

# Development of a Protocol to Measure Team Behavior in Engineering Education

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## Abstract

In engineering education, research on performance measurement has characteristically focused on the performance of individuals and has not addressed the measurement of team performance. There is growing research, which indicates that team behavior affects team performance and effectiveness. However, an extension of this research in engineering education could not be found. In an effort to assess and advance the science of measuring teamwork in engineering education, this study concentrates on the development of a protocol to measure team behavior. Results indicate that the protocol, which uses a structured checklist, is moderately reliable. Although some progress has been made, there is still much to be learned about team performance measurement in engineering education. This body of research and the results it produces will be useful to engineering faculty in their efforts to assist students in developing their teaming skills, which will lead to an effective team experience.

## Keywords

Team performance and effectiveness, team behavior, Engineering education

## Introduction

The use of teams in industry is becoming increasingly more common. There is every indication that it will continue to grow in the future. In many organizations, teamwork has become a critical element since modern task demands are likely to exceed the capabilities of single individual [7]. Such is the importance of teams that all organizations have teams and essentially all employees are members of at least one team [4]. In recent years, business publications and corporate recruiters alike have reported that businesses are increasingly looking for college graduates who can work effectively in teams and understand management processes. In response to this trend, institutions of higher education are incorporating teamwork more frequently in their curriculum in order to facilitate students' adaptation to the corporate environment.

In engineering education, graduates' readiness for teamwork is not meeting expectations. When hiring engineers, employers report that engineering graduates, astute and well prepared technically, lack in their ability to function effectively in teams. Felder, Woods, Stice and Rugarcia report that engineering programs in the United States have been asked by the Accreditation Board for Engineering and Technology (ABET) to modify their curriculum to teach more about teamwork skills [2]. Now, educators in engineering are faced with new challenges including measurement of team behaviors.

Despite the well-recognized significance of team behavior in team performance and effectiveness, few studies have examined behaviors specific to teams in engineering education. Instead, studies have focused on team behaviors in environments such as military [6] and business organizations [5,8]. Therefore, a fundamental gap remains in the understanding of team behaviors that affect team performance and effectiveness in engineering education. Attributes of these studies such as categories

of behavior (i.e. dimensions) and the measures used to identify these behaviors may not be applicable for other studies involving teams such as academic and business teams.

The purpose of this research is to develop a protocol to observe team member behaviors in engineering education and to determine if members are behaving effectively. In this study, a structured checklist, derived from direct observation, was used to identify different team behaviors. The advantage of the direct observation technique is the ability to study an event, an institution, a facility or a process in its natural setting [3]. The model used for identifying these behaviors is from earlier research by one of the authors of this paper [1]. Based on this model, team behaviors are categorized into seven distinct constructs: common purpose, clearly defined goals, psychological safety, role clarity, mature communication, productive conflict resolution and accountable interdependence.

## Methodology

### The Sample

The sample consisted of engineering students from a large Midwestern university who were enrolled in an engineering management course. There were four women and fifteen men all aged nineteen years and older. Three students, (one woman and two men) were Hispanic, one man was African-American and the rest were Caucasian. The participants were grouped in five teams of three to four members. The instructor assigned teams making sure all women and Hispanic students belonged to different groups with the objective of making the teams as diverse as possible. The rest of the class was randomly assigned to a team. The teams were videotaped and observed by three raters twice during the course while working in teams. Training was given to the raters in behavioral observation techniques such as body language of participants and various other operations in the measurement process.

### Effective Team Behavior Checklist

Thirty-five behaviors were identified, see Table 1, and divided among seven different checklists/forms corresponding to one of the constructs. The forms were designed to allow each behavior to be rated as it was exhibited by each of the members of a team. The results were given as a function of the behaviors exhibited by all the team members. This was achieved by having a matrix that includes behaviors in rows and a team member in every column.

Table 1: Construct and their corresponding checklist items.

<b>Construct</b>	<b>Accountable independence</b>
	<ol style="list-style-type: none"> <li>1. Honestly expressed abilities, capabilities and limitations.</li> <li>2. Completed a task by the time agreed.</li> <li>3. Reviewed work with other team members to ensure it satisfies the team's goals, assessed quality of work and proposed improvements if necessary.</li> <li>4. Changed the way he/she performed the task if the team's needs required it that way.</li> <li>5. Started working on a different task or helped another team member after completion of the one(s) assigned without waiting to be asked.</li> <li>6. Assisted another team member accomplishing their task through suggestions, providing direction or sharing useful information.</li> </ol>
<b>Construct</b>	<b>Conflict Resolution</b>
	<ol style="list-style-type: none"> <li>1. Stated unconformity and willing to approach it providing clear explanations to others.</li> <li>2. Listened and explored alternative positions</li> <li>3. Deviated discussion from issues and addressed the task related conflict.</li> <li>4. Defined common ground for assessment.</li> <li>5. Proposed alternatives to try to satisfy both sides of the conflict relating solutions to the purpose of the team.</li> <li>6. Ensured that all team members are convinced and satisfied with the solution and/or added to consensus.</li> </ol>
<b>Construct</b>	<b>Mature communication</b>
	<ol style="list-style-type: none"> <li>1. Listened actively without interrupting</li> <li>2. Asked questions or clarified what others said to ensure understanding.</li> <li>3. Articulated ideas clearly and concisely giving compelling reasons for ideas.</li> <li>4. Provided constructive feedback and specific criticism</li> <li>5. Spoke loudly and distinctly when communicating information.</li> </ol>
<b>Construct</b>	<b>Role clarity</b>
	<ol style="list-style-type: none"> <li>1. Recognized what his/her individual task was.</li> <li>2. Defined the outcomes expected from an individual member's task.</li> <li>3. Summarized or agreed upon group decisions on assignments to each member.</li> </ol>
<b>Construct</b>	<b>Clearly defined goals</b>
	<ol style="list-style-type: none"> <li>1. Defined goals to attain the common purpose.</li> <li>2. Proposed a plan to achieve a specific goal.</li> <li>3. Proposed a time frame to accomplish goals and/or kept team to its agreed time frame and deadlines.</li> <li>4. Reiterated or asked for explanation about a goal and confirmed that all other team members agree and understand.</li> <li>5. Related new information or unfocussed tasks to a specific goal.</li> </ol>

<b>Construct</b>	<b>Psychological safety</b>
	<ol style="list-style-type: none"> <li>1. Used we not me or I when referring to the team.</li> <li>2. Spoke out to propose an idea.</li> <li>3. Encouraged another team member to voice their opinion.</li> <li>4. Used positive language and attitude to discuss another team member's idea criticizing ideas not people.</li> <li>5. Took the time to analyze and evaluate a teams</li> </ol>

	member's idea and carried it out if possible.
	6. Included all team members without being biased.
	7. Sympathetic and respectful to another team members.
<b>Construct</b>	<b>Common purpose</b>
1.	Agreed on a main purpose for the team (proposed it or agreed with proposal of other team member).
2.	Exchanged ideas to reiterate and make sure there is a clear understanding of the common purpose.
3.	Stated how a task related to the common purpose of the team.

Each of the forms allowed space for information as it was gathered by the observer. The first space is for the date, which should be recorded to distinguish between observations made on different days. The space below the date identifies the team members, in order to keep the information recorded for every team member in the same column (under the same team member number) throughout all observations. This was important if a researcher was interested in analyzing the behavior of single team members throughout the observations. Space was also provided to record the discipline of every team member, the name of the person performing the observation and the observation length, which are factors that can affect the results of an observation and should be recorded for analysis. A team code and observation number should be assigned to every team observed and to all observations performed, and recorded on the checklist in order to match the forms and the tape containing the group meeting observed. A synthesis of the instructions on how to fill out the form is also provided. The last column on the checklist was provided to calculate the results of every observation. Given the wide spectrum of behaviors that can be displayed it was possible that a behavior that describing a construct was not included in the corresponding form. Extra space was given in every form for these behaviors to be recorded if a rater finds any during an observation.

#### Scoring the Observation

Items on the checklist were scored using a Likert scale ranging from 0 to 2. This study used a nominal scale in which every behavior would be rated with a 0,1,2 or N/A, representing behaviors not exhibited, somehow exhibited, highly exhibited and not applicable behaviors respectively. This type of rating was used because the behavior exhibited is a variable that depends on the frequency of occurrence of the behavior. For example, if a behavior was present consistently throughout the observation the rater would score it as a 2. Whereas, if it was slightly present it was assigned a score of 1 and if it was not exhibited at all it received a 0. It was important to understand that the frequency itself was not a factor with a fixed scale but depends upon the kind of situation itself.

Under these same terms, there were behaviors that were not present in an observation because the situation did not allow for such behaviors to occur. In this case, using zero as a score would indicate that the team members lacked the ability to exhibit this behavior when applicable. This would not be a valid interpretation of the situation. For this reason N/A was been among the rating options. To obtain the results of a single observation the rates (0, 1 and 2) were totaled for every behavior. In this manner a sum was obtained for every behavior (row) on each of the seven forms. The score for every behavior was obtained by dividing the sums by the number of members in the team. Behaviors that were rated N/A were assigned a total score of N/A. This procedure was followed with every behavior for every form for all observations.

#### Calculating the Final Score

Once all observations were performed, it was necessary to summarize all the scores. The scores were assigned in the row that described the behavior and under the column of the observation for which the score was obtained. Make sure to record the team number in the space provided at the top of the form as well as the construct being scored.

Once all the scores were summarized on the Score Calculation Sheets the rows were all totaled to obtain the total sum of scores for a behavior throughout observations, and averaged by dividing them by the number of observations. N/A behaviors in an observation were not be considered in the sum or average. In this case, only those with an applicable rating were added and divided by the number of applicable behaviors (the ones included in the sum). After calculating these averages for every behavior the final score was calculated. The averages were totaled and then divided by the number of behaviors that defined the construct. The result was used to compute the Overall Construct Score. This number was multiplied by 100% and divided by 2 (the maximum possible score). In this manner we obtained a percentile that was used to interpret the results. Table Two shows an example on how to perform the calculations detailed above.

Ques.	Ob 1	Ob 2	Ob 3	Sum	Score
1	2	2	n/a	4	2
2	.333	N/A	1	1.333	667
3	0	.333	0	.333	111
4	0	1.667	2	3.667	1.222
				Total	4
				Average	1
				Total Score	(1 X 100)/2
				Final Result	50%

Table 2. *Final Score Calculation Example*

A final result was computed for each construct using the same procedure. These percentages represented the extent to which each of the seven constructs was present in a team. For example, 70% scoring in mature communication indicates that there is still room for improvement in this area. The tool can be described as an assessment of the extent to which each of the seven constructs is present in the team based on what is exhibited by the team member's behavior.

Reliability was tested using inter-rater reliability. Inter-rater reliability defines the capacity of the protocol to provide similar results from different observers in the same observation. Three observers were used to complete the forms after videotapes were obtained from group working sessions in an Engineering Management course. The scores obtained by the three raters were compared and analyzed using Cohen's Kappa for statistical analysis to determine the inter-rater reliability of the tool.

## Results and Discussions

A combined inter-rater reliability rate (by taking the average of both observation results) was computed and findings show a 62% rate of agreement between raters. As mentioned in the previous section, the results provided by this checklist are percentages relative to each of the seven constructs. While this is lower than the desired 70% it is encouraging and we can conclude that the protocol is moderately reliable but requires significant improvement.

The low reliability is attributed to a few checklist items that were problematic. According to feedback from the raters, these items were either: 1) related to tasks that were not complete enough for the team members to exhibit

most of the behaviors or 2) related to tasks in which participants' characteristics were more related to collaborative groups than teams. Consequently, the raters found it difficult to identify behaviors specified by these items and also to interpret and score such behaviors. Hence, a significant inconsistency in rating prevailed for certain behaviors among the raters.

## Conclusion

In this study a behaviorally based protocol was developed with the objective of measuring team behaviors specific to engineering education. The protocol provides an assessment of the extent to which a team exhibits each of the seven constructs in the team effectiveness model. The findings of the study conform moderately to the reliability expectations of the protocol. The data and the feedback from raters suggest that rater training in addition to more observations is necessary to achieve higher value of reliability.

The impact of this study is far-reaching for students and faculty members from a professional development perspective. Faculty members can use behavioral protocols to enhance their knowledge about issues to consider in managing student teams. By using this model of team effectiveness (specific to their field of study), faculty members can integrate teamwork into core curricula. Using the research findings, resources and appropriate training can be subsequently developed for students working in team projects.

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