WIP: Using a teamwork model to manage large teams in a large lecture

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Background

Competition and globalization in the contemporary world has led companies to the need for increased productivity and adaptability to societal demands. One way that companies, as well as academic institutions, have tried to meet this need is by using teams (Varvel, Adams, Pridie, & Ruiz Ulloa, 2004). Organizations recognize the importance for employees to understand how to work effectively with others, but also express that new employees do not bring adequate teaming skills to the workplace (S. Adams & Ruiz, 2004; Pascarella & Terenzini, 2005). Despite calls to promote teamwork as "an indispensable quality for engineering"(Lingard & Barkataki, 2011) engineering schools have been generally slow in developing pedagogies that successfully promote collaborative behaviors. Several initiatives have been done in engineering education -like project-based learning and team-based learning to try to promote teamwork skills (Felder & Brent, 2009; Prince, 2004). However, in engineering classrooms, teamwork is seen by most of the engineering students as a requirement of a course in order to get a grade, rather than as a skill that they need to master to become effective engineers. Part of the problem is that students are selected and assigned to teams with the expectation that they will know how to effectively work with others, without providing any previous teamwork training.

Students need to be able to develop the competencies, knowledge, skills, and attitudes towards effective teamwork that allow them to become effective team contributors when they face the demands of the job market. Hence, teamwork's purpose goes beyond assigning a task to a group of people to achieve a goal. Teamwork has a bigger purpose, to create synergy that allows the team to provide with the most effective way to solve a problem.

The purpose of this work in progress is to implement a teamwork effectiveness model to manage large teams in a large lecture to promote teamwork competencies in engineering students. Our focus was to provide structured team training addressing required individual and team competencies, designed under instructional strategies that allowed individuals the opportunity to experience real team situations (a problem-based design project) and have time

for reflection on their learning process. In this paper we focus on answering the following research question:

RQ: Do students' perceptions of teamwork changed after receiving teamwork training in a large lecture?

Literature Review

The teamwork model we used as a reference for this study is the "Model for the development and assessment of teamwork" proposed by S. G. Adams, Vena, Ruiz-Ulloa, and Pereira (2002). The goal of the study was to be able to implement a model that help students understand how they could work effectively in teams. According to the authors highly effective teams exhibit certain characteristics described as constructs (i.e. common purpose, clearly defined goals, psychological safety, role clarity, mature communication, productive conflict resolution, and accountable interdependence). In order to implement the model, the first step is to understand the difference between effective teamwork, and team effectiveness.

According to S. G. Adams et al. (2002) effective teamwork refers to the process teams go through while displaying specific characteristics that make them effective. These characteristics can be considered constructs that are measurable. Therefore, the constructs to identify effective teamwork are (S. G. Adams et al., 2002):

- *Common purpose* defined as the main objective of the team which should be understood and shared by all team members. This element should lead to the development of the team's goals.
- *Clearly defined goals* refer to quantifiable and commonly agreed upon statements that define the actions to be taken by the team. Clear and common goals help team members maintain their focus.
- *Psychological safety* is the shared belief that the team is safe for interpersonal risk taking (Edmondson, 1999). The team climate is characterized by interpersonal trust and mutual respect in which people are comfortable being themselves. Team members are confident that the team will not embarrass, reject or punish someone for speaking up.

- *Role clarity* is the team members' common understanding of each individual's expected role that helps to minimize misunderstandings regarding task assignments and avoid role ambiguity.
- *Mature communication* refers to team members' ability to articulating ideas clearly and concisely, giving compelling reasons for their ideas, listening without interrupting, clarifying what others have said and providing constructive feedback.
- *Productive conflict resolution* refers to the procedures and actions taken when conflict occurs that lead to results such as facilitating the solution of the problem, increasing the cohesiveness among team members, exploring alternatives position, increasing the involvement of everyone affected by the conflict, and enhancing the decision-making process (Capozzoli, 1995).
- *Accountable interdependence* refers to the mutual dependence that all team members have regarding the quality and quantity of each individual's work within the team.

Team effectiveness on the other hand refers to the degree to which a group's output meets requirements in terms of quantity, quality, and performance (Hackman, 1990). According to S. Adams and Ruiz (2004) there is a relationship between team effectiveness and effective teamwork. Team effectiveness is the result of an effective teamwork process. When the teamwork process is carried out based on the seven characteristics of common purpose, clearly defined goals, psychological safety, role clarity, mature communication, productive conflict resolution and accountable interdependence, then it is expected that team members will perform well, and feel engaged with the process of teamwork. However, this requires students' understanding of the effective teamwork process.

The focus of this study was to provide structured team training addressing required individual and team competencies, designed under instructional strategies that allow individuals the opportunity to experience real team situations (i.e. the design project) and have time for reflection on their learning process.

Teamwork model implementation

The model was implemented in a design course in a school of engineering in a research-centred Australian university. The course had 236 students enrolled that were assigned to 17

teams. Students assignments to the teams were purposefully designed to have diverse teams in terms of different levels of academic performance (as indicated by GPA), English as first language, gender, and intended major. Each team was working on a real design project with focus on a real company vision, mission, corporate values, objectives, and strategic planning. Teams were divided in sub-teams according to the 3+ tracks that each project has (i.e. geotechnical, environmental, transport and if required other disciplines of engineering). For every team, there was a team leader, and each track had a student leader as well. In addition, each track had a lecturer that was consulted on technical issues associated with that aspect of the project. A researcher, in consultation with the course coordinator, advised on the development of the implementation of the model, supervised the development of teamwork skills, provided teamwork training and helped with conflict resolution.

To ensure that students understood their roles and the purpose of the teamwork model, they received teamwork training in the first week of classes. In addition, students were invited to reflect on their own process by writing blog posts every time they finished a role.
As mentioned before, S. G. Adams et al. (2002) model guided our study, therefore we developed several interventions in the classroom to make sure we were offering the students with each construct of the proposed model. Details as follows:

- Common purpose: The primary grade in the design course was based on teams' development of their design project. Every team had a common purpose (i.e. the real design problem to solve by the engineering team).

- Clearly defined goals: teams were required to develop quantifiable and commonly agreed goals, based on the needs of all the tracks.

- Psychological safety: students were trained on safety for interpersonal risk taking in the team. In addition, students provided their experiences by sharing reflections on the process on their blogs, all students on the team had access to the posts and were encouraged to participate and comment in their peers' posts.

- Role clarity: each team member had a different role. They received clear instructions on the expectations of their roles. In addition, students needed to change roles at least

two times during the semester, allowing them to get familiar with different roles. The presence of role clarity minimizes misunderstandings regarding task assignments.

- Mature communication: students had several channels to communicate effectively, they had a blackboard site, a blog repository, they used social networks interactions, and traditional email. During their training, teams were asked to maintain a log of every communication that the team have so they could understand how they evolve in the process. Mature communication among team member ensures a higher level of understanding.

- Productive conflict resolution: a researcher specializing in large team interactions was available to advise on communication methods and dispute resolution within teams. The researcher provided support to solve all the possible conflicts that the team had.

- Accountable interdependence: students continuously evaluated their peers regarding the quality and quantity of each individual's work within the team.

Methods

In order to answer the research question, data were collected quantitatively using the teamwork effectiveness questionnaire (TEQ) (Varvel et al., 2004). Students took the TEQ as a pre-test at the beginning of the semester before the teamwork training started to determine their attitudes toward teamwork. The same test was administered at the end of the course to be able to compare how students' perceptions of teamwork changed (or not) over the experience. The survey was administered during class time in the second and last week of the semester. Students had 20 minutes during class to take the survey. All the students had access to computers/electronic devices during class, however, we had several iPads available for students in case they don't want to access their own devices.

Data were collected electronically using checkbox, a survey management online service available at the University that aligns with the Australian Code for the Responsible Conduct of Research. The study secured ethical approval, and participation was voluntary. Students were asked to provide consent for his/her data to be used for study purposes in the

questionnaire. Results from the survey were analysed using the Statistical Package for the Social Sciences (SPSS). SPSS provide researchers with a secure platform to analyse quantitative data and conduct different statistical procedures.

Sample/Population

Participants included 236 undergraduate engineering students enrolled in a third year compulsory engineering design course at the same research institution. 106 students took the pre-test on the first week of the course representing 44.5% of the number of students enrolled. On the last week of the semester 130 students took the post-test representing 54.6% of the students enrolled in the course. Table 1 shows some demographics characteristics of the sample which was representative of the population.

Table 1.
Demographics of the sample

Characteristic	Students n= 236	Percentage
Gender		
Female	86	36.5%
Male	150	63.5%
Prefer not to answer	0	0%
Race/Ethnicity		
Asian	69	29.2%
Black or African	1	0.4%
Caucasian or White	166	70.4%
Prefer not to answer	0	0%
Type of student		
Domestic	201	14.8%
International	35	85.2%
Prefer not to answer	0	0%

Results

In order to determine if students' perceptions of teamwork changed after the experience of working in large teams and receiving teamwork training, we used the TEQ instrument to measure the 7 teamwork effectiveness constructs, as well as the students' perceptions on the

importance of teamwork as future engineers. Descriptive statistics representing the mean scores for each construct are presented in Table 2.

Table 2.
Descriptive statistics of the constructs

		N	Mean	Std. Dev.
Importance of teamwork (IMP)	Pre	106	3.0113	.80051
	Post	130	3.9108	.62756
Productive conflict resolution (PCR)	Pre	106	3.8491	.47016
	Post	130	3.9827	.54291
Mature communication (MC)	Pre	106	3.8923	.40363
	Post	130	4.2113	.50249
Clear defined goals (CDG)	Pre	106	4.1156	.46952
	Post	130	4.0750	.55392
Common purpose (CP)	Pre	106	4.1085	.54228
	Post	130	3.9442	.53034
Accountable interdependence (AI)	Pre	106	3.2154	.50253
	Post	130	4.6057	.54991
Role clarity (RC)	Pre	106	3.0135	.46430
	Post	130	4.7392	.56746
Psychological safety (PS)	Pre	106	3.4175	.60427
	Post	130	4.0692	.53285

In order to determine if there were significant differences in the responses of the students before and after the semester, an independent sample t-test was conducted. It wasn't possible to conduct a paired-sample t-test because students were not identified in the pre-test. The independent sample t-test was conducted assuming equal variance; the assumption was tested using Levene's Test for Equality of Variances. Table 3 present the results for the independent sample t-Test.

Based on the data analyzed it is possible to affirm that there are statistically significant differences in the responses of the TEQ before and after the semester in most constructs but Clear defined goals (CDG). Based on the t-test results (table 3), after the semester students perception of the importance of teamwork increased (t= -2. 145, p=0.033). Students also showed a slight increase on *productive conflict resolution* (M=3.84 in pre-test to M=3.94 in the post-test), with a significant variation (t=-1.996, p=0.047). Similarly, *mature communication* had a significant (t=5.291, p=0.000) increase on students perceptions

(M=3.89 pre-test to M=4.21post-test). Regarding clearly defined goals, and common purpose the differences in these two constructs were negative, meaning that students' perceptions about them decreased after the experience. In the discussion sections we explain our rationale on why we believe this was the case.

Table 3.

Independent sample t-Test results

	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Importance of teamwork (IMP)	-2.145	234	.033	-.19945	.09297
Productive conflict resolution (PCR)	-1.996	234	.047	-.13364	.06694
Mature communication (MC)	5.291	234	.000	.31901	.06030
Clear defined goals (CDG)	.599	234	.550	.04057	.06776
Common purpose (CP)	2.343	234	.020	.16426	.07011
Accountable interdependence (AI)	2.748	234	.006	.19028	.06925
Role clarity (RC)	4.752	234	.000	.32569	.06853
Psychological safety (PS)	-8.799	234	.000	-.65178	.07407

The constructs that demonstrated a higher increase on the students' perceptions were *accountable interdependence* with a significant difference (t=2.748, p=0.006) of 1.4 in the mean responses (M=3.2 pre-test to M=4.6 post-test), *role clarity* (M=3.01 pre-test to M=4.73 post-test) and *psychological safety* (M=3.41 pre-test to M=4.06 post-test). In the following section we elaborate more about each construct.

Discussion

We provided students with a course design that helped us implement an effective teamwork model to train the students on how to develop the competencies they require, without losing the main focus of the class that is to develop problem-solving and design skills. Results suggest that providing teamwork training had a positive impact in some of the teamwork constructs as perceived by the students, and helped them overcome the challenges of working in large teams. Students benefited from working on a large project because they had exposure to a real project sponsored by a company where needed to assume different roles throughout the semester, therefore they learned how to solve a real problem, achieve results by working with others, assume leadership positions, and manage a large project.

Regarding some of the effective teamwork constructs we were able to identify those students' perceptions about the importance of teamwork increased after the experience. They also recognized how crucial was to work effectively on teams to be able to finish the project and deliver the expected results.

There were two constructs that didn't show any improvement based on the experience (i.e. clear defined goals, and common purpose) we believe that part of the problem was the nature of the design problem they needed to solve. We used a problem-based learning approach and information given to the students regarding what they were supposed to do with the project was limited, we believed that this created a sense of misdirection on regards to what was expected and created confusion regarding the clarity of the goals of the team.

Regarding *mature communication*, students demonstrated a considerable increase on this construct, meaning that they used different communication strategies based on the training provided to communicate better as a team. The fact that students had to reflect on their process and were required to archive all their communication logs also helped for them to realize the importance of this construct.

Students also demonstrated high levels of improvement after the experience regarding *role clarity, accountable interdependence, and psychological safety*. The fact that students had to work on defining their roles and be very clear about expectations helped them to realize its importance. Also students were trained on how to deal with conflict and how to include diversity in their design process which translated in an improvement of their perceptions of psychological safety.

Limitations and Future work

There are several limitations to be considered in this work in progress. One limitation is regarding the sample size, although our sample represented almost 50% of the populations, results need to be read with care, the small number of the sample makes limited any inferences done regarding the significance of the differences in the pre-and-post test. In addition, we didn't have a comparison group (i.e. engineering students teams without the training) in order to determine if the training experience in the course was the one causing the changes of perceptions regarding the constructs.

Another limitation of this study is participant bias. Participants were actively trained in teamwork and its constructs, therefore it is possible that students who choose to participate in the post-test were very aware of the importance of our experiment, and their responses could be influenced by the training, and the expectation of receiving some reward from the teaching team.

For future work, we will continue conducting this experiment next semester and more quantitative data will be collected. Specifically, we plan to do an experiment having a control and experimental group to measure what is the impact of the students receiving training and the model, against the ones that didn't. In addition, we will use a mixed methods approach to collect data qualitatively. An interview protocol is being developed based on the preliminary results of this survey in order to better capture students' experiences of receiving teamwork training while developing a complex design project.

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