

## Session 3153

### **Assessing Student Design Team Performance in a Learning Community of University Freshman and High School Students**

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#### **Abstract**

This paper describes methods used to assess teamwork effectiveness. The assessment methods were developed to evaluate the overall success of the project itself, the students' perception of the experience, and how much the students actually learned. The assessment methods include both subjective measures, such as student surveys, (namely, communications methods effectiveness survey, team communication survey, short-term surveys, team peer evaluation forms), and objective measures, such as evaluation of email communication trail and net-meeting communication notes, as well as achieving design and communication milestones. The teams are evaluated in terms of the following categories, defined by the TIDEE "Design Team Readiness Assessment". These include: team's purpose, leadership, accountability, climate, productivity, resources, and communication. The paper links these categories with the abovementioned assessment methods to establish the effectiveness of the teams in each category. Teams are assessed at least twice each term and the results are used as guidance for improvement.

This paper also presents the results obtained by applying this teamwork assessment method to a learning community of students in a geographically isolated locations and with different technical backgrounds. The teams in the learning community are comprised of four students from a university freshman design course, and three students from a high school technology course. The goal of the learning community is to design, build, and test an original design. The communication between two sets of students in a team is achieved via net-meetings and emails. The paper presents the results of team assessment completed for two freshman design courses at Seattle University and two Central Kitsap High School Technology Courses.

#### **Introduction**

Fueled by industry requirements and ABET accreditation criteria<sup>1</sup>, the emphasis on teamwork has become common practice in engineering education. Projects requiring teamwork are now regularly integrated into class curriculums in order to teach teamwork skills. Developing such projects, while time consuming, is well documented. The difficulty occurs when trying to assess the team's actual performance in the light of their teamwork skills.

Teamwork includes in-class and out-of-class effort of team members, making it difficult for an instructor to evaluate each team-member's performance. Teamwork includes technical performance, the production of written documents, and presentation of oral reports – all of which require different skill-sets from the team members. In addition, an essential part of teamwork is written and oral communication, which can be done in-person with peers, with an instructor, or in a team setting. The overabundance of aforementioned factors involved in the assessment of teamwork traditionally leads instructors to survey the students' perception of the quality of teamwork. Notable examples of these survey methods are documented by Angelo and Cross<sup>2</sup>, and by the NSF-CCLI-sponsored BESTEAMS program<sup>3,4,5</sup>. When the team members are situated at remote locations, additional factors can affect team communication. Communication must occur using a medium such as a phone call, email or video conferencing. Adams et al.<sup>6</sup> addressed the assessment of teamwork when team members were located at distinct locations.

While all of the aforementioned methods provide some measure of the team's performance, they all rely on surveys to assess the students' team performance. Although the students' perception is an important factor, it provides only a subjective measure of the students' performance. A better assessment technique would involve both subjective and objective measures.

In this paper we present a set of assessment tools which build on the subjective assessment methods previously mentioned, but adds objective measures obtained by grading selected work representative of the team's performance. This teamwork assessment method was applied to a freshman design course at Seattle University. The course uses the "learning community" structure<sup>7</sup>. The learning community centers on a common design project where teams of students are responsible for the design, analysis, documentation, fabrication, and testing of their ideas. The design teams are composed of students from both Seattle University and Central Kitsap High School. The university students are responsible for the research, conceptual design, final testing, and reporting. The high school students create the dimensioned orthographic drawings and fabricate the parts. While the students each have their own responsibility, they still must work together and communicate effectively in order for the project to be a success. One of the key obstacles in this project is that university team members do not ever meet in person with high school team members. All communication is done using email, video conferencing or net-meeting software equipped with video, voice, chat, white board, and file-transfer.

The remainder of this paper is divided into three sections. In section two we discuss the various categories we use to assess teamwork and the actual assessment tools used to assess each measure. Section three presents results of using these tools to assess teamwork in the learning community design class over two quarters. The summary of results and planned class improvements are given in section four.

## **Teamwork Assessment**

Assessment of teamwork in an academic setting is difficult because the instructor must assess more than just the overall success and failure of the team. The success is generally regarded as whether the team delivered a successful product in the allotted time and with proper

accompanying documentation. However, in a classroom setting, where timelines are prescribed, and the instructors manage parts of the projects, the total teamwork experience is what is valued. The assessment of that total teamwork experience is fairly complicated, as mentioned previously. In order to assess the total teamwork experience, we looked at seven different aspects of teamwork. These seven aspects, or categories, were defined by TIDEE<sup>8,9</sup> and are summarized below. They are:

*Purpose* – The team can establish a purpose and focus on a particular goal

*Leadership* - The team can establish a leadership structure

*Accountability* - Each team member is responsible and accountable for duties

*Climate* - Team members maintain a positive and supportive attitude

*Productivity* – The established tasks are achieved in a timely manner

*Resources* – The team utilizes the skills and knowledge of its members

*Communication* - The members are able to communicate technical concepts

Within the context of these teamwork categories we identified various assessment tools which were useful in measuring an individual and team's performance. These tools include both subjective measures, such as student surveys, (namely, communication methods effectiveness survey, team communication survey, short-term surveys, team peer evaluation forms), and objective measures, such as evaluation of email communication trail and net-meeting communication notes, as well as achieving design and communication milestones. The assessment tools are linked to the abovementioned teamwork categories to establish the effectiveness of the teams in each category. Table 1 below contains a list of the assessment tools, teamwork category they assess, a brief description of the tool, type, i.e., individual or team, and the frequency of when it is administered. The tools are briefly described in the paragraphs that follow.

Table 1. Assessment Tools

	Assessment Tool	Category Assessed	Description of the Tool	Individual or Team	Frequency
Subjective	Communication Methods Effectiveness	Communication	Survey	Individual	Middle and End of term
	Team Communication	Communication	Survey	Team	Middle and End of term
	Short Term	Climate, Communication	Survey	Individual	Three times per term
	Peer Evaluations	Leadership, Accountability, Climate, Productivity, Resources	Survey	Individual	Middle and End of term
Objective	Email Trail Evaluation	Purpose, Leadership, Accountability, Climate Productivity, Resources, Communication	Grading of team emails	Team	As needed
	Net-Meeting Notes Evaluation	Purpose, Leadership, Accountability, Productivity, Resources, Communication	Grading of team net-meeting notes	Team	As needed
	Team Achievements	Productivity	Grading of team with respect to milestones established by course	Team and Individual	End of term

### *Communication Methods Effectiveness Survey*

- Description: Each student is surveyed about which communication methods they perceived as being effective when: 1) discussing drawings and specifications, 2) having technical discussions about the designs, manufacturing and testing, and 3) making decisions.
- Evaluation Method: Survey results are tallied and summarized.

### *Team Communication Survey*

- Description: Each team is surveyed about the type of the communication methods they used, i.e., emails with scanned sketches, net-meeting with chat and whiteboard, etc. Teams are also asked about how effective they felt they are in communicating specific technical concepts amongst themselves. This is important in our case because the teams are comprised of both university and high school students who do not meet in person. Finally, the university students are asked to rate how well the physical prototype supplied by the high school matches the technical description provided by the university students.
- Evaluation Method: Survey results are tallied and summarized.

### *Short-Term Surveys*

- Description: Short-term surveys are used to improve the course outline, syllabus, the project complexity or relevance, and the teaching style, homework, or tests. A complete description and discussion of short-term surveys is given in Rutar and Mason<sup>10</sup>. Three of the survey questions pertain to teamwork assessment. In these, students are asked to rate importance of teamwork and technical writing in engineering practice. They are also asked whether they enjoy working in a team.
- Evaluation Method: Survey results are tallied and summarized.

### *Team Peer Evaluation*

- Description: Team peer evaluation forms are modified versions of similar forms presented at the BESTEAMS workshop at the ASEE Annual Conference 2001<sup>5</sup>. Each team member is asked to rate themselves and the other team members in various categories relating to the member's performance in the team. The BESTEAMS surveys were modified by adding the following questions: "Does the team member contribute to:" 1) everyday hands-on work and drawings, 2) writing of the project report, 3) management of the design project, and 4) engineering and technical components of the project.
- Evaluation Method: Survey results are tallied and summarized.

### *Evaluation of Email Communication*

- Description: The university students are required to communicate with their high school teammates using email for certain aspects of the project. For example, they are asked to first introduce their conceptual design to the high school students via emails. Students are coached in writing this email. They are asked to do the following: 1) state the purpose, 2) place the design into the “big picture” context, i.e., explain the design requirements and constraints (testing, timeline), 3) describe the design with sufficient information to picture and replicate the design, and 4) explain the reasoning behind major design features.
- Evaluation Method: The emails are evaluated in two different ways. First, they are scored for a letter grade using a rubric that evaluates whether the abovementioned categories are completed, somewhat completed or not completed at all. Second, they are used to assess whether the team met major teamwork categories defined at the beginning of this section.

### *Evaluation of Net-Meeting Communication*

- Description: The university and high school students communicate using net-meeting several times per year. During these meetings students are required to take notes about what was discussed and which components of net-meeting were utilized, i.e. voice, chat, video, whiteboard, or file sharing.
- Evaluation Method: The net-meeting notes are evaluated in two different ways. First, they are scored for a letter grade using a rubric that evaluates whether the abovementioned categories are completed, somewhat completed or not completed at all. Second, they are used to assess whether the team met major teamwork categories defined at the beginning of this section.

### *Team Achievements*

- Description: Teams are evaluated as to whether they completed design and communication milestones by the deadlines specified by the instructor. Those milestones include completed prototypes on testing dates, prepared presentations for required presentation dates, report deadlines, research project deadlines, and others.
- Evaluation Method: Teams are given full credit for completing the milestone by the required time. Partial credit is given to teams whose work is late.

## **Results**

The assessment tools discussed in the previous section are used to assess the performance of teams involved in “learning community” projects at Seattle University. (Refer to the Introduction for more details on the learning community.) These learning community projects were offered two successive terms and involved a total of forty university freshman and thirty high school students. Each term, five teams were involved in the learning communities – thus the results

below are for ten teams spread over two terms. Each team consisted of a freshman sub-team of about four students, and a high school sub-team of about three students. Only the university freshman teams were assessed in detail. The results of the assessment are summarized below in terms of the assessed teamwork categories and by the assessment tools that were used.

### *Purpose*

Assessment Tool: Email Trail Evaluation

Only two out of five teams in the first term and three out of five in the second term described in their emails the goal of the team project and how the design fulfills that goal.

Assessment Tool: Net-meeting Notes Evaluation

Four out of five teams in the second term mentioned the goal of the team project in their net meeting notes.

### *Leadership*

Assessment Tool: Peer Evaluation

All team members took part in project management.

Assessment Tool: Email Trail Evaluation

None of the teams showed evidence of leadership teamwork characteristic, and there was no mention of the leadership structure.

Assessment Tool: Net-meeting Evaluation

None of the teams reported talking about team leadership.

### *Accountability*

Assessment Tool: Peer Evaluation

All team members reported taking responsibilities for tasks and have been coming to meetings prepared.

Assessment Tool: Email Trail Evaluation

- 1) Only one of the ten teams showed evidence of accountability.
- 2) Most of the teams did not mention assigning responsibilities or establishing accountability.

Assessment Tool: Net-meeting Notes Evaluation

All teams had a known set of responsibilities, and they all reported talking about accountability for getting the tasks completed.

### *Climate*

Assessment Tool: Short-Term Survey  
Students enjoy teamwork throughout the quarter.

Assessment Tool: Peer Evaluation  
No significant teamwork problems were encountered in teams within each institution.  
Note: Similar observations can not have been made between team members in other institution, since the team members never meet in person, and net-meetings are rare and short (on average, a few minutes per week are spent in net-meetings)

Assessment Tool: Email Trail Evaluation  
In the first term, only four out of five teams opened a friendly path for communications, or offered to answer any further questions. In the second term, only two out of five teams did.

### *Productivity*

Assessment Tool: Peer Evaluations  
Most team members completed work in timely and acceptable manner.

Assessment Tool: Email Trail Evaluation  
Most of the teams did not mention the timelines and tasks.

Assessment Tool: Net-Meeting Notes Evaluation  
All teams reported discussing productivity.

Assessment Tool: Team Achievements  
All teams completed the required work on time.

### *Resources*

Assessment Tool: Peer Evaluations  
All team members contributed to the project with their skills and knowledge.

Assessment Tool: Email Trail Evaluation  
All emails in the second term showed some evidence of the thought process used in the design phase, i.e., some design features were justified through engineering theory. It should be noted that the students were coached by the instructor to include that. In the first term, when students were not coached, only two out of five teams mentioned resources used.

Assessment Tool: Net-Meeting Notes Evaluation  
All teams reported on the resources used.

## *Communication*

### Assessment Tool: Communication Methods Effectiveness

- 1) Students prefer email over net-meeting for design communication, i.e., for understanding of drawings and specifications, technical discussions about the design, manufacturing and testing, and for decision making.
- 2) If students were to choose one communication means, they would choose emails.  
Note: The initial excitement about net-meeting fades towards the end of the term when they actually focus on the effectiveness of each method.

### Assessment Tool: Team Communication

- 1) All teams used a variety of communication means.
- 2) All teams perceive that their counterparts always or almost always received all the necessary information to successfully sketch and build the design.
- 3) Most teams perceive that their counterparts always or almost always fully understood the design.
- 4) Teams used multiple measures, such as emails, net-meetings, and informing the professor, to ensure complete understanding from the counterparts.
- 5) The prototypes mostly or completely met designers' expectations.

### Assessment Tool: Short-Term Survey

- 1) Students maintain high appreciation of technical writing and teamwork in engineering practice throughout the term.
- 2) Students believe that their technical writing skills are improving throughout the quarter.

### Assessment Tool: Email Trail Evaluation

All freshman student teams clearly explained the email's purpose and clearly presented the designs. The sketches and accompanying written explanations were unambiguously describing the design.

### Assessment Tool: Net-Meeting Notes Evaluation

All teams reported talking about descriptions and understanding of the designs.

## **Conclusions and Future Course Improvements**

The paper presents a method for assessing teamwork in a "learning community" setting. The "learning community" is comprised of students from a university freshman design course and a high school course and organized so that design teams from the two institutions never meet in person but communicate using email and net-meetings. The teamwork assessment method includes both objective measures, in the form of graded work, and subjective measures, in the form of student surveys, to provide information on both the student's perception of their performance and their actual performance. Overall, the objective measures and peer evaluation surveys proved to be the most useful in evaluating teamwork performance. Although communication and short-term surveys provide numbers for "hard data" they were not as useful in evaluating the students' understanding of teamwork. A summary of these assessment results for the "learning community" follows:



- 1) The teams were fairly successful in describing their designs using emails and net-meeting.
- 2) Most of the teams showed awareness of the goal of the team project, but only half of the teams ever discussed these goals. Also, there is no data on project goal awareness of an individual student.
- 3) The teams rarely displayed evidence of having a leadership structure or recognizing a need for one.
- 4) Students generally prefer email over communication via net-meetings for understanding technical drawings, technical discussions about the designs, and decision making.
- 5) Students displayed little understanding of how to utilize the varied skills and knowledge of their team members.
- 6) While the emails were not used to discuss accountability or productivity, net-meeting conversations were.

Based on these results we identified several curricular changes that will be made to improve the “learning community” projects.

- 1) Teams need to be encouraged to clearly enumerate project goals early in the project. The results showed that many teams didn’t have a clear understanding of the project goals. There is also no evidence of each student’s understanding of the project goals. Ensuring that student’s clearly understand their project goals will help keep them focused on what is important in the project during the process of design. In order to elicit project goal understanding for each student, classroom techniques such as in-class discussions, written assignments, and small tests will be utilized.
- 2) Students need to be given more instruction about how to use net-meeting software. The fact that students favored to communicate via email over net-meetings is likely due to technical problems they encountered using net-meeting, and the fact that they are more familiar with the email as communication medium. In the future, the net-meeting will be introduced earlier in the term and student’s will be given more time to become proficient with the net-meeting software before using it in their project.
- 3) Students need guided assistance to help them identify individual team-member skills useful to the project. Recognizing ways in which each team member can uniquely contribute to the project will also encourage all team members to equally participate in the project. In order to achieve that, faculty-guided classroom team discussions are planned.

Teamwork assessment in academic setting is complicated due to variability in factors contributing to the team’s performance. Those factors are various skill-sets from each team-member, variability of communication scenarios, and teamwork done in and out of class. The abovementioned findings and resulting planned curricular changes demonstrate a successful model for teamwork assessment, which utilizes both subjective and objective measures.

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