiveness of a student in a team, as approached in this work, is the ability of the student to contribute to team performance in a manner that: i) focuses on putting the performance needs of the team before their own, ii) takes an open and cooperative approach to the work, and iii) values and leverages the abilities and contributions of all team members. To facilitate developing these ideal behaviours in students, this approach aims to develop individual team-effectiveness competencies that are necessary to create a high-performance team. Developing these competencies in the individual instead of the team as a whole is necessary as students change
project teams across courses and need to be able to use these skills in their work after graduation; the competencies developed by these students need to be transferable across different project teams. These competencies can be seen as the individual building blocks of team-effectiveness; the more competent a student is, the stronger their building blocks, and the more students with greater individual effectiveness, the stronger the structure their entire team can build. Similar approaches to developing individual behaviour competencies around teamwork in engineering classes have been presented at other universities.\textsuperscript{2-8}

To facilitate the development of these competencies, a web-based tool is being designed to create a virtual environment in which students can learn about and develop these competencies through the use of self- and peer-assessment in their project teams.\textsuperscript{9} Formative assessments and feedback, which help students identify the next steps to improve their performance and create personalized learning experiences, are a powerful means of enhancing deep learning and meta-cognitive abilities.\textsuperscript{10} In relation to teaching team-effectiveness, students may spend 2-3 hours a week working in a classroom with their instructors on their team-based project but they spend significantly more time working together outside of the classroom. As a result, students may be in a better position to assess and provide personalized feedback on their team members’ effectiveness than instructional staff.\textsuperscript{8} However, students require diagnostic instruments with which to assess their team situation along specific behaviours to identify targeted areas for improvement; students often lack the language or experience to identify these areas on their own or may provide a narrow assessment that focuses on only those aspects they feel are important. A Team-effectiveness Inventory (TEI) has been developed to be used in this web-based tool as the basis of the individual behaviour competencies. The objective of this inventory is to guide student reflection by creating a common language by which structured assessments can be provided based on these competencies and converted into personalized feedback.

Teaching of team-effectiveness can occur at either the team or individual level through developing group processes or individual behaviours.\textsuperscript{11} However, at the individual level, while there is a fair consensus about developing skills related to aspects of project management, social and interpersonal relations, collaboration and accountability, there is some divergence in terms of the specific behaviour competencies that should be developed. The focus of this paper is on the development and refinement of the TEI designed to be used by engineering students to facilitate self- and peer-assessments of individual team-member effectiveness. This paper will describe the TEI’s initial development, the study in which it was assessed, and the resultant understanding of how students perceived and used the inventory. Finally, improvements made to the inventory will be presented along with future work.

2. Initial Team-effectiveness Inventory

The team-effectiveness inventory (TEI) was derived from existing models/inventories on individual team-effectiveness as well as from feedback obtained on common team-dysfunction issues from instructors of team-based project courses at the University of Toronto. A focus in its development was to ensure that it was not solely a measure of team contribution, but an instrument that students could use to reflect past the work-completion component of teamwork to the other non-work-related competencies necessary for success. This inventory was initially presented in Sheridan’s framework for teaching team-effectiveness,\textsuperscript{9} and is summarized below, Table 1.
Table 1: The 27 competencies of the Team-effectiveness Inventory divided into the three aspects of individual team-effectiveness as presented in Sheridan’s framework.9

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

The TEI categorizes individual competencies into three aspects: Organisational, Relational, and Communication. The Organizational Competencies deal with managing the workflow of the team, the Relational Competencies deal with fostering positive interpersonal relations, and the Communication Competencies deal with the way in which issues and work are presented and discussed. To develop the inventory, a synthesis of other inventories was created and redundancy between behaviours eliminated. Some inventories which informed this development include Bushe and Coetzer’s 5 and Maxwell’s 7 inventories which focused heavily on what this inventory terms Relational (conflict management, decision making, cohesion, interdependency) and Organizational (team-member and team performance expectations, direction/goal setting, work processes, etc.) competencies, and Lingard’s 3 which presented some Communication competencies (share opinions and knowledge, listen to others’ opinions, consider others suggestions). The resultant list of competencies from this synthesis was then combined with instructor feedback on competencies that they felt should be incorporated or eliminated based on their experience. Utilizing both information sources, the list was refined and simplified based on
instructor feedback to create the inventory of 27 individual team-effectiveness competencies shown in Table 1.

Students use this inventory as outlined in Sheridan’s framework,\textsuperscript{9} as a guide for providing structured assessments on their own and their team-memers’ effectiveness along each of the competencies. When providing an assessment, students use a behaviorally anchored rating system, and 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 used to develop the descriptions of each competency describes a student’s level of engagement in utilizing that competency to improve team performance. The model starts at unengaged (1-3), moves to self-focused (4-5) and finally to team-focused (6-7). To obtain a team-focused rating along each competency the student has to demonstrate an ability to model the behaviours necessary of a competency and promote these behaviours in their team members. As an example, the descriptive assessment scale is presented for three competencies 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 their performance level and how they need to improve.

Table 2. Examples of the descriptive assessment scale for some of the competencies listed in the TEI as presented in Sheridan’s framework.\textsuperscript{9}

<table>
<thead>
<tr>
<th>Competency</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Support team rules</strong></td>
<td>Did not contribute to the development or team rules, nor did they abide by them during the project</td>
<td>Supported only those rules which were convenient or they felt were appropriate</td>
<td>Contributed to the development of the rules and supported most of the rules, most of the time</td>
<td>Contributed to the development of the rules, and not only supported but assisted other teammates in supporting them</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Motivate others on the team to do their best</strong></td>
<td>Did not demonstrate interest in the motivation of anyone on the team, including self</td>
<td>Did not demonstrate interest in the motivation of others on the team</td>
<td>Attempted to motivate others when it was beneficial to self, or was not too time consuming</td>
<td>Motivated others on the team to do their best at all times during the project</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Openly express opinions</strong></td>
<td>Did not express opinions</td>
<td>Expressed opinions in a manner which demonstrated hesitation or reservation</td>
<td>Expressed opinions in an open manner</td>
<td>Expressed opinions in an open and unbiased manner that solicited input from others</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Once the team has completed the TEI for all team-members, the assessments are combined and distributed to students as feedback such that they can see their self-assessment and an anonymized list of assessments their team-members provided. The three competencies in which the student’s performance was the weakest are highlighted in red on the feedback, and the three competencies in which the student’s performance was the strongest are highlighted in green to allow students to easily identify their strengths and weaknesses. The feedback is provided to the student along with a copy of the TEI and a list of tools and techniques on how to improve in each competency.

3. Study Design

A pilot study to assess the utility of the Team-effectiveness Inventory (TEI) in facilitating useful feedback was tested in the Winter 2012 term of a 250-student cornerstone design course in first year engineering. The objective of the study was to understand how students perceive, interpret and use the inventory so as to revise it to make it more accessible and useful for assessment and feedback.

Before providing assessments, the class attended three half-hour lectures on individual team-effectiveness, and how these behaviours manifest in highly-effective, high performance teams. Following this, in week 7 of a 13 week term, students were asked to provide self- and peer-assessments on their effectiveness as team members. Forty-eight percent of the class completed this assessment using the Team-effectiveness Inventory in Table 1, with the remaining 52% providing free-form feedback. Simultaneously, Teaching Assistants (TAs) in the course completed TEI assessments of all students in their tutorial sections.

One week after completing the assessment, students received their self- and peer-assessments as feedback for review with three strengths and three weaknesses highlighted. At the end of the course (week 13), students in both groups completed the same survey on the usefulness of the feedback they received. Questions in the survey analysed the quantity, depth, and breadth of the feedback as well as its motivation to incite students to improve their individual team-effectiveness. Focus groups with TAs and students who used the inventory were conducted after the second survey to assess the TEI’s utility, and capture data on how students perceived and used the TEI.

The rate of students’ consent to participate in the research study was high at 77.5%. Thus data was obtained from 100% of the students but only the data from this 77.5% was used for the analysis reported in this paper. Since the students had to complete the assessments of their team members for course purposes, as part of a 2% completed/not-completed deliverable, this high portion of the students were willing to allow their anonymized assessments to be copied over to the research database for this study. However, student participation in the focus groups (either due to the lack of grade-based incentive, or focus group timing - after all exams were completed) was significantly lower than expected making all findings from the focus groups informative, but not statistically significant. All teaching assistants involved in the study participated in a TA focus group.

To guide improvements to the inventory, we sought to understand how students perceived and used the inventory. Using the data gained from the study described above, a mixed methods
approach was used to develop this understanding as well as how well the inventory mapped to students’ beliefs about team-effectiveness in general. First qualitative information from the focus groups was transcribed and coded to surface common themes from both students and TAs about their experiences using the inventory. Following this, findings from the focus groups were then compared to the quantitative data available from student and TA assessments. These data included: i) correlation analyses between competencies, ii) the frequency of a TA not being able to assess a student on a competency, and iii) student feedback on the inventory from the end-of-term survey (both quantitative and qualitative). From these analyses, general observations of students’ perceptions and use of the inventory were obtained, as well as aspect-level interpretations and perceptions of the individual competencies.

4. How students perceived and used the inventory

Overall, students perceived the inventory as a useful tool to provide feedback to themselves and their team-members on their individual team-effectiveness as well as to develop a greater understanding of effective team-work. Students found that the feedback was generally phrased in a neutral to positive tone, and that they received enough feedback from the inventory to develop an understanding of themselves and their performance. Of the students who used the inventory, approximately 80% reported that they felt motivated to improve their performance based on their feedback and over 85% reported that they spent some time planning or practicing to improve their performance after receiving the feedback. Students did not report any jargon or language in the inventory that was inaccessible.

During the focus group discussion, when students were asked to describe an effective team-member they presented competencies which would have fallen under the organizational or communication aspects of the inventory. Students described operational aspects of team-work with a focus on equitable contribution, commitment, and work initiative. This finding was expected, as the relational component of team-work is the area that was described as the most overlooked by the faculty interviewed in the development of this inventory. One finding that was not expected was that when asked to describe the competencies of an effective team-member, the students described team-members with a learning-orientation – team-members who were fast-learners, were self-directed and were critical thinkers. This demonstrated that students may still be privileging the work-related competencies over the other competencies.

Both students and teaching assistants commented that they would have liked an opportunity to provide textual comments to the recipient of the feedback to explain their assessment. There was much disagreement among the members of the focus groups as to whether the comments should be related to specific competencies or holistic for one team-member’s general performance. The students felt that this would be particularly useful as their assessment of each team-member is informed by the student’s relative performance compared to all other members of the team, and that by providing such feedback a student could outline the specific behaviours that the team-member did or did not demonstrate in comparison to other members behaviours to justify their assessment.

Teaching assistants who used the inventory commented that it is best-designed for use by team-members and not by outside observers. Several of the competencies required knowledge of team-mechanics that were important to successful team performance but that were not visible to them
in the amount of time they spent interacting with the team. This confirmed that the inventory is an internal assessment tool appropriate for self- and peer-assessments. However, students did comment that a debrief for the entire team, facilitated by a teaching assistant, would allow the entire team to determine how to be more effective as a whole than they would be able to individually by processing their feedback.

The placement of the inventory in the project cycle was reported by students to be well-timed. Students reported that the mid-term TEI allowed them to gauge their process, reminded them about aspects of teamwork that they otherwise would not have thought about until too late in the project, and as a result, allowed them to readjust their path and fix potential team issues before they became significant. This demonstrated that the students used the competency listing from the inventory both as a guide to reflect on the processes they and their team members were using as well as to provide feedback.

5. Improvements made to the Team-effectiveness Inventory

Four types of modifications were made to the inventory: removal of competencies, combining competencies, relocating competencies between the aspects, and rephrasing competencies. These modifications were informed by the analysis discussed in the previous section as well as two requests from the instructional staff of the design courses at the University: i) to create an instrument that allowed students to assess their entire team in less than half an hour, and ii) to allow the instructional staff to obtain information about student work contribution. As a result, modifications which reduced the total number of competencies, and those which created the greatest amount of differentiation amongst the behaviours being assessed were privileged.

A Spearman’s rank correlation was first completed to determine competencies which should be flagged for further investigation using qualitative data. Overall, all 27 competencies were highly correlated with each other; no two competencies had a correlation of less than 0.5. Such high correlation values were expected as the competencies combine to create an effective team-member, and thus someone who is a highly-effective team member would be expected to have high competence across all of the behaviours. As a result, the critical limit of 0.1 was not informative in completing this flagging and a cut-off of 0.75 was decided on as it identified an appropriate number of competencies to be investigated to reduce the inventory. All competency correlations which fell above this cut-off value are presented below in Table 3.

5.1. Removal of competencies

Competencies whose intended meanings were encompassed by other competencies, and those which the students and teaching assistants found difficult to understand or had multiple interpretations of were considered for removal.

Within the organizational aspect, three competencies were removed: support team rules, contribute to making meetings effective, and display dedication and determination. The support team rules competency was removed as some courses do not have students document a set of rules or norms of behaviour and as a result this question was not relevant to all students. This made assessments along this competency unreliable. The contribute to making meetings effective competency was removed as the term effective was interpreted in many ways by the students making the competency too vague. Instead of rephrasing, this competency was removed as it was
seen to be included partially in the *attend team meetings prepared* competency and the competency *promote productive discussion* that will be discussed in the combined competencies section. The *display dedication and determination* competency was removed as the focus group data demonstrated that it was a difficult competency to assess due to interpretation and its assessments were highly correlated with those of *motivate others on the team to do their best*, and *encourage progress to meet goals and deadlines*. Since the essence of this competency was already encompassed in other competencies it was deemed redundant and eliminated.

Table 3. Competency correlations which had a Spearman’s rho (ρ) of greater than 0.75 and were identified as candidates for potential modification.

<table>
<thead>
<tr>
<th>COMPETENCY</th>
<th>COMPETENCY</th>
<th>ρ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do their fair share of the work</td>
<td>Deliver their work on time</td>
<td>0.83</td>
</tr>
<tr>
<td>Track team progress vs. project timeline</td>
<td>Encourage progress to meet goals and deadlines</td>
<td>0.80</td>
</tr>
<tr>
<td>Help to plan, set goals, and organize work</td>
<td>Encourage progress to meet goals and deadlines</td>
<td>0.76</td>
</tr>
<tr>
<td>Encourage progress to meet goals and deadlines</td>
<td>Display dedication and determination</td>
<td>0.76</td>
</tr>
<tr>
<td>Help to plan, set goals, and organize work</td>
<td>Track team progress vs. project timeline</td>
<td>0.76</td>
</tr>
<tr>
<td>Support team rules</td>
<td>Encourage progress to meet goals and deadlines</td>
<td>0.76</td>
</tr>
<tr>
<td>Do their fair share of the work</td>
<td>Produce high quality work</td>
<td>0.75</td>
</tr>
<tr>
<td>contribute to making meetings effective</td>
<td>Help to plan, set goals, and organize work</td>
<td>0.75</td>
</tr>
<tr>
<td>Display dedication and determination</td>
<td>Motivate others on the team to do their best</td>
<td>0.75</td>
</tr>
<tr>
<td>Adopt suggestions from other members</td>
<td>Accept feedback about strengths and weaknesses</td>
<td>0.76</td>
</tr>
<tr>
<td>Demonstrate accountability</td>
<td>Collaborate effectively</td>
<td>0.75</td>
</tr>
<tr>
<td>Show respect for other team members</td>
<td>Collaborate effectively</td>
<td>0.75</td>
</tr>
<tr>
<td>Collaborate effectively</td>
<td>Help the team build consensus</td>
<td>0.78</td>
</tr>
<tr>
<td>Promote constructive brainstorming</td>
<td>Provide constructive feedback</td>
<td>0.80</td>
</tr>
<tr>
<td>Make sure that team members understand important information &amp; instructions</td>
<td>Help team build consensus</td>
<td>0.77</td>
</tr>
<tr>
<td>Openly express opinions</td>
<td>Promote constructive brainstorming</td>
<td>0.76</td>
</tr>
<tr>
<td>Provide constructive feedback</td>
<td>Make sure that team members understand important information &amp; instructions</td>
<td>0.76</td>
</tr>
<tr>
<td>Actively listen to team members</td>
<td>Provide constructive feedback</td>
<td>0.75</td>
</tr>
</tbody>
</table>

Within the relational aspect, two competencies were removed: *accept feedback about strengths and weaknesses* and *collaborate effectively*. The *accept feedback* competency was removed as feedback is a form of suggestion for improvement, and this competency was seen as the self-efficacy component that is a precursor to the competency *adopt suggestions from other members*. 
Additionally, the two competencies were highly correlated and students often referenced the two competencies together. The collaborate effectively competency was removed as it was highly correlated to three other competencies and was not a well-defined, observable behaviour in its own right.

Within the communication aspect only one competency was removed: make sure that team members understand important information and instructions. This competency was a point of contention in the focus groups as to whether this type of behaviour would result in a dominant person taking control of the group or if it was a more specific version of the exchange information in a timely manner competency. Due to its similarity to the exchanging information competency and its high correlation with the competencies that formed the promote productive discussion competency, it was removed.

5.2. Combination of competencies

Competencies whose intended meanings were seen as very similar, and which students and teaching assistants often discussed together were considered for combining into one competency. This allowed the number of competencies to be reduced without the removal of meaning from the inventory.

Within the organizational aspect the two competencies help to plan, set goals, and organize work and track team progress vs. project timeline were combined as both addressed aspects of setting up and monitoring the progress of the workflow in the team. Both of the competencies were highly correlated to each other as well as the competency encourage progress to meet goals and deadlines. As the monitoring component of the competencies was seen to be encompassed in the encouragement competency, it was felt that the two competencies should be combined to reflect establishing and organizing the work for the team. The wording help to plan and organize workflow was chosen as it eliminated the goals component covered in the encouragement competency, and by using the term workflow instead of work, the competency aims to demonstrate a sense of timeline and progression instead of work completion.

Within the communication aspect, the competencies introduce new ideas and openly express opinions were merged as students often referred to the open discussion of ideas and opinions together. Teaching assistants expressed concerns that the introduce new ideas competency privileged extraverts in particular due to the nature of conceptual design work, but did not express concern over expressing opinions. As a result these competencies were combined to create an openly express ideas and opinions competency.

5.3. Relocation of competencies between aspects

Competencies whose intended meanings did not map to the meaning of the aspect as expected were relocated to a more appropriate area of the inventory. Competencies were moved between the relational and communication aspects based on focus group findings and the correlation analysis as it emerged that students did not perceive their relevance to the aspect in the way that the inventory designers did.

Two competencies were relocated from the relational to communication aspect: raise contentious issues in a constructive way, and solicit input before proceeding. While both of these
competencies have relational and communication aspects, the designers believed that both competencies required high trust, and emotional intelligence to facilitate the types of discussions addressed by these competencies. However, the assessments along these competencies were more highly correlated with those of the communication aspect, and when these competencies were discussed by the students and teaching assistants, they were discussed as though they were communication-related competencies. As a result, they were moved to the communication aspect.

One competency was moved from the communication aspect to the relational aspect: help the team build consensus. Given the discussion of different perspectives and negotiation to build consensus, this competency was perceived by the designers to be primarily communication focused. However, based on the correlation analysis and from student discussions in the focus groups it became clear that this competency was perceived to be more related to the relational aspect competencies. This was due to the fact that consensus building requires the ability to understand your and your team members’ perspectives as well as the collective good of the team. As a result, given the competencies relational merits, it was moved to the relational aspect.

5.4. Rephrasing of competencies

Rephrasing of competencies was considered for competencies which had similar wording and where student assessments between these competencies were highly correlated. Two common words demonstrated high correlations in assessment: effective and constructive. As all competencies with the term effective have already been eliminated, only those with the term constructive were considered herein. These competencies were: raise contentious issues in a constructive way, provide constructive feedback, and promote constructive brainstorming. While these three competencies all deal with presenting information in a manner that will facilitate greater openness and productivity amongst the team members, it was unclear whether the correlation could be attributed to the common phrasing or to the actual competencies themselves. As a result, the competency on contentious issues was left with the term constructive, as that competency required an essence of building a better functioning team that no other word could provide. The providing feedback and promoting brainstorming competencies demonstrated an open sharing of ideas in a manner that would increase team productivity that did not touch require the same caution as raising contentious issues. Additionally, both providing feedback and promoting brainstorming were seen to be highly linked, both in correlation analyses and in the language students used in the focus groups to describe the types of discussions that were helpful to making progress. Feedback was seen as increasing the productivity of the team members, where brainstorming was seen as increasing the productivity of the design work. As a result, both competencies were decided to be merged into a new competency promote productive discussion that did not have the term constructive and encompassed the types of conversations previously outlined by the two competencies.

5.5. Improved Team-effectiveness Inventory

Based on the changes discussed above, the revised team-effectiveness inventory developed from this study is presented in Table 4. As can be seen in the revised inventory there is now an equal number of competencies in each aspect such that no aspect can be perceived to be more important. The organizational aspect continues to have a high work focus so that instructional
staff can deduce team-contribution information in a manner that is not explicit to students. The total number of competencies was also reduced by 1/3 to reduce average completion time from 45 to 30 minutes.

Table 4. The 18 competencies of the Team-effectiveness Inventory divided equally into the three aspects of team-effectiveness.

<table>
<thead>
<tr>
<th>Organisational Aspect</th>
<th>Relational Aspect</th>
<th>Communication Aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourage progress to meet goals and deadlines</td>
<td>Build the trust of teammates</td>
<td>Exchange information in a timely manner</td>
</tr>
<tr>
<td>Attend team meetings prepared</td>
<td>Motivate others on the team to do their best</td>
<td>Openly express ideas and opinions</td>
</tr>
<tr>
<td>Do their fair share of the work</td>
<td>Help the team build consensus</td>
<td>Promote productive discussion</td>
</tr>
<tr>
<td>Deliver their work on time</td>
<td>Adopt suggestions from other members</td>
<td>Actively listen to teammates</td>
</tr>
<tr>
<td>Produce high quality work</td>
<td>Show respect for other teammates</td>
<td>Solicit input before proceeding</td>
</tr>
<tr>
<td>Help to plan and organize workflow</td>
<td>Demonstrate accountability</td>
<td>Raise contentious issues in a constructive way</td>
</tr>
</tbody>
</table>

6. Conclusions and Future Work

This paper presents the results of a study to assess and improve the utility of a team-effectiveness inventory used to guide reflection and provide feedback to students on their individual team-effectiveness competencies in team-based project courses. The inventory presented is designed to be used in conjunction with the online tool presented in Sheridan’s framework for students to develop these competencies in a manner which is integrated with their technical course material. Based on student feedback from surveys and a focus group, the students found that the feedback received from the inventory motivated them to improve and reminded them of all the aspects of team-work at the midpoint of the course which allowed them to improve their performance. The inventory was then reduced from an initial 27 competencies to 18 competencies based on the results of this study such that competency behaviours were more distinct and so that inventory completion time would be reduced.

The improved inventory has been tested in two upper-year courses at the University of Toronto in Fall 2012 in a leadership-focused and an energy-policy focused course to obtain preliminary information about how students are using the new inventory. In Winter 2013, the inventory will be tested again in two cornerstone design courses (1000 and 300 students each) to assess its ability to guide first-year students in developing their individual team-effectiveness and statistically validate the inventory. It is expected that through this intentional teaching of team
effectiveness that there will be an increase in student performance in team-based projects due to a greater ability to understand and address team dynamics.

Acknowledgments

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References

Appendix P. “Understanding Teaching Assistants’ Assessment of Individual Teamwork Performance”


A team-effectiveness inventory of behavioural competencies was used as a conceptual framework with which teaching assistants were asked to assess each students’ individual teamwork skills. The reliability and confidence of teaching assistant assessments as well as the way in which teaching assistants used these assessments to support students to become more effective team-members is presented.

1. Introduction

Team-based projects have become a common teaching practice in engineering courses as a means to simulate real-world environments and meet accreditation requirements for the development of teamwork skills\(^1\). In particular within design courses, team-based projects allow students to engage in problems that are technically more complex and larger than one student would be able to tackle, but that can be solved by a group of students working effectively together. In these courses, students are often instructed on the technical aspects of the project material in detail by the course instructor, however they may receive little or no instruction on how to function effectively as a team. Integration of team-effectiveness or teamwork skills into these courses in a manner that is applicable to the team-based project is necessary to achieve student buy-in that these skills are equally as valuable to learn as their technical counterparts. In particular, the ability to support and assess the development of team-member effectiveness is necessary in the classroom environment where instructors and/or teaching assistants work directly with these student teams.

The type of courses which this study aims to inform are integrated design and communication courses where students have minimal experience working in teams at the university level. At our University, courses like this can have from 250-1000 students, making teaching assistants (TAs) a valuable part of the instructional team. In these courses, instructors are often not present in the tutorial classrooms in which observations of teamwork are possible, removing their ability to assess the student development of team-member effectiveness. In addition to the TAs responsibilities to support the technical development of their students, the instructors rely on these TAs to identify any dysfunctional teams or team issues that may arise in their tutorial classrooms and for the majority of issues address them as well. With TA to student ratios at our university ranging from 1:12 to 1:30, the ability to identify and address these issues in addition to other classroom responsibilities can become challenging.

As a result of these demands on TAs, the assessment of student team-member effectiveness often falls to the students in the teams. Several online tools have been developed as platforms for
students to develop and assess team-effectiveness competencies through the use of self- and peer-assessments (e.g. CATME\textsuperscript{2}, TeamDeveloper\textsuperscript{3}, WebPA\textsuperscript{4}). These tools have primarily been designed to be plug-and-play type instructional tools that are designed to be dropped into any team-based course and work with the team situation with minimal customization from the course instructor. These tools provide great resources to students who utilize them, and have been shown to identify teams which may be dysfunctional\textsuperscript{2}. While studies have shown that the information from team assessment systems can enhance instructor assessment capabilities\textsuperscript{6}, few of the above systems integrate with the TAs who have to deal with several different team situations in their tutorials on a day-to-day basis. Studies into these tools’ effectiveness as self- and peer-assessment instruments is well documented\textsuperscript{7}, however there is little on their utility in assisting TAs to assess student development of these skills.

TAs who support these design courses in tutorials are predominantly hired to assess student competence in, and support the development of, the technical or design components of their students’ work. They are not necessarily capable of, or comfortable with, assessing students’ abilities to work effectively in a team environment. In the medical literature, the assessment of technical and non-technical skills (such as teamwork) has shown to be assessed differently by students as compared to instructors. Greater convergence exists between instructor and student assessments in technical skills than in non-technical skills\textsuperscript{8}, with some instructors rating non-technical skills higher than student peers\textsuperscript{9}. Whether this stems from less observation time with the students being assessed or from students being more relaxed in their behaviour around peers than instructors, medical faculty have argued that non-technical skills are more suited for self- and peer-assessment\textsuperscript{10}. In business, a study of faculty and students at business schools has shown that faculty perceive there to be more team dysfunction in team-based projects than students do\textsuperscript{11}, indicating that students and instructors may be observing different markers of team functioning. Since the assessment need of technical and non-technical skills differ, TAs need to have clear frameworks as to how to assess these non-technical skills such as teamwork.

However, the way in which TAs can assess teamwork in tutorial situations varies drastically from the observational approach used in many behavioural assessments. In medical and pharmaceutical education non-technical skills (like teamwork) are assessed during clinical simulations. In these situations, the instructors are able to focus their entire attention on a single team’s simulation without the need to support or respond to it during its execution\textsuperscript{12}. However, in the design tutorial classroom, TAs are interacting with and observing several teams at once (upwards of six to eight), responding to student needs, and observing students’ abilities to work effectively in teams. This cognitive demand is significantly greater for TAs than those documented in the behavioural assessment studies, and may result in differences between the behaviours a dedicated observer is able to assess, as compared to a TA. One approach researchers have undertaken to avoid this in-classroom assessment, is to video-record select intervals of team functioning and evaluate them outside of the classroom\textsuperscript{13}. While this provides researchers with an understanding of the teams’ functioning, it does not provide the TAs with any information on how to assess and adapt their teaching in real-time. Training to be an effective observer in this context is necessary.

In terms of TA training, much research has focused on developing the teaching skills of TAs. In design courses with team-based projects, TAs are often required to act as facilitators, adapting their teaching based on assessing the different needs of each team. Spike and Finkelstein\textsuperscript{14,15}
their research on teaching/learning assistant training programs in physics, have shown that training meetings and having teaching assistants complete a tutorial in advance of running it, converged teaching assistant awareness towards known student content difficulties and allowed them to better identify and articulate these difficulties. In chemistry, the use of real-time behavioural rubrics in laboratories has allowed TAs to become more aware of student experimental skills and adapt their instruction to student need. These behavioural rubrics were useful in this context as the TA to student ratio was 1:2, but in ratios much higher than this, it would not be possible for TAs to fill them out in real-time and respond to student needs simultaneously. One approach that could allow student assessment of larger classrooms is the use of behavioural checklists, such as those used to simultaneously assess technical and non-technical skills in medicine, which provide a binary assessment of the existence of observable behaviours. While this has potential for demonstrating weaknesses in terms of missing behaviours, it provides no scaffolding to enhance the performance of students who exhibit behaviours poorly. Minimal research exists into how TAs assess behavioural or non-technical skills in tutorial settings when provided with behaviours to observe and a rubric to complete post-hoc.

1.1. Study Objective

Over the past three years at our University, we have implemented the use of a Team-effectiveness Learning System to assist in the development of teamwork skills in student design teams. This system comprises two frameworks to define team effectiveness, a related self- and peer-assessment instrument with observable behavioural competencies, and on-line tools and techniques to assist students in improving upon their competency based on these assessments. This system is discussed in detail in the conceptual framework section of this paper, and in Sheridan’s Team-effectiveness Inventory. Our initial objective in involving TAs in the use of the assessment instrument was to provide a ‘gold standard’ by which to validate student self- and peer-assessments of their competence, but has led us to investigate how TAs attempt to assess individual team-effectiveness skills in their students.

This paper outlines a study of teaching assistants in a first-year cornerstone design course in an attempt to understand their ability to assess and support the development of individual team-effectiveness skills in their students. The study aimed to respond to the following research question:

\[ \text{How do TAs assess student teamwork using a conceptual framework for individual team-member effectiveness?} \]

The remainder of this paper will present the models of teamwork presented to students in the course and the conceptual framework of individual team-member effectiveness used in this investigation, followed by the study design, methods used, and results. The paper closes with key findings and implications for the assessment of student teamwork skills in design courses.

2. Design Course Context

The course in which this study occurs is a required first-year engineering design and communication course taken by 250 students at a large, public, research-intensive university. All students are part of a program in which their first two years are general, and their final two years
are specialized. The course divides the students into 10 “studio” sections of 25 students, which are analogous to tutorials. A conscious language choice was made in the naming of this part of the course so as to break students away from expecting the studios to follow a traditional tutorial model of a TA solving problems at the front of a classroom.

Students attended two hours of studio each week during a 13-week term. During studios, students work in teams of three or four on either their term-long design project or on specific concept development activities that will support their design project. During these studios, the role of the teaching assistants is to facilitate team-level or class-level discussions on course concepts, support individual teams in the development of their project work, and to engage in dialogue with students one on one to critique their team and project work so as to support their development as credible engineering designers. Teaching assistants move from team to team around the room, having conversations with each team at least twice during a typical studio.

Each studio was staffed with two TAs (forming a teaching pair), providing an instructor to student ratio of approximately 1:12. Each teaching pair staffed two or three studio sections per week, with teaching pairs held constant over the term. This allowed each pair to get to know the students and teams in each of their studio sections and to build rapport with them over the term. Each pair was comprised of one engineering TA with an engineering background and one communication TA with a background in the arts or humanities. These pairings were set up to ensure that the students were supported in developing their design and communication skills equally, to ensure the students practiced communicating their designs to non-engineers, and to model the multiplicity of perspectives that exist around the problems their designs aimed to address.

3. Team-effectiveness Frameworks

Two conceptual frameworks for team-effectiveness were employed in the first-year engineering design course studied. A team-level framework of teamwork comprising four models that describe how the team should work together was the foundation of team-level team effectiveness instruction in the course. This framework existed within the course before any individual-level team-effectiveness development was introduced. An individual-level framework of competencies that describes the behaviours of an effective team-member was the foundation of individual-level team effectiveness instruction in the course and the framework which was used by TAs to assess individual student’s competence. This conceptual framework of individual team-member effectiveness will be referred to as the ‘conceptual framework’ for the remainder of the paper. The team-level framework is provided to give the reader insight into the team situation in the course, however it is not used in the analysis of the conceptual framework.

3.1. Pre-existing Course Framework of Effective Teamwork

The course already employed models of teamwork that were introduced to both students and teaching assistants in an interactive lecture-type format with specific examples to describe each of the components/stages of the models. The first model was Tuckman’s model of team development which was used as a way to describe to students the different types of actions and work they should undertake to form a high performance team. Components of Tuckman’s model that were employed included discussing team norms and communication schedules, and determining the key design values the team would embody from individual’s design values. The
The second model was Toulmin’s model of argument\textsuperscript{20} which was presented as a means of critiquing work and providing constructive feedback based on specific team encounters. This allowed students to have a structured way to introduce issues they believed were creating problems, or critique other students’ project-work in a manner that focused on the circumstances and beliefs of the presenter rather than the motives of anyone involved in the situation. The third model was the five dysfunctions of a team\textsuperscript{21} which was used to demonstrate to students how teams fail when there is no trust between team members, and to dissuade the students from starting to think about their team project from the results perspective and instead to start thinking of it from a team building perspective. The fourth model was Johari’s Window\textsuperscript{22} which was provided to students as a means of developing their understanding of their self and how they are perceived by others. This particular model was the primary theoretical framework that was used to inform the integration of the conceptual framework of individual team-member effectiveness into the course; information gleaned from the use of this framework could be used to better inform the ways in which other students on their team perceived their behaviours and actions.

3.2. Conceptual Framework of Individual Team-member Effectiveness

The conceptual framework of individual team-member effectiveness followed in this paper is comprised of the 27 competencies outlined in a Team-effectiveness Inventory\textsuperscript{18}. This inventory presents 27 competencies that comprise three aspects of individual team-member effectiveness: organizational aspects (project management), relational aspects (interpersonal relations), and communication aspects (information presentation and discussion) as shown in Table 1. These competencies are developed in students through the use of an online Team-effectiveness Learning System that allows students to complete and reflect upon self- and peer-assessments of their actions along these competencies. The inventory is comprised of a 7-point behaviourally anchored rating scale for each competency which describes what each of the competencies should look like in a team working at the ‘performing’ stage of Tuckman’s model. Students can review their self- and anonymized peer-assessments as feedback in the on-line system and determine opportunities for improvement using the Johari’s window concept and on-line lessons about each competency.

4. Study Design and Methods

This study involved teaching assistants (TAs) in a first-year cornerstone design course of approximately 250 students. The study aimed to determine how TAs assessed individual team-effectiveness behaviours when given a conceptual framework for assessment – the Team-effectiveness Inventory. The study took place in the winter term of 2012.

4.1. Study Participants

This study consisted of seven teaching assistants working as pairs across nine different studio sections that ran three in parallel on three different days of the week. Four teaching assistants staffed three sections per week, and three teaching assistants staffed two sections per week, creating five different pairs across the nine sections. All teaching assistants were in the process of completing either their Masters or Doctoral program in Engineering, the Arts, or the Humanities. Five of the seven TAs had worked as a TA for the course previously, with the two new TAs having completed the course as part of their undergraduate degree program; thus, all
TAs had prior experience with the course. Four TAs were female, and all TAs were native English speakers. All TAs involved in the program participated in the study.

Table 1. The 27 competencies of the Team-effectiveness Inventory divided into the three aspects of team-effectiveness as presented in Sheridan’s framework.

<table>
<thead>
<tr>
<th>Organisational Aspects</th>
<th>Relational Aspects</th>
<th>Communication Aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1. Support team rules</td>
<td>R11. Build the trust of teammates</td>
<td>C20. Exchange information in a timely manner</td>
</tr>
<tr>
<td>O2. Attend team meetings prepared</td>
<td>R12. Motivate others on the team to do their best</td>
<td></td>
</tr>
<tr>
<td>O4. Do their fair share of the work</td>
<td>R14. Solicit input before proceeding</td>
<td>C22. Openly express opinions</td>
</tr>
<tr>
<td>O5. Deliver their work on time</td>
<td>R15. Adopt suggestions from other members</td>
<td>C23. Promote constructive brainstorming</td>
</tr>
<tr>
<td>O7. Help to plan, set goals, and organize work</td>
<td>R17. Show respect for other teammates</td>
<td>C25. Provide constructive feedback</td>
</tr>
<tr>
<td>O8. Track team progress vs. your timeline</td>
<td>R18. Demonstrate accountability</td>
<td>C26. Make sure teammates understand important information and instructions</td>
</tr>
<tr>
<td>O9. Encourage progress to meet goals and deadlines</td>
<td>R19. Collaborate effectively</td>
<td></td>
</tr>
<tr>
<td>O10. Display dedication and determination</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2. Study Design

At the beginning of the course, teaching assistants participated in a 1.5 hour training session on teamwork and were invited to participate in the study. This training session comprised two objectives. First, it introduced the TAs to the course models of teamwork. TAs were introduced to what each of the competencies in the Team-effectiveness Inventory looked like at the high and low levels of performance through example team situations recounted from previous years. TAs were then provided a space to negotiate amongst each other working definitions of the
terminology in the framework to ensure they were all assessing the behaviours in the same manner. Additionally, TAs had the opportunity to ask the designer of the inventory to clarify each behaviour with examples of what the behaviour would look like in their course context. Second, TAs discussed high-functioning and dysfunctional teams from past years, indicators of dysfunction and strategies to support both types of teams in their development. In addition to this training session, TAs also attended the same lecture on teamwork that was attended by students, where the models were introduced and discussed in relation to students previous successful and unsuccessful team experiences.

During the final two weeks of the course, after the TA pair had been working with the students for eleven weeks, each TA was asked to independently assess the students in their studio sections on their teamwork ability using the Team-effectiveness Inventory. Assessments were completed online by the TAs on their own time during these final two weeks of the course. For each competency, TAs selected the student’s behaviour along a 7-point behaviourally anchored rating scale, and were given a ‘do not know’ option in case they were unable to assess that competency. Following collection of all assessments, the seven TAs participated in a focus group to articulate their experiences providing assessments and to discuss how well this framework mapped to the team situation in the course and their perceptions of successful teamwork.

4.3. Analysis Methods

Using Creswell and Plano Clark’s definition of mixed-methods research\textsuperscript{23}, this study aims to provide an explanation of how TAs assess student teamwork skills through combining their quantitative assessments of students’ teamwork competency with follow-up qualitative discussions of how the TAs perceived and used the assessment instrument. Quantitative descriptive statistics were used to determine which competencies were most and least observable by the TAs in the tutorials. Inter-class correlations between TAs assessing the same students were computed, and confidence intervals for the reliability of TA assessment determined. Qualitatively, focus group transcripts underwent thematic analysis to determine the issues TAs had using the framework, discrepancies between the framework and the teamwork situation in the course, and how the framework assisted them in supporting student development of individual team-work skills.

5. How TAs assessed teamwork using the framework

Overall, TA assessments were 2-20% lower than student self- and peer-assessments, and had greater spread across all 7 options for each competency. TAs assessed an average of 16/27 (61%) competencies, with a low of 2/27 and a high of 27/27. TA frequency of response ‘do not know’ for each competency is shown in Figure 1, with competencies colour coded to distinguish the different aspects of individual team-effectiveness.

As can be seen from Figure 1, there is no general pattern in terms of TA ability to assess; TAs were able to assess all three aspects of individual team-effectiveness to a similar degree. In particular, there were 5 competencies in which TAs responded ‘do not know’ over 60% of time: O8 - track team progress versus your timeline, R18 - demonstrate accountability, C20 - exchange information in a timely manner, C25 - provide constructive feedback, and C26 - make sure teammates understand important information and instructions. These 5 competencies are
highly related to the internal workings of the team which would not be visible in discussions in tutorials, or oral or written assignments. The 3 competencies in which TAs responded ‘do not know’ less than 20% of the time were: O3 - contribute to making meetings effective, R19 - collaborate effectively and C22 - openly express opinions. These 3 competencies are all aspects that are not highly related to the internal workings of a team and would be visible to an outside observer watching the students work, or when interacting with a TA.

Figure 1. Percent of total assessments by competency that teaching assistants were unable to assess. For these assessments teaching assistants responded that they ‘did not know’ the student’s competency. Abbreviated variable names correspond to the competency numbering provided in Table 1.

To determine the reliability of TA assessments when using the tool, the inter-class correlations (ICC) between the pairs of TAs were determined for each student. The students whose assessments were included were limited to those in which: 1) both TAs assessed at least 1/3 (9) of the competencies; and 2) both TAs demonstrated considered assessments, i.e. did not give the same assessment across all competencies. Forty-five percent of students assessed met these criteria and were used in this comparison. As can be seen in Figure 2, the average reliability between assessments is very poor, with a significant spread from high to no correlation. This can be understood well through the focus group data, where TAs discussed their difficulties in assessing individual team members. In particular, they found that teams which were neither high nor low performers, but were average were the hardest to assess, as less time was spent with these teams in the tutorials. Discussions with these teams also often focused on technical and design related material where students had the most questions, rather than on team dynamics. As a result, TAs discussed feeling less confident about their assessments of these teams. While
grades data is unavailable to corroborate this finding, there was almost complete unanimity amongst TAs that this was likely the reason.

![Figure 2](image)

**Figure 2.** Distribution of inter-class correlation ICC(2,1) assessments for TAs.

In the focus group, TAs commented that this framework is better designed for use by team-members than by outside observers. As discussed above, some competencies were very difficult for an outside observer to assess as they required observation of aspects of team work that are not normally visible during a tutorial. In particular, given the limited time spent with the students and the types of interactions with the teams, TAs found it impossible to assess the competencies which they felt were vital to successful team performance, but were not visible in discussions with an outside observer. In particular, TAs felt least comfortable assessing the relational aspects of the framework as these competencies were not closely associated with any course content (in terms of material or presentation) and as a result TAs found it difficult to assess these on an individual basis unless the teams became dysfunctional. Additionally, TAs felt that the framework favoured extroverted and assertive students to the detriment of their team members. These students were the ones that the TAs felt most capable of assessing as they usually dominated the team discussions with the TAs and as a result were the students that the TAs knew most about.

The TAs felt that they were much better equipped and competent to assess the functionality of the teams as a whole rather than to assess individual students. TAs felt competent to address minor issues that surfaced in the teams regarding team dynamics, and at times where they did not feel equipped, they referred the teams to the course instructor for management. However, TAs did feel that as a result of the inclusion of the assessments in the course they were better able to identify dysfunctional teams faster, and provide the necessary supports to them sooner since they were consciously looking for these individual team-effectiveness behaviours. More often than not, TAs would provide their own advice on how to develop these behaviours based on past experience rather than based on the tools and techniques that were provided on-line with the
framework. TAs commented that when you are in a classroom dealing with a question, such resources are not always accessible and that recommending them to the students at times is not as effective as providing a recommendation from personal experience.

Reflected upon the use of the conceptual framework in the course, TAs agreed it was, in general, a useful tool. However, TAs felt that competencies around critical thinking, risk taking, and empathy were missing, while competencies around consensus building, input and feedback were overemphasized. Additionally, TAs felt that effective team-members in the course required self-awareness and the ability to acknowledge and work within their strengths and weaknesses but they did not see how this could fit into a teamwork assessment framework.

6. Conclusions and Future Work

This paper presents an initial study into the value of using TAs as outside observers to assess students’ individual team-effectiveness behaviours given a conceptual framework of individual team-effectiveness. The assessments and feedback provided by TAs demonstrate that many of the competencies of the framework are not assessable by observers outside of the team, and that during normal tutorial work periods TAs are only able to assess the functionality of a team as a whole rather than the effectiveness of each individual team member. Resources to assist TAs in supporting individual team-effectiveness development that stem from the framework need to be more accessible in the classroom situation for TAs to make use of them.

Given that TAs may not be the most appropriate observers to assess individual team-effectiveness competence in the classroom setting, further investigations are needed to determine how to assess these competencies independently on an individual basis.

References


Appendix Q. “The Role of Shared Physical Space in Affording the Creation of Shared Conceptual Spaces in Design Project Teams”


1. Introduction

Project-based and team-based learning have become a core component of the undergraduate engineering curriculum in recent years in response to the need to meet accreditation requirements. In design courses, a focus on team-based projects has enabled students to work on topics that are much more complex and model real-world situations. However, this pedagogical shift is predicated on students being able to work effectively together (both at an interpersonal and task level) to be able to co-construct a response to the design challenges posed. Further to this, the focus on inter- and multi-disciplinary design work requires students to be able to communicate and work with students whose understandings of concepts may not necessarily match to their disciplinary knowledge and understanding. Thus, the ability to provide students with scaffolding to negotiate and make meaning of their specific team’s work with one another is critical to being able to work effectively together.

Design-team-based projects are both production environments and learning environments. They encourage each participant to develop a greater understanding of the concepts/processes of design work, and of the subject of their design work. Students in these teams need to be able to engage with each other to debate and discuss their respective understandings of the design project and different design concepts, and be able to co-construct a shared meaning that will create a coherent product. This is different from the collaboration required of routine work. Students in these types of projects cannot simply subdivide the projects into smaller individual, independent tasks that can be reassembled into a coherent whole as that is not the way in which design happens. Design teams need to be able to leverage the individual perspectives and understandings of the team members to develop, as a team, a collective understanding of and relationship between the interdependent components of their work. Thus, the concept of a singularity of understandings of a design problem from the outset is not realistic, rather the concept of a multiplicity of understandings that a team makes meaning from to co-construct a shared understanding of their work is more useful. As per Borrego et al. in their review of the team-effectiveness literature, design teams have intensive interdependence.

A common approach that is used in design teams to construct this shared meaning is the use of shared mental models. Much of the research on shared mental models in teamwork has focused on the impact of these models, or on these models as building blocks that can be used to ensure a
common understanding to work from. Teams which have a higher degree of “coherence” among their individual mental models are seen as higher performing teams. In this context, the use of these models has focused on building a consensus of terminology and concepts among team members – the focus has been on harmonizing rather than building understanding. Relevant to student design teams, Van den Bossche et al. found that student teams engaging in co-construction and constructive conflict were able to build shared mental models. Marques Santos et al. determined that teams that build shared mental models can foster creativity – a necessity of design team work. However, in the literature the process of how student design teams build shared mental models and shared understanding from their disparate understandings is lacking.

An implicit assumption that by working together students will learn the content, underpins this team- and project-based learning model. However, the tools and techniques students are provided with only address strategies students may use to complete the project and produce the end product. Working from a sociocultural perspective that privileges social interactions as a site of learning, helps make this assumption visible. The students are not only struggling to solve a design problem, they are simultaneously using the process of solving the design problem to develop fundamental design and engineering concepts. Thus, students are required to both build mental models of the constructs, coordinate them to create shared mental models within their team, as well as apply these models to the challenge they are addressing – they need to create shared meaning together.

Students have the opportunity to use different symbolic and material mediational means to help them understand, coordinate and guide their actions within the team. Material mediational means include classroom space, tables and chairs, and shared common writing areas (flipchart paper or whiteboards). Other mediational means are more symbolic such as different design models or decision-making tools. The use of mediational means, in particular in a team setting affords the coordination of team thinking and development as it provides an external representation of the team’s current conception. A space of joint interaction provides the affordances for the students to suggest, test, challenge and develop the shared understanding that initiates their learning. Through creating an external representation of the current thinking, the team creates an artefact that they can then manipulate to develop shared understanding. A reciprocal process of internalization and externalization ensues – a continuous (in the best of worlds) process of expansion and cognitive transformation. We propose that a space of joint interaction affords the opportunity to develop shared conceptual space.

The shared conceptual space is the cognitive and affective environment in which team members ideate, negotiate, determine, and specify the work that they are engaging in by creating intersubjectivity in their understandings. Consider conceptual space to be a sandbox in which all team members work together to create a shared structure. Each will enter with their individual understandings of structures, the tools at their disposal, and the sand. Each “sees” the structure differently. Through committing to negotiating these disparate understandings in a way that the concepts are comparable (through creating intersubjectivity, which includes disagreement) the teams can create a shared conceptual space in which they can co-construct a shared understanding of what they want to create. Radford and Roth remind us that “learning is always
an attempt at grasping and overcoming differences (even if these differences may never disappear). The differences that students bring to their teams’ sandboxes include very different levels of conceptual understanding as well as very different levels of practical skill and knowledge. We argue that a space of joint interaction can afford the opportunity for this grasping and overcoming of differences to occur in order to develop a shared conceptual space that affords the development of shared understanding and shared mental models.

This paper follows up on a previous study on team ‘togethering’ and its effect on making meaning in teams. This study looks specifically at how the physical space a design team uses affords them the ability to create a shared conceptual space to work in. For this analysis of how teams create a shared conceptual space (a space of joint action), we have scoped our analysis to focus on the team use of specific material mediational means -- a shared common writing space. Using an activity-theory framework of ‘togethering’ this paper analyses and compares the way in which five first-year engineering design teams used a common writing space (for text and visual representation) in their design team meetings to ‘together’ and build a shared conceptual space.

2. Conceptual and Theoretical Framework

This research is grounded in Vygotskyian sociocultural theory and specifically activity theory as this particular theoretical perspective allows us to simultaneously examine the interactions of both individual and social actions. The negotiation of these social interactions includes the relationships of: the topics to the object of the team, the team members to each other, and the team as a whole to their object(s). We use the term object here in its activity theory sense to refer to the problem or purpose towards which an activity is directed. An activity is a set of various actions (such as ideating, negotiating, planning, agreeing, disagreeing) carried out by a group, a social unit such as a team, motivated by a socially constructed goal. For our use, the activities studied in this paper are team meetings in which a team uses a whiteboard to mediate a decision or series of decisions.

Togethering, as described by Radford and Roth, “has the purpose of realizing a collectively motivated object”. The concept of togethering allows us to analyze the actions and interactions of the team members from the different perspectives of the team members as well as from the perspective of the team, almost as if we were in the team. Togethering is described as “an analytical category that accounts for the ethical manner in which individuals engage, respond, and tune to each other, despite their cognitive, emotional, and other differences.” The three key components of togethering, which build upon each other, are engaging, responding, and tuning.

When a team engages, each individual team member makes a commitment, manifested in action, to work with others in the joint activity. When team members respond, they make efforts to coordinate individual contributions (their engagements) through agreements and disagreements. When the engagement and response contributions of team members results in the emergence of a common object for common understanding of the activity, the team members have attuned to one another.
The individuals in a team each bring a slightly different set of experiences, conceptual understandings, and mental models to the activity. They have engaged by committing to work together. They respond to one another as they coordinate their individual contributions. To attune to one another requires that they, at least partially, enter into one another’s conceptual spaces – that they refract their team member’s contributions in their mental models of the activity.

Refraction, defined by Radford and Roth, is a kind of seeing what another person is saying and simultaneously seeing that contribution in the context of what you are offering. Each individual’s understanding refracts what others say and do differently but if they are ‘close enough’ in their understanding, they can use these refractions to build and transform the shared object of their activity.

In activity theory, mediational means offer an affordance to individuals or teams to coordinate and facilitate inter-and intramental activity. Symbolic artefacts include languages, discourses, gestures, and visual symbols. Material artefacts include physical tools or technology, anything from a piece of chalk to a smart phone. Mediation means offer an affordance of representing or manipulating an individual’s or team’s idea such that those present in the discussion can see and interpret it. They also offer an affordance to represent an emerging object.

The concept of 'togethering' creates, with a variety of mediational means, an interactive activity where team members engage with and respond to one another. At a team level, when there is coordination of individual responses the team achieves intersubjectivity. We will label these coordinated contributions as intersubjectivity, following Matsuov in his conceptualization of intersubjectivity. When the group of individuals only responds to one another without tuning a distributed conceptual space results. Each individual maintains his or her own ideas and no shared conceptual space emerges.

When the group of individuals also tune to one another they begin to create a space of joint action. According to Radford and Roth, “The space of joint action is more than a spatial notion where interaction would occur. It is a space of relations and embodied reciprocated tunings occurring in the concrete space of interaction.” It is this emergence of a common object for common understanding that constitutes an activity occurring in a space of joint action. It is in this tuning that the unity of affect and cognition, a central component of joint activity, is most apparent. The cognitive processes and products do not emerge or exist separate from “the motivating sphere of consciousness, a sphere that includes our inclinations and needs, our interests and impulses, and our affect and emotion. The affective and volitional tendency stands behind thought.” Without this aspect, it becomes difficult to fully analyze the qualities of the interactions we observed - how the affective demeanour of the individuals influenced the discussion, the emergent object, and the cognitive and affective demeanour of their team members. With this in mind, we can more clearly differentiate the different qualities of the interactions of the teams studied.

This paper analyzes how student teams in a first-year design course leveraged the physical mediational means at their disposal to attune to one another and create a shared conceptual space in which to do their design work. In particular, we are interested in knowing how students did or did not use the common writing space (for text or visual representation) to create this attunement.
Our conceptual framework of how this shared conceptual space is built from student interactions, is described below in Figure 2-1. This framework is used in subsequent sections to analyse the interactions of the teams in their meetings.

![Conceptual Framework Diagram]

Figure 2-1: Conceptual Framework of how shared space is (a) constructed and (b) not constructed through the interactions of the team members.

3. Study Design, Methods and Population

This study involved non-participatory observation of five first-year engineering design teams during their team meetings from two different cornerstone design courses. The study took place at a large, publicly-funded, research-intensive university, with a first-year student population of approximately 1300 students. Two of the teams participating in the study took the general engineering client-based consulting engineering cornerstone design course, and the other three teams took the engineering science student-driven entrepreneurial engineering cornerstone design course. Both courses require teams of 3-6 students to work together to define and address a design challenge in their geographic area and interact directly with the client/stakeholders involved. Deliverables consist of written documentation specifying their design as well as a presentation to course instructors and interested stakeholders.

3.1. Study Design

This study follows on a study presented at ASEE 2015\textsuperscript{10} which follows the same study design. Five teams from the course were followed during the winter semester, January to April 2014. Teams volunteered to be a part of the study, and each team member received a gift card to the university bookstore upon completion of the study. Students consented to have three of their team meetings video-recorded. All teams in the study had different tutorial instructional staff, and had their tutorials on different days of the week to minimize any bias one instructor could have over the teams. Video recordings occurred during the week where the team first met, the week immediately after their first major deliverable, and in the last week of the project.
All video-recordings were taken in a private room where only the team was working. Three cameras were positioned around the room to capture each student’s facial expressions as well as any shared work spaces (i.e. whiteboard, flip chart, communal computers). The videos from the three cameras were then synchronized using video-editing software to create a panoramic video of the team and their workspace. Large common writing/recording spaces such as easels, flip chart paper and whiteboards, were available to all of the teams at every meeting recorded in this study. These tools were also available in their regular tutorial meeting times although they may have been encouraged to use them differently according to the TA in charge of the tutorial.

3.2. Research Methods

The methodology followed in this paper is that of a discourse analysis of social events, grounded in an activity theory perspective – specifically ‘togetherness’. Discourse analysis in this paper incorporates both the language (vocabulary, tone, etc.) and the demeanour (gesture, gaze, posture, etc.) of the team members in face-to-face social interaction. Thus, our unit of analysis is the (reciprocated) interaction between the team members rather than their individual behaviours.

We were interested in determining how these students used the physical artifacts at their disposal in these team meetings to develop a shared conceptual space amongst the team members. We scoped our analysis to similar events across the five teams studied – situations in which the teams used a large common writing space (e.g. whiteboard, flipchart paper, etc.) to work on an activity collaboratively. Within each event, we looked for interactions between team members, and between team members and the artifacts at their disposal that allowed the team members to engage with the activity at hand, respond to each other in the context of the activity, and attune their understandings of the activity with those of each other.

Using the definitions from Section 2.1 we analysed these events to determine if and how the teams engaged, responded and tuned to each other and their activity. To determine if team members were engaging with each other or the activity at hand we looked for the orientation of team member gaze and posture, the artifacts they interacted with, and the conversational topics and/or ideas they initiated. To determine if team members were responding to each other we looked at both team member gaze and posture as well as the type and sequencing of discourse moves made by the team members conversation (build, clarify, confirm, agree, disagree, counter, etc). Discourse moves that were coordinated about the activity and allowed the team to move towards greater understanding of the activity were coded as responding; those that were not coordinated about the activity were coded as not responding. To determine if team members were tuning to the activity at hand we looked for building, expanding another’s idea, finishing another’s utterance, supplying the word or gesture needed to clarify or confirm to another.

3.3. Demographics of the Studied Course and Population

The teams who volunteered to participate reflected the demographic of the Faculty, a purely serendipitous occurrence. Of the 22 participants there were five students who were not visible minorities in engineering, nine students who appeared to be English dominant and seven who were female. None of the teams investigated in this paper consist of all monolingual English speakers, and only one team, Team 4, consisted of all domestic students. The language diversity
of the teams was representative of the University’s (and in particular the Faculty’s) linguistic diversity. Given the demographics of the teams and the student population in this course, the probability of having teams volunteer that did not have similar diversity to the student body was minimal. The students’ motivations for participating ranged from “I had a terrible experience first term so I want to do everything I can not to repeat it” to “This might be interesting” to “I wanted the $30 gift card”. With this range of demographic and motivational diversity in each of the teams, we do not feel that there was a unified demographic or motivational volunteer bias.

4. Analysis

The analysis of the teams’ interactions and their ability to engage, respond, and tune to create shared conceptual space follows the conceptual framework presented in Fig. For each team we will first describe the incident by providing a narrative of the interactions within the team and providing select quotations from the incident that define the type of interactions present. Then we will discuss how the team used the mediational means at their disposal during the incident, with specific reference to the shared writing space as the main physical space used. Next, we will discuss the interactions of the team-members using the engage-respond-tune model of togethering, and conclude with whether the resultant activity was in fact one that occurred in a space of joint action that led to shared conceptual space, or in an uncoordinated activity that led to distributed conceptual space. The names of team members discussed below have been replaced with pseudonyms to maintain participant anonymity. A summary of our findings is presented in Table 4-1.

4.1. Team 1

Team 1 was a team of 5 males from different first-year engineering disciplines taking the client-based consulting design course. The team was comprised of Michael, Farid, Tony, Da, and Karim. Michael was both the designated team leader and the only English-dominant member of the team.

This section analyses Team 1’s interactions in the first half of their second recorded team meeting. The team is filling time during their scheduled tutorial meeting throwing out their frustrations with the way they worked on their first deliverable. The team names this activity their “Lessons Learned” – modeled after an individual assignment each team member must submit in approximately two weeks’ time.

4.1.1 Activity Description

The meeting for Team 1 occurs later in the same day that they had handed in their first deliverable. The five team members are initially seated around the table but re-distribute themselves to get comfortable, Figure 4-1. Michael, the designated team leader, is busy on his laptop searching for a meeting agenda, expecting one to be provided by the course instructors as had been done for the first three meetings.
There are three topics in play at this time, “Lessons Learned”; instructions for the next deliverable, the Conceptual Design Specifications document; and the Status Report, a weekly report due during the tutorial. While Michael is searching for an agenda, Farid and Michael begin discussing the document they just submitted. When Michael realizes there is no prepared agenda, he proposes working on “Lessons Learned”. Everyone quickly agrees with this, and two critiques of their previous work process are quickly introduced but neither followed up or developed before another idea is introduced. Tony reminds the team they talked about this the night before but only Da pays attention to his comment.

Farid describes an issue with their process while Tony and Michael suggest how to record the issue for the Lessons Learned. During this time, Da is looking down and Michael makes no eye contact with anyone even when he provides his extended summary of his perception of their work process. Over the next thirty minutes individuals introduce multiple topics of discussion with interjections of content or evaluative comments. All of the team members talk over each other, competing to be heard. They phrase each point as a negative criticism, sometimes sarcastically, with limited recommendations of what to improve.

The whiteboard comes into use when Farid says that they need to write on the whiteboard as evidence that they are working so that the TA can just glance through the window and see that they are working. Da then gets up and goes to the whiteboard and asks what he should write, Figure 4-2.

He is given one idea before the discussion shifts again. Farid finds the instructions have been posted for the next assignment and as he reads out the section names of the next document. The list of sections names prompt criticisms of the deliverable they have just handed in. Da writes the “Lessons Learned” from memory as others continue introducing other topics. Da then resumes his seat. Other team members only glance at what Da has written.
Table 4-1: Comparison of design work, space usage, and shared conceptual space development across the studied teams.

<table>
<thead>
<tr>
<th>Teams</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared Conceptual Space? Y/N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Physical Space &amp; Artifacts present</td>
<td>- physical handouts - engineering notebooks - whiteboard - markers - individual computers</td>
<td>- physical handouts - engineering notebooks - whiteboard - markers - individual computers - smart phones</td>
<td>- 3 computers - common writing space - markers</td>
<td>- printed/written agenda - computer - smart phones - common writing space - print outs of resources - markers</td>
<td>- whiteboard - markers - 3 computers</td>
</tr>
<tr>
<td>Topic</td>
<td>Reasons why they did poorly at delivering their last assignment</td>
<td>Design problem: Real-time tracking of a campus service's usage and purpose</td>
<td>Relative importance of aspects of their design</td>
<td>Criteria for selecting a community</td>
<td>The key features of their design</td>
</tr>
<tr>
<td>Task</td>
<td>Brainstorming &quot;Lessons Learned&quot;</td>
<td>Brainstorming possible design ideas</td>
<td>Determining the poster layout for Showcase</td>
<td>Determine the target community they wanted to work with</td>
<td>Determining the poster layout for Showcase</td>
</tr>
<tr>
<td>How the physical space is used</td>
<td>Ad-hoc and post-hoc single member recording of discussion points on the whiteboard</td>
<td>Single member records ideas on the whiteboard while individual members follow an agreed upon speaking path to voice their ideas</td>
<td>Members took turns drawing their personal representations on the whiteboard</td>
<td>Single member records on a large sheet of paper in the centre of the group that all can access and point at to focus discussion</td>
<td>Members write over each other on the whiteboard to work out and visualise different ideas, while the computer is used to record the agreed upon representation</td>
</tr>
<tr>
<td>Physical Artefacts Leveraged</td>
<td>- whiteboard - markers</td>
<td>- whiteboard - markers - individual recording mechanisms (some engineering notebook and a smart phone)</td>
<td>- whiteboard - markers</td>
<td>- printed/written agenda - computer - smart phones - common writing space - print outs of resources - markers</td>
<td>- whiteboard - markers - 1 computer</td>
</tr>
<tr>
<td>How physical space is used to construct shared conceptual space</td>
<td>Not used</td>
<td>Whiteboard used to record, build, and clarify ideas until agreement was reached</td>
<td>Whiteboard used to find grounds for discussion, but no tuning occurred</td>
<td>Large flip chart paper placed where all had access to it, and used to record the progress and outcomes of the discussion</td>
<td>Whiteboard used as a shared drafting and recording space</td>
</tr>
</tbody>
</table>
Later, when the topic has shifted back to the “Lessons Learned” discussion Karim stands and goes to the whiteboard to add to the list with more critiques previously put forward by the team. Farid make a coherent critique of their writing process, including a proposal of a new process that could help them, but no one listens. It is not recorded on the white board. The team continues their three separate conversations and after a while Karim returns to the board and records a question of his own, “Do you have any particular complaints about team members?” Karim leaves the board to eat but returns a second time and draws stars around the question he had written previously, Figure 4-3. He states it aloud as he goes back to his seat. The team members glance at the board or Karim briefly, and then continue their three separate conversations.

4.1.2 Use of Common Writing Space

The team used the common writing space only as a display of evidence that the team was working on a course activity. This was done so that it could be easily seen by the teaching assistant if he passed by the room they were working in. Separate from the conversations at the table, “Lessons Learned” were recorded from memory. The use of the whiteboard did not focus or guide the discussion, it simply recorded (after the fact) for display, Figure 4-4.
Figure 4-3: Karim tries to draw the team's attention to his question.

Figure 4-4: The team's whiteboard with all recorded information at the end of the activity.

4.1.3 Engagement

The team could not engage as there was no commitment to any shared goal. The team was constantly distracted during the discussion, sometimes getting sidetracked by other courses. The team bounced back and forth between different topics within and across the separate
conversations that were happening almost simultaneously. In short, there was no continuous
discussion or focus on a topic shared by the team.

4.1.4 Response or Attunement

During the haphazard discussion of the lessons learned, the team is not focused on the topic nor
do they use the tools at their disposal to develop their discussion. These contributions were not
intended by all parties to be coordinated. The team members speak over each other and at the
same time compete to have their point be the one heard. They continually introduce new topics
or re-introduce their own previous topic. They are not responding to each other. The irony of
competing perspectives on “what went wrong” within the team is not noticed, as they are
perpetuating the same patterns they are describing as being troublesome. As a result, their
contributions were not coordinated and the team could not attune.

4.1.5 Uncoordinated Activity

This team is a strong example of distributed conceptual space as can be seen in the conversation
pattern of the team members, where the team’s utterances do not overlap, or build on each other,
but instead pass by each other without ever intersecting. Shared conceptual space does not
emerge for this team through the use of their shared physical space as the team does not treat the
space as a tool to leverage in developing their work. The team sees and uses the whiteboard as a
display mechanism to signal their compliance with a perceived course requirement – to work
during the tutorial. As a result of using it post-hoc of their discussion, it cannot be used to guide,
refine, or clarify the discussion points being raised.

4.2. Team 2

Team 2 was a team of 4 females and 2 males from different first-year engineering disciplines
taking the client-based consulting design course. The team was comprised of Barb, Tala, David,
Shen, Lily and Sanova. Barb was the designated team leader, and she and Tala were the only
English-dominant members of the team.

This section analyses Team 2’s interactions in the second half of their second recorded team
meeting. At this time, the team is attempting to brainstorm ideas for their design challenge as a
group. They follow an unstructured brainstorming process where all team members are asked to
contribute ideas to the team’s repository.

4.2.1 Incident Description

The incident begins when Barb asks who wants to write down their ideas for brainstorming and
David moves to the whiteboard to record, Figure 4-5. Barb and Tala begin throwing out ideas
and Barb asks the team what other ideas they have. David reinforces the activity by reminding
everyone that it is a judgment free space. As two vocal team members begin to throw out ideas,
David recommends and the team accepts that they go around the table clockwise to ensure
everyone gets to voice their idea. He also asks if the team should be taking individual notes as
well as him writing on the board as some team members are already taking notes. The team
agrees that they want to take notes but that they should also have a ‘collected focus.’ They then
move clockwise around the table to have each team member share an idea, or pass on their turn, Figure 4-6.

Figure 4-5: David moves to the whiteboard to start the team's brainstorming session.

Figure 4-6: The team decides to go around the able in a clockwise manner. They determine this through moving their hands in a circular motion demonstrating the direction of flow.

David records the ideas on the board, but always turns around to face the group when ideas are being pitched. He often asks questions of clarification, as do other team members, or provides critique to ensure sufficient understanding of the idea being presented before completing the recording. Barb and Tala summarise out loud what the team members say while David records it
on the board. As David records the idea, so do the other team members in their personal notes. As new ideas are introduced, team members re-clarify or modify designs they had previously proposed based on new understandings of the problem. David steps out for a moment and Barb takes over on the whiteboard. As she watches students from other teams stare at their team, she comments that other teams must be jealous because of their ‘awesome whiteboard’, Figure 4-7.

As they are drawing near the end of their meeting time, a few team members share ideas out of the agreed on rotation. Tala comments that they have come up with 47 ideas from this brainstorming session. Barb suggests they do some individual brainstorming at home before their next meeting, which Tala requests the team do on their collective GoogleDoc. Barb takes a picture of the whiteboard, and Tala tells the team she will send everyone the notes she took on her phone.

Figure 4-7: Barb goes to the whiteboard to summarize the team's progress and comments on how 'awesome' their whiteboard is.

4.2.2 Use of Common Writing Space

The whiteboard is used as a negotiating and recording space to ensure everyone on the team had the same understanding of the ideas being proposed, Figure 4-8. The recording on the whiteboard guides the discussion as it facilitates an understanding of when an idea has been understood and accepted by the group. Once an idea has been accepted in this way, the whiteboard signals to the next team member in the rotation that it is their turn. It is used as a means of developing a greater understanding of the design problem as team members re-clarify and modify previous ideas as new ideas are added to the set. Visually, the whiteboard allowed for each person to speak and be present in the collective set of ideas and provided a source of pride and evidence of progress to the team.
4.2.3 Engagement

The whiteboard focuses the team’s attention to the activity and the ideas being proposed. The re-orientation of team members to face the whiteboard during recording and the change in the focus of their gaze to individual speakers during idea sharing demonstrates the team’s commitment to the activity. At no time during the activity was another topic of activity introduced, nor was a team member not visually or verbally acknowledging the ideas being presented by the other team members. No one stepped on the speaking space of others. All team members were fully engaged in the brainstorming activity which they committed to continuing beyond this meeting time.

4.2.4 Response

The whiteboard provides a grounding for the team members to respond to each other’s ideas and coordinates the sharing of ideas. It mediates the transition between ideas and speakers and allows for other team members to build on, clarify, or confirm the ideas being proposed. During the activity, no idea is recorded as initially proposed, but instead a development of the idea as generated through the response of other team members is what is finally accepted and recorded.

4.2.5 Attunement

The whiteboard is the artefact of the attunement, because David both scribes and changes what gets written based on the interactions of the team members (their responses). This coordination and tuning of responses facilitates the team to create a space of joint action about their design problem. The tuned interpretations of the ideas (the ones consistent with their intention and
shared understanding of the design challenge) are the ones that are recorded on the whiteboard. The process of negotiation and development of ideas, and the subsequent development of the design problem preceding the recording, allowed the team to tune their respective understandings creating a shared conceptual space of the team’s emerging, shared, understanding.

### 4.3. Team 3

Team 3 was a team of 3 males and 1 female from the same first-year engineering discipline taking the student-driven entrepreneurial design course. The team was comprised of Benjamin, Gregor, Makin, and Ashima. Makin was the acknowledged, but not designated, team leader, and Gregor and Benjamin were the only English-dominant members of the team.

This section analyses Team 3’s interactions in their third recorded team meeting. At this time, the team is attempting to select a poster layout from the poster layouts proposed by different team members.

#### 4.3.1 Incident Description

Team 3 is in the midst of designing their poster for the final public presentation of their design that was to occur a few days from the time of this meeting. Three team members are present at this meeting, Gregor, Benjamin and Makin. The incident begins with the team reviewing two different poster layouts, one proposed by Ashima, and one proposed by Makin, Figure 4-9.

![Figure 4-9: Makin shows Benjamin and Gregor the poster layout he had determined on his laptop.](image)

A discussion between the team members ensues comparing the two posters. They agree that they prefer the colour scheme of Ashima’s poster, but Benjamin is uncertain of the layout Makin has proposed – Benjamin is having trouble understanding the difference in representation of the internal and external components of their design. Gregor interprets the layout as trying to describe the two functions of the buckling mechanism (automatic buckling and manual buckling) as compared to the whole design, however Makin is trying to show their design in his poster as a three-phase system comprising three key physical components: casing, handle, and fire sensor. Gregor challenges Makin’s idea that he can just “zoom-in” to show the interior of the design as it
is a 1:1 scale and thus not a zoom. He proposes that they show that the visuals are branching into the two subsystems of the main system (manual and automatic) rather than zooming in.

Makin does not like Gregor’s suggestion, as he feels it does not market his idea the way he wants it presented. He then proposes that they show the design as three components (casing, manual function, and automatic function) as in his original poster. However, these are three different components than he had initially presented as being the content of the poster.

Gregor proposes a third poster layout based on his branching idea, and he and Makin move over to the whiteboard where Gregor sketches out his and Makin’s posters’ layouts side-by-side with Gregor’s showing the branching with the two functionalities, and Makin’s showing the three stage progression of components, Figure 4-10.

Makin argues that Gregor’s branching idea has a better visual layout but leaves a lot of white space and requires redundant information to be displayed in multiple places – he says that he likes it, and then verbally and with gesture but not with marker on the whiteboard, converts it into a design almost identical to his original idea. Benjamin argues that the two posters explain the same thing just one is analytic in description and the other holistic, Figure 4-11. Gregor and Makin point at the two posters layouts to critique how each poster could incorporate the team’s design considerations. Neither hear Benjamin’s comment.

Gregor describes how the poster layout facilitates their presentation of the functionality of their design. Makin responds by discussing how the poster shows the physical components of the design. Makin is uncomfortable with focusing on the functionality of the buckle in terms of manual and automatic release, as it does not highlight the functionality of the casing to hold the buckle together. Gregor argues that a figure of the whole buckle covers the casing, but Makin insists that it needs to be presented separate from the whole. He is worried that demonstrating a branching pattern in the poster representation will “segregate” the casing such that it will not look as important as the other components. This conversation pattern between Gregor and Makin
is repeated as Gregor paces about the room while Benjamin goes to get a snack from his bag, Figure 4-12.

Figure 4-11: Benjamin shares with the team that he thinks the two posters are looking at two different levels of the design.

Figure 4-12: Gregor (center) paces about the room while Benjamin eats a snack.

The conversation moves to a new topic of how to communicate the design decisions the team made. Makin does not believe they made any intentionally so they don’t want to talk about them in specific, but Gregor argues that the modifications he made while he was doing the solid model count as they were intentional. Gregor proposes a way of outlining only a few design considerations pointing to his poster layout. Makin concludes that if they present a few key
design considerations, pointing to his poster layout on his computer, they are done, barring some small additions, Figure 4-13. Gregor comments that they need to get it done quickly so that he can focus on the prototype. No visible or verbal selection of a particular layout occurs.

Figure 4-13: Gregor re-looks at Makin's poster design on his computer.

4.3.2 Use of Common Writing Space

In this incident, the team uses the whiteboard as a way to ground their discussion – it is used to compare poster layouts of similar fidelity, Figure 4-14. The whiteboard is used to sketch out alternate poster designs, and once to modify one of the proposed poster designs. They use the sketches on the board to point out where they can place their design decisions on the poster and discuss how they will use the white space around the images of their design. It is used to show which components of the design fall under the manual and automatic functions of the buckling mechanism.
4.3.3 Engagement

All three team members are engaged in the discussion. They are focused on and invested in the conversation, are able to provide their thoughts and input as needed and are comfortable sharing their ideas. The whiteboard provides a space for the team to focus on the ideas under consideration and allows them to critique specific aspects of the designs.

4.3.4 Response

All three team members respond to each other in the discussion. The whiteboard is used medially to capture these responses as they describe, annotate, explore, and explain the poster representations. Their contributions are coordinated, and they are on the same topic. Gregor and Makin use the whiteboard to create representations of similar fidelity which allows them to coordinate their input. Sketching in the physical components of the two functions of the buckle by Gregor provides a better way for Makin to respond to Gregor’s comments as it allows him to see the physical components of the design in their functions.

4.3.5 Attunement

The team members are not tuned to each other. We see this as a product of the students engaging in different conversations. Gregor is engaging in a discussion on how best to represent and present their design at the showcase, whereas Makin is engaging in a discussion of how the poster layout demonstrates the importance of the physical components of their design. As a result the discussion can contain the same content and topics, but because of the different objects (goals of the discussion) they cannot tune as they do not realize the different activities taking place. Benjamin is the only one who realises that there are two separate conversations, however his voicing of this is not taken up by the group as Gregor and Makin continue their separate discussions. We see these as different conversations rather than different perspectives refracted
in the activity as neither Gregor nor Makin acknowledge the two differing aspects of the poster layout under discussion.

4.3.6 Uncoordinated Activity

This team is an example of distributed conceptual space. The whiteboard is able to focus the discussion and ensure the team members are discussing the same layout of the poster, but is not able to afford them a shared conceptual space. It does not help them determine they are having two different conversations about different objectives for their poster. Their activity is uncoordinated as they are engaging in two different activities with two different objects. Without coming to an agreement on what the objective of their poster is, they are not able to form the conceptual space required to debate the poster layout in an effective manner that allows for them to build on and develop each other's ideas.

4.4. Team 4

Team 4 was a team of 3 males and 1 female from the same first-year engineering discipline, taking the student-driven entrepreneurial design course. The team was comprised of Adam, Bart, Isaac, and Sahar. All were English-dominant speakers.

This section analyses Team 4’s interactions in their first recorded team meeting. At this time, the team is determining which community they should decide to work with from the candidates proposed by different team members.

4.4.1 Incident Description

Team 4 is engaged in their second official team meeting, and the first recorded meeting, in the third week of the course. The team has a clear intention that determining a community to work with is the focus of the meeting, as per the agreed upon agenda that Adam drafted. As they begin their meeting, they rename the communities they had discussed in their meeting the day before, and Bart records them on the agenda that Adam has made for the team while all team members share their impressions and feelings about the communities, Figure 4-15. Bart confirms that no team members have concerns about any communities.
As the discussion ensues, Bart goes to the easel in the room to remove a sheet of flip chart paper which he places at the centre of the team’s table. As he goes up to the easel, Adam confirms that they are going to use a Pugh Chart as their selection method and Sahar and Bart agree with this. Bart goes and gets a marker and starts to write the team’s communities from the agenda onto the sheet of flipchart paper. Sahar asks what the team will use as criteria for selection while Isaac confirms the parameters of a Pugh Chart. Once Bart has recorded these communities, the team starts to work through what their criteria are. Bart offers as suggestions what he thinks the ‘[team] values’ in a community, Figure 4-16. The team responds by critiquing, offering alternate suggestions, and rephrasing these ‘values’ into criteria.
The team then moves through the chart cell-by-cell from the upper left corner moving through their communities. Isaac begins the discussion by phrasing the first community as a question. Bart and Isaac guide the conversation by Bart placing his marker in the cell to be discussed, or by either mentioning the criteria at hand, Figure 4-17. All team members debate what value (+ / 0 / -) should go in the cell and then Bart records it. Sometimes as Bart is recording, a team member will voice that they are unsure and two values will be recorded by Bart. As they move through the criteria the team explores their understandings of each criteria. As they debate them some criteria are renamed, some are removed, and some are clarified until the team is comfortable to proceed with using them to assess their communities. One criteria, ‘available problems’ is eliminated by Isaac as he believes it is unassessable. Bart, similarly, comments that their last criteria ‘structure’ is not properly phrased, as it is trying to get at a concept they already have defined as ‘accessibility’. The team ignores both these columns in their future assessments.

As they go through the Pugh Chart, Adam tries to find a way to combine all the communities in a way that they could address all the criteria. This becomes a recurring joke throughout their meeting, and surfaces whenever the discussion gets intense. At this point it becomes evident that their leading community according to the Pugh Chart does not meet their criteria of ‘fun’ – something Isaac was very intent on. As they discuss this community in more depth, Adam brings in a new criteria ‘researchability’ which their leading community would be good for, and their ‘fun’ communities would not be. Bart crosses out ‘available problems’ and replaces it with ‘researchability’. He quickly fills out that column without seeking input from the team, and without the team challenging any of his value assignments. At this point Isaac agrees that ‘researchability’ trumps “fun” and the team agrees to move forward with that community. Isaac begins researching it, and Adam gets some notes he had about the community from his folder to share with the team, Figure 4-18.
4.4.2 Use of Common Writing Space

The team uses the flip chart paper as the place to create a Pugh Chart, Figure 4-19, which serves as the focus of their discussion. By locating the paper in the centre of the table, Bart provides the entire team with access to point at different criteria and communities. Team members take this up, and point at criteria, communities, and cells in the Pugh Chart as a way to direct their questions and critique. Additionally, it is used as a way to represent the team’s thinking about the selection process. It demonstrates the evolution of their criteria in selection, and visually compares their candidate communities. When the leading candidate community does not match the team’s implicit criteria, they use the Pugh Chart to determine the criteria they were missing in their analysis.
4.4.3 Engagement

The team is engaged with one another, the flipchart paper and the task they are completing. Bart demonstrates this commitment to the team by opening the activity with the language ‘we value’, and all other team members demonstrate that commitment by taking up that language in the rest of their discussions. Team members direct their gaze at the flip chart paper or a specific team member while they are speaking.

4.4.4 Response

The team members’ responses are coordinated through the flip chart paper and by the verbal or visual motions to the particular cell they are discussing and completing. No discussion topic was ignored and the continual build of the team to create humourous communities that met all the criteria demonstrates their ability to build ideas in response to their situation and their team members’ contributions. Crossing out, and adding criteria visually on the Pugh Chart displays their responses so they can keep track of where the discussion has evolved.

4.4.5 Attunement

The team is attuned to one another and to the activity. This can be seen through the manifestation of the team’s thinking on the flipchart paper and the clarifying discussions that occur to ensure everyone has a similar conception of the topic at hand. This is seen most evidently in the team’s rephrasing and elimination of criteria as they develop, together, a better understanding of the characteristics they as a team want in the community they work with. As a result of the team’s attunement to the similarities and differences in the understandings each team member voices, the team as a whole is able to build a shared conceptual space in which the different perspectives are acknowledged, and discussed until a collective understanding emerges.

4.5. Team 5

Team 5 is comprised of 2 males and 1 female from the same first-year engineering discipline, taking the student-driven entrepreneurial design course. The team is comprised of Case, Grant, and Amy. None of the team members were English-dominant speakers, and were operating in their second or third language during all of their team meetings.

This section analyses Team 5’s interactions in their third recorded team meeting. Team 5 is in the midst of designing their poster for the final public presentation of their design that will occur one week from the day of this meeting. This incident occurs over an hour, during which the team discusses their title, their design focus, their design itself, and how they want to represent it on the poster they are laying out during the meeting.

4.5.1 Incident Description

At the beginning of the meeting, Grant wrote a series of consonants across the top of the white board, Figure 4-20, representing the words in the draft title of their poster. Grant and Case both move back and forth between the whiteboard and the table as they speak and eat their lunches. Amy is seated at the table with her laptop open. She is working on the design of the poster and so
records wording and placement of information as it is discussed and tried out on the whiteboard. She is also eating her lunch at the same time.

The team begins their discussion by critiquing the title Grant has laid out on the board in letters. No one asked for clarification as to the meaning of these letters, they simply begin discussing whether the title has all the information in it that they want to convey. They can’t decide whether it has all of the information in the title, so Grant proposes that they move to the rest of the layout and then return to their title. He proposes to look at the poster their TA’s way – by organizing the poster according to the objectives of their design.

Grant initially holds a marker to write on the white board as they make suggestions about the organization of the information to be included on the poster. He passes the marker to Case when Case moves in to explain his ideas, Figure 4-21. Case returns the marker to Grant when Grant begins to add to, amend or move on with another idea.

As they attempt to decide on how they want to approach the organization of information in their poster, Grant begins to describe how he would approach a poster as someone who was unfamiliar with their project would approach the poster. Amy proposes a one-line summary of their design to introduce it to a reader. As they determine how to state this design problem, the team debates the meaning of multiple words that they used to describe their design’s purpose. Grant uses the white board as a composing area asking the others to be quiet as he figures out the phrasing of his intended meaning. They both silently watch Grant compose. When he finishes, the team reads his sentence, and then tries out different words to describe their users and their use cases. The description of the team’s design becomes more precise and clear through this discussion, which they agree will be clearer to a poster reader now.

![Figure 4-20: Grant records the initials of their poster's title on the board while Amy and Case eat their lunches.](image-url)
Figure 4-21: Grant and Case exchange the marker to give Case control over the whiteboard.

As they move on to discussing how they will represent the important features of their design, Case expresses concern that one of their key features is not fully represented. He goes up to the board, and points to one of the consonants recorded at the top of the board referring to their idea of energy efficient as an element of their design that needs to be represented in their poster, Figure 4-23. Grant agrees is not currently represented in their summary sentence. Amy argues that they cannot have everything represented in the title, and clarifies the meaning of certain words in their sentence that imply the meaning that Grant is missing. Grant is insistent that it is not clear enough, however Amy convinces the team that the meaning is in the words they have already chosen.

As the team explores the difference between the meaning conveyed in the sentence and their intended meaning, the team begins debating the energy efficiency of their design. Grant then uses the whiteboard as a computational space to determine whether they can argue that their wind turbine is actually an energy efficient means of powering their design. Ultimately, Case argues that the design needs to be more cost-efficient than energy-efficient, and the team accepts that they do not need to explore the energy-efficiency of their design any further in that moment.
Figure 4-23: Case uses the marker to direct the team's focus on the area he thought was important while the others look on.

Although Case and Grant began by passing one marker back and forth between them, Case acquires a marker of his own when he doesn’t wait for Grant to finish, but moves in to add to the poster layout. Amy remains at the table but watches the whiteboard carefully, building their poster on her laptop as Grant and Case continue to develop the poster design and freely interjecting her ideas and comments, Figure 4-24. Case insists that there needs to be a picture in the middle of their poster, which he adds to the layout without challenge.

When Amy speaks, both Case and Grant turn to face her. Either Case or Grant will record some of her comments and suggestions on the whiteboard. They speak in phrases, picking up and often finishing each other’s phrase or providing a word that the other is searching for. Even though Amy never leaves her seat, she reads what has been written on the whiteboard and gestures towards either words or sketches to emphasize or confirm everyone’s attention.
Figure 4-24: Amy records the developing poster in a virtual version while Grant records on the whiteboard the information he and Case are debating.

4.5.2 Use of Common Writing Space

The whiteboard, Figure 4-25, creates a physical, visual artefact that facilitates discussion and the creation of different representations and understandings of the purpose and content of their poster. It is a space for test running their ideas, a space where they can visualize the team’s thinking and can contribute to it verbally as well as physically. The whiteboard is also a holding area for ideas.

Figure 4-25: The whiteboard used by Team 5 which shows its use as a record of thinking.
4.5.3 Engagement

All team members were engaged in the discussion. They were committed to developing their poster and their understanding of their design. During these discussions gaze is always directed at the speaker or at the whiteboard, showing their commitment to working with each other. The team also shows their commitment to their work in their unwillingness to drop a topic until it has been resolved.

4.5.4 Response

The team members readily respond to one another, their contributions are focused and coordinated on the topic under consideration. They are attentive to one another’s ideas and contributions, willing to share, express agreement or disagreement or ask questions. The marker as ‘talking stick’ coordinates their response patterns and focuses attention on the speaker, even though others may interrupt to add or build the ideas. The whiteboard records their responses and then focuses their attention on that aspect of their discussion. In effect, the whiteboard represents the coordination of their thinking in demonstrating the evolution of multiple different concepts over time.

4.5.5 Attunement

Amy, Case and Grant are attuned to one another throughout this discussion. This can be seen in the way they follow on each other’s utterances, clarifying an idea, and building on what has been said, often before the speaker fully completes the utterance. This is also demonstrated in the way that they can work from a general idea to find the specific word that best fits their meaning. They do this by each sharing their ideas, and then debating them as a team until suddenly all agreeing once the right word emerged. The whiteboard focuses their attention, allowing them to visually work through their personal refractions of the concept they were debating by “staying on the same page” even when they change topics. The repository of ideas it contains for them, and the workspace it provides, allows the physical space to model the conceptual space in which they are adding, revising and modifying their understandings. Thus it facilitated their attention to the emergence of their shared understanding of their poster design, their design concept and their rationale for design decisions.

5. Discussion

This discussion aims to contrast the teams which succeeded and did not succeed at developing shared conceptual space through their engagement, response, and attunement within the team. The key difference between the teams was how they interacted with the affordance of the shared writing space.

Each of the teams had a different interaction pattern and the use of their shared writing space mirrored their interaction patterns. It also afforded team members a way to ‘see’ other team member’s contributions from a different perspective. For teams that used it effectively, the space represented a collective perspective or understanding that emerged from the use of the shared
writing space. For teams that were less effective, it afforded them a way to see what each other was saying but not necessarily to build a shared understanding – they didn’t necessarily take advantage of the space to engage with multiple perspectives. For these teams, no collective understanding emerged from their interactions with their shared writing space.

From our data, we have identified three different ways in which teams took up the affordance according to our togethering framework. Other than Team 1, the shared writing space allowed the teams to operate one level higher in the togethering framework than was seen through their interactions without using it – from engage to respond, or from respond to tune.

Teams 1 did not engage with the whiteboard because they did not interact with it as part of their discussion. It was for “the other” as a display of their work after the fact. They did not take up the affordance that the whiteboard could have provided to coordinate their conversations. Although the five individuals were in the same room at the same time for the same activity, they each remained in their own individual conceptual spaces pursuing their own individual goals, Figure 5-1. Thus, they could not respond to one another. Team 1 did not create a space of joint action, and thus a distributed conceptual space emerged. Because they chose to use the shared writing space for display only, they did not leverage the its affordances to create any shared conceptual space.

Figure 5-1: Diagram of engagement-only conversation, nodes represent individuals and arrows represent the direction of conversation they are attempting to pursue.

5.1. Engagement → Response

The whiteboard serves as a mediational tool that allowed Team 3 to operate one level higher in togethering than where they started their discussion – it afforded them the ability to respond to one another. Before Makin proposed drawing the posters on the whiteboard, the team members were engaging by providing their opinions, but were not able to compare them. By having the sketches of similar fidelity on the whiteboard, the team members were able to coordinate their discussion by “seeing” the others arguments in their perspective using the sketches of the posters on the whiteboard. Makin was able to see the relationship between the physical components and the functions of the design, Gregor was able to determine that Makin saw the figures of the casing and the whole as showing two different, but equally important, parts of the design, and Benjamin was able to see where Gregor and Makin were seeing the design differently. While they were able to use the whiteboard to see these different perspectives in a way that they
couldn’t before sketching on it, they were not able to build a shared understanding as they continued to see their design from their perspectives only, Figure 5-2. They did take the opportunity to see each other’s perspectives in the design, but did not take up the affordance of the whiteboard to see and represent each other’s arguments through the lenses of their own perspectives. Thus, the team was not able to negotiate and build a unified perspective with which to see (and work on) their design. Thus it allowed the team to be more effective than they would have been without the whiteboard as they were able to coordinate and respond. However, they did not leverage its ability to build shared understanding together.

Figure 5-2: Diagram of engagement-response conversation, nodes represent individuals and arrows represent the direction of conversation they are attempting to pursue.

5.2. Response → Tuning

With the teams that we saw attuned to each other, the shared writing space was used to either collaboratively co-construct an idea or to create a singular representation of a verbal co-construction of an idea. The common writing space was used to record only that which was mutually agreed upon or co-developed.

In Team 2, the whiteboard displayed the content of their discussion that provided an artefact that mediated their idea generation process. David stood at the whiteboard and constantly watched the other team members when someone proposed an idea. He coordinated the development of their conceptual space as he watched for comments, questions, clarifications or additions to the ideas before he would turn to begin to write. Sometimes he would initiate a clarification question himself to ensure his understanding and the recording of the idea matched that which the team intended. There appeared to be an understanding that he would not begin to record until there was a sense of shared understanding, guaranteeing that what was recorded was an accurate representation of what had been co-developed.

In Team 4 the paper mediated and focused the team on the concept that they were building of an acceptable community. As in Team 2, there was only one writer, Bart, and the two teams were similar in the way there appeared to be an understanding that nothing would be written without agreement and that what was written could be changed, e.g. crossed out, amended or ignored. However, Team 4 was physically much closer to the shared space allowing for the additional affordance of directly pointing to the word or area the speaker wished to focus on. All four team members made use of such gestures to ensure their idea as presented was the idea taken up by the
team. Because of this the team was able to discuss all ideas until the team built their own understanding from the contributions of others into a shared perspective. In addition to constructing their shared understanding, the space also afforded them the opportunity to recognize when their agreed upon community did not fit with the concept that had emerged from their discussion. By the team being able to identify this, it shows us how Team 4 was working from a space of joint action that gave them the ability to recognize and comfortably challenge the outcome of the design tools they were using.

Team 5 collaboratively used the space as an idea holder, composing space and negotiation space where they co-constructed their poster layout, their design and the process they were engaged in. They had two writers, Grant and Case. Both had shared access to the whiteboard although they respected each other’s turns, initially passing one marker back and forth, almost like a ‘talking stick’, allowing the speaker to use the marker and the whiteboard to develop his idea. Team 5, unlike Teams 2 and 4, used the shared writing space as both an individual and collaborative space. The whiteboard afforded both individual and collective development of candidate understandings. These candidate understandings were countered, challenged, modified, and built into a shared understanding that they were all willing to accept as their shared concept. In the end both Grant and Case had markers and moved fluidly in and out of the writing space, much in the same way their verbal utterances overlapped, completed and built on one another. Amy participated equally through her use of gesture, and interjection, and in her transcription on the computer of the ideas worked out on the whiteboard.

All three of these teams used the whiteboard to collaboratively develop a shared understanding of the task they were pursuing. They each used it as a way to understand the contributions of their team members, accept/counter/develop the idea into one that worked with their individual understandings, and build with each other through this process a shared understanding of the idea that represented all of their perspectives and contributions. We see this attunement, or togetherness, as the development of a space of joint action at the intersection of the team members individual conceptual spaces, where an agreed upon direction of idea development emerges, Figure 5-3.

Figure 5-3: Diagram of attuned conversation, circles represent the conceptual space of individuals the arrow represents the unified direction of conversation they created.
6. Conclusion and Implications for Supporting Student Design Teams

We have shown that teams who take advantage of a shared writing space are able to tune and collaboratively co-construct a shared conceptual space through the representation of their shared understandings. Shared writing space is an affordance that must be taken up by the students to be used effectively as a tool to mediate this process. The teams we observed took up this affordance in a variety of ways. However, we see that when student teams take up the shared writing space as a means of coordinating and consolidating their individual contributions and perspectives, they allow the teams to operate one level higher towards togethering — to move from engagement to response, or from response to tuning.

Three ways in which we have seen teams take up shared writing space effectively to build shared conceptual space are:

1) focus and coordinate a discussion and record a shared understanding that is visible to all team members
2) to make an explicit representation of implicit individual understandings to compare and adapt until those understandings are aligned
3) to represent the construction process of an idea for all to participate in.

Thus, simply providing a shared writing space for students to use is insufficient, something we saw with Team 1 who only used it as a display to authority. Students need to see shared writing spaces as a site for the development of ideas. This use needs to be modelled and introduced as a learning/design concept distinct from the ideation and selection tools in which students are asked to use it. Instructors, tutors and teaching assistants are in the best position to provide both the explanations and the modelling of the effective use of shared writing space in their interactive discussions with students. We propose that if instructors want to support the use of shared writing spaces then they need to introduce the idea and the rationale for its use to their students. They need to talk about how a shared writing space can provide a place in which students can build models of their thinking and of their ideas that others can see and respond to. They also need to demonstrate this practice through samples of their or other’s work (images of shared writing spaces, models and paper prototypes) as well as in their direct interactions with students and student teams.

Acknowledgments

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References


Appendix R. Holistic Feedback Examples for the 12 TEI Behaviours

<table>
<thead>
<tr>
<th>TEI Behaviour</th>
<th>Positive Phrasing (Strength)</th>
<th>Negative Phrasing (Weakness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1 – Attend team meetings prepared</td>
<td>“You were timely prepared and always contributed to important discussions.”</td>
<td>“Try to be more poignant on coming to meetings. Also try to keep the meeting schedules there were several times when you didn't show up because you were unaware that we were meeting even though we had announced one.”</td>
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<tr>
<td>O2 – Does their Fair Share of the Work</td>
<td>“[Student] is ready to do any work that is needed... [They] did more work than assigned in the [deliverable] because it needed to be done.”</td>
<td>“doesn't always contribute as much as everyone else in the work shared among the team (for example final revision etc)”</td>
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<tr>
<td>O3 – Delivers their Work on Time</td>
<td>“[Student] is a respectable person who finishes his allotted work on prior to the internal due date allowing it to be more polished by the deadline.”</td>
<td>“On some occasions [they] promised to do a certain part by a certain time. [The parts] were never done and another team member did said part. All team members were working on the project on a certain day [they] did not get on until very late in the evening.”</td>
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<tr>
<td>O4 – Help to Plan and Organise the Workflow</td>
<td>“I think you do your job to keep us on track and organized. You also do a really good job of setting up the documents and making sure that everything that needs to be done is done.”</td>
<td>“It would be even better if the work is divided more evenly among team members so that certain team members don't feel left out. It would also be great if you can give clearer instructions so the team knows what they are expected to do.”</td>
</tr>
<tr>
<td>R1 – Demonstrate Accountability</td>
<td>“Also thank you for admitting to not doing work at times and indicating when you would make up for this work!”</td>
<td>“Does work but does not raise awareness if there is a lag in the project.”</td>
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<td></td>
<td></td>
<td>“tell others if you can't follow through”</td>
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<tr>
<td>R2 – Seeks and Includes the Input of Others</td>
<td>“You made sure to seek the team's opinions and help whenever you had doubts about how things should be done. You welcomed their input and incorporated it into your work.”</td>
<td>“I think you should be more open-minded about other people's opinions and feedbacks and not take everything personally since we're all working towards the same goal at the end”</td>
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<td></td>
<td></td>
<td>“You sometimes ask for opinions too much trust your instinct.”</td>
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<td>R3 – Shows Respect for Team Members</td>
<td>“I appreciate all the hard work [they have] done and especially for the fact that [they are] always paying attentions to what others are saying and let others feel respectful.”</td>
<td>“[Student] is very stubborn and generally ends up having fights with members regarding team decisions. [They] need to proactively work on [their] attitude. Also [they are] very pushy and need to start trusting [their] team mates more.”</td>
</tr>
<tr>
<td>TEI Behaviour</td>
<td>Positive Phrasing (Strength)</td>
<td>Negative Phrasing (Weakness)</td>
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<tr>
<td><strong>R4 – Listen and Pay Attention</strong></td>
<td>“On top of that [they] attended all team meetings engaged actively in discussions and followed through suggestions made by others to improve his designated section.”</td>
<td>“You could listen to other team members more instead of cutting them off in mid-sentence. All of us listen to your opinions and you should value other opinions as well and be less stubborn and open to other ideas.”</td>
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<tr>
<td><strong>C1 – Exchange Information in a Timely Manner</strong></td>
<td>“[They were] very encouraging to the team but at the same time [they were] making sure things are done on time by reminding others constantly.”  “[Student] is keen on contributing to the team especially in recording and delivering information or research to the team.”</td>
<td>“The amount of workload you have done is definitely enough but team effectiveness might be improved further more if you could communicate the current progress of your work more frequently... Frequent communication will not only make me feel safer but also will make it easier for me to know what I need to do next without overlapping with your work too much or missing some important points.”</td>
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<tr>
<td><strong>C2 – Openly Express Ideas and Opinions</strong></td>
<td>“you are able to express yourself really well when we work together and you contribute to team discussions very often which is great.”</td>
<td>“My only advice to you would be to try to interact more with us during the team discussions and not be afraid to express your opinion.”</td>
</tr>
<tr>
<td><strong>C3 – Promote Productive Discussion</strong></td>
<td>“It’s great how you come up with out-of-the-box ideas that help get the team thinking.”</td>
<td>“just try to keep team discussions focused on matters at hand and avoid talking about unrelated matters”</td>
</tr>
<tr>
<td><strong>C4 – Raises Contentious Issues in a Constructive Way</strong></td>
<td>“I really like how you will give your opinion respectfully and honestly. Please continue to do so we need everyone's opinion and ideas moving forward in this project.”</td>
<td>“I think you should be more open-minded about other people’s opinions and stop criticizing ideas. Furthermore you should learn to express your opinions and communicate with people in a less aggressive manner.”</td>
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Appendix S. Sample TEI-based Lessons

Example lessons provided for O1 – Attend team meetings prepared, R2 – Seek and Include Input from Others, and C4 – Raise Contentious Issues in a Constructive Way. Text in blue are links to other online resources where the URL follows in parentheses.

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O1 – Attend team meetings prepared

Attending team meetings prepared requires a student to:
1. know what they need to do before the meeting, and complete it
2. engage in an effective meeting with their team by showing up on time and bringing all materials with them.

An effective meeting is well organized so that every team member knows what role they play in the meeting and how they will be contributing to it. An agenda is used to set the tone for the meeting and documents what will happen at the meeting, and how long it will take. Make sure your agenda is sent out at least one day in advance of the meeting so everyone can remember what they need to do to be prepared. This information will be found in the agenda's action items at the end of the document which list what each team member needs to do and by when. This sets clear expectations within the entire team of what needs to be completed in advance of the meeting.

Some tools we have found effective at helping students remember what needs to be done before a meeting are:
- **Agendas** (http://www.pearse-trust.ie/blog/bid/91183/Writing-The-Perfect-Meeting-Agenda-5-Simple-Rules) - these are an essential tool to help a meeting stay on time, and on track to make sure everything that needs to be discussed is. Follow this agenda template (http://www.meetingagenda.org/team.html) to create an effective agenda for your next meeting.
- **Action Items** (http://www.isixsigma.com/implementation/change-management-implementation/meeting-action-item-planning-worksheet) - these are helpful to remind everyone on the team of what they need to complete before the meeting. It also allows the entire team the ability to see what everyone is doing and hold members accountable to their obligations.
- **Checklists** (http://www.projectcheck.org/checklist-for-checklists.html) - these are helpful to remember what action items you need to complete before the next meeting.

Some tools we have found helpful for running an effective meeting are:
- Ensure your agenda is sent out at least a day before the meeting. Clearly outline when and where the meeting will be.
Follow the agenda during the meeting and try to stay on time. Always start by reviewing the meeting minutes so everyone remembers how the team is progressing.

At the end of the meeting determine the action items for the next meeting, write them up in the meeting minutes, and send them to the entire team immediately following the meeting.

If you are presenting something at the meeting bring handouts, or ensure everyone has a virtual copy to view on their computer/tablet.

Follow these additional tips and strategies (http://www.isixsigma.com/implementation/change-management-implementation/meeting-facilitation-important-ingredient-change) to facilitate your next meeting more effectively.

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**R2 – Seek and Include Input from Team Members**

**Seeking and including input from team members requires a student to:**

1. Ask for input and ideas from team members in critical areas of the project and in areas in which they do not know how to proceed
2. Listen to and consider the input of their peers
3. Work with the team to find a way to include everyone's ideas and suggestions for the benefit of the team
4. Acknowledge the value of different ideas and opinions in creating a better product/solution

When everyone contributes to a discussion or a piece of work its quality increases. This stems from the value of more perspectives and more experience being brought into the work. Team discussions are one of the ways that a team can become greater than the sum of its parts; as team members share ideas and provide input on others ideas, the discussion can bring about ideas that are much greater than any one member could have thought of on their own. As a result, in team situations it is important that input is sought from all members of the team and included into the work created by the team. The act of seeking and including team members’ input demonstrates to them that they share in the ownership of the work created by the team and that the knowledge and perspective they bring to the team is valuable. Seeking input from others encourages them to voice their ideas and opinions, and motivates others to contribute proactively in future discussions.

**Some tools we have found effective at helping students seek and include input from others are:**

- Go around the table and give everyone a chance to speak. Be aware of who tends to speak most or least and try to equalize participation.
- Make sure there are opportunities for peers to provide input in a non-verbal manner. Solicit input for key discussion points at a meeting by email the night before so that those that like to present fully-developed ideas have some time and way to provide these ideas in a written medium.
• Avoid making decisions on your own- bring your ideas forward and allow others to strengthen them by adding their input
• Review your personal plan of action with your team members and confirm that it makes sense/ sounds good to them
• Ask others what they think of your work and how it can be improved- be open to hearing their suggestions
• Provide feedback (http://www.articlesbase.com/leadership-articles/how-to-give-feedback-easily-and-effectively-3265389.html) to your peers on the quality of the input they are providing or to seek feedback from your peers. The fourth model in the link is the most effective when seeking input from others.
• Use DeBono’s Thinking Hats (http://www.debonogroup.com/six_thinking_hats.php) to make sure every voice and issue is heard from multiple perspectives. This process allows all members bring valuable insights and viewpoints, especially those that you may not agree with, to the table in a structured manner.

C4 – Raise Contentious Issues in a Constructive Way

Raising contentious issues in a constructive way requires a student to:

1. present their arguments about the issue focusing solely on the issue, and not targeting any specific team members
2. present their arguments about the issue in a manner that focuses on developing understanding, team improvement rather than personal gain
3. present their arguments in a non-destructive manner. Arguments should not be mean-spirited or use derogatory/defamatory language

Contentious issues are items that are controversial within a team where two or more people hold opposing opinions or feelings about the subject. These issues, if not addressed can split the team apart along the team members’ sides resulting in the team not being able to work effectively together and forcing those that work together to work in a difficult and stressful environment. When discussed constructively - meaning that those discussing it focus on the issue, and not on their beliefs or motives behind the issue, in a civilized and resolution-seeking manner - these issues can be resolved in a way that contributes to the growth of the team.

Discussing a contentious issue can be difficult or possibly scary. By focusing on discussing the issue and how it makes you feel is important to making sure that the issue gets addressed. While this can be done through written means (like an email) often it is better to bring these issues up in person as it allows both people to share their sides of the issue and work towards consensus. It is important to remember that the issue is separate from the person it comes from - it is not who they are. For example, if you have an issue with someone delivering their work late, or not showing up to meetings, it is important to remember that you cannot assume to know why this is happening (i.e. you cannot assume they are a slacker). By discussing the issue of late work or poor attendance as an issue distinct from who the individual is, you are more likely to find a way that you can work together.
Some tools we have found effective at helping students raise contentious issues constructively are:

- separate the person from the problem and identify the specific behaviour that is creating an uncomfortable situation. Express the impact of that specific behaviour on you
- Use either of the one-way feedback models (http://www.articlesbase.com/leadership-articles/how-to-give-feedback-easily-and-effectively-3265389.html) discussed in the link. These allow you to focus on the issue at hand in a productive manner.
- Use "I statements" - Take ownership for your thoughts, and present them from your perspective. Begin ideas or opinions with "I statements" and discuss how the issue you want to discuss makes you feel. (i.e. "I feel that I am not listened to when I am cut off in the middle of my sentences by someone else. Can we work to make sure that everyone on the team can finish their sentences without being cut off?")
- Rehearse or practice the conversation in advance - sometimes when we are nervous about discussing a difficult topic we do not actually say what we need to. When we practice what we want to say, no matter how difficult it is, we become more comfortable with saying it. If you are nervous about discussing the issue, rehearse or role play the conversation with a friend in advance of having it
- If you have an issue with one person, speak to them calmly and privately. Do not bring up the issue in front of the whole team. This way you preserve the dignity of your team member by giving them the opportunity to address the issue with you and not have it affect other team members