Capturing Student's Teamwork and Open-Ended Design Performance in an Undergraduate Multimedia Engineering Design Class

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Abstract

The current paper describes our experiences capturing student performance in the freshman design class ME39C: Multimedia Case Studies of Engineering Design, at the University of California, Berkeley. The focus of the ME39C class is to facilitate students as they work in teams to develop an original web based multimedia case study of an engineering design. The class emphasizes learning outcomes that have been identified by both the Synthesis Coalition and the ABET as important attributes of a professional engineer. These learning outcomes include teamwork, open-ended problem solving, hands-on facility, and creative design. Since these learning outcomes are difficult to assess by traditional assessment tools, we used a series of different methods to triangulate, compare, and evaluate student performance. For example, specific methods that were used included an original web-based discussion tool, student observations and interviews, and questionnaires. This paper will describe the various methods we used to capture student performance and will present the results obtained from each of the methods. Initial findings reveal that information obtained by one method sometimes contradicted data obtained from another. These contradictions suggest caution when analyzing student performance based on just one point of view. The data also indicates that team work, both in terms of product and process, can and should be collected continuously throughout the semester in order to provide the necessary feedback essential to student learning and improvement. Using a variety of assessment techniques affords a more comprehensive analysis of student performance.

I. Introduction

As part of the reform movement to redefine and improve undergraduate engineering education, the Synthesis Coalition was formed to address education issues surrounding the adoption of the new Accreditation Board for Engineering and Technology (ABET) criteria [1]. The University of California at Berkeley, as a member of the Synthesis Coalition, has developed new, and revised existing, engineering courses to incorporate the pedagogical goals of the coalition. The pedagogical goals of the coalition were established to be consistent with the learning outcomes defined in the ABET criteria. Specifically, the Synthesis Coalition learning goals are to develop the students'; 1) ability with open-ended problem solving, 2) familiarity with multi-disciplinary content and design, 3) teamwork skills, 4) facility with hands-on activities, and 5) ability to communication effectively.

The ME39C class, Multimedia Case Studies of Engineering Design, was designed to encourage students to develop an understanding of engineering through investigation and design in a collaborative learning environment [2]. The class activities and projects were structured to maximize student performance in the five Synthesis learning goals. The instruction was based on the Scaffolded Knowledge Integration Framework [3] which emphasizes the use of social supports through collaboration and teamwork, as well as making thinking explicit through reflection and articulation [4].

The ME39C class culminated in a final team project. The students worked in teams to develop an original web based multimedia case study of an engineering design. In order to capture the students' teamwork and open-ended design performance as they developed and presented their projects, we used a series of different methods to triangulate, compare, and evaluate student performance. Since teamwork and open-ended design are ongoing processes, the methods of evaluation were employed in an ongoing basis. For example, it would be difficult to capture teamwork performance based solely on the final product or presentation. Therefore, data was collected throughout the semester to provide a more comprehensive analysis of the student performance. Specific methods we used to collect data included an original web-based discussion tool, student observations and interviews, and questionnaires.

The paper will provide a brief overview of the ME39C class structure and describe the nature of the team projects. Specific data collected using each of the different methods will be presented and discussed. Finally, the paper will summarize the results and suggest future directions for analyzing student performance in engineering open-ended design team projects.

II. Class Overview

The Spring 1997 ME 39C course was a sixteen week course attended by fifteen students, eight female and seven male. The class was co-taught by two instructors and all class sessions were held in a Macintosh computer laboratory. In addition, six graduate students regularly observed the class, and assisted with teaching various segments of the course. The class met one day per week for a period of two hours with additional hours reserved in the computer laboratory for student use. Since a major focus of the class was web-page development, the students were expected to spend additional time outside the class to work on projects either in the computer lab or from a remote computer. Communication among the instructors and students often took place through the class web site[5]. The course syllabus, course philosophy, homework assignments, and other pertinent information regarding the class are contained on this site [5].

Along with the learning goals discussed previously, specific task goals were also part of the course objectives. These tasks included learning to build web pages using HTML, using the World Wide Web to gather information, and learning to use specific computer applications such as Photoshop. The course curriculum was designed to introduce the students to concepts, skills, and methods early in the course so that they would have many opportunities to develop them throughout the semester.

The first five weeks were devoted to familiarizing the students with the World Wide Web, engineering case studies, and the process of open-ended design and teamwork. Specific class activities included introductions, small group discourse, viewing web-based and CD-ROM case studies, and mechanical dissection. The students also created personal home pages during the initial weeks of the semester. These early projects were intended to scaffold students with little or no mechanical and computer experience to an operable level of proficiency and comfort with the topics.

The students completed the on-line Myers-Briggs Analysis (Keirsey Temperament Sorter Test) in week 6 [6]. One purpose of the Myers-Briggs (Keirsey) unit was to introduce students to the notion that people prefer to approach problems in many different ways. This variety of approaches can lead to both positive effects and negative effects within a group environment. Diversity within a team may result in an abundance of unique ideas but may also cause conflicts because of different perspectives. Other activities that occurred during this portion of the semester included a unit on user interface design, group and project topic selection, and a mid-course feedback survey.

Brainstorming and storyboarding were presented as effective group strategies during week 6-10 of the semester. The brainstorming unit culminated in a small group session in which students looked at an existing web-based Boeing 777 case study and

suggested changes to its user interface. Particular emphasis was placed on the philosophy of brainstorming as a divergent process, not a convergent one; therefore ideas should never be disparaged in this preliminary stage of design. A storyboarding exercise was also done to provide students with the experience of laying out a design idea and thus recognizing the steps that are required for completion.

During week 12 the on-line discourse tool, SpeakEasy, was introduced to the classroom [7, 8]. SpeakEasy is an asynchronous web-based discussion tool that allows for a threaded dialogue to take place among all of the participating class members. The participants enter comments, questions, and responses to one another about various issues, and a threaded line representation appears which allows one to follow the sequence of comments. SpeakEasy allows instructor and student generated topics and questions to be responded to by any member of the group. The asynchronous dialog created by SpeakEasy may allow individuals who normally don't speak out or raise questions in class to do so in a non-threatening environment [9]. Each person has the option to attribute comments to her/himself or make the comment anonymously. One purpose of SpeakEasy is to allow the class to reflect on course experiences and make thinking visible. The students were expected to make contributions to SpeakEasy dialog every week.

The final course project was the group design of a web-based case study. The class first brainstormed case study topics based on their own interests, previous class topics, and instructor suggestions. Each student ranked his or her three favorite topics and, based on these rankings, the groups were formed. This process resulted in four group case study design projects; a five student group whose focus was the Boeing 777, a four student group whose topic was the U.C. Berkeley Human Powered Vehicle (HPV), a three student group which developed a case study on the topic of ski design, and a three student group that worked on the topic of digital video.

The final group project began in week 8 and was completed in week 15. Two presentations were given by each group to the class: one at the midpoint showing progress to date, and a final presentation of the case study web-site design. The instructors met weekly with each group and were available outside of class time as well.

III. Methods

The web-based discussion tool, SpeakEasy, was used to obtain continuous student feedback throughout the semester [7, 8]. Discussion in SpeakEasy is organized around different topics, each encompassing various sub-issues. For example a main topic was 'How does your design team function?'. This topic was further broken into sub-topics such as team functioning during 1) project definition, 2) the development phase, and, finally, 3) during wrap-up and finalization. The participants enter comments, questions, and responses to one another about these various issues, and a threaded line representation appears which allows one to follow the sequence of comments.

SpeakEasy provided valuable information regarding the team's progress and functioning. Since the students entered comments weekly, we obtained information about the group dynamics on a continuous basis throughout the term. Therefore we were able to capture elements of team performance during the entire design and problem solving process.

In an effort to gain additional perspective on what was happening in the class and among the students, observations were done to gauge student behavior and interaction. The majority of the observations were done by two graduate student researchers who were introduced to the class as 'graduate mentors'. While the graduate students were not the actual instructors for the course, their role was to assist students when they had questions, or to offer support where necessary. Therefore the graduate students acted as 'participant observers' as they performed the dual role of helping students while at the same time collecting information and data about the class dynamics. Since the class size was fairly

small (15 students) the 'participant observer method' worked well because it allowed for interaction between researcher and student. Often this interaction resulted in conversations with students that provided useful information about team dynamics and project development. We used the observation data to compare the students actual behavior to the results obtained from the interviews, the personality test, and SpeakEasy comments. Therefore we can triangulate between what the students actually *did* in the classroom and what they *say* they did (do) through questionnaires and interviews. The individual student interviews were conducted by two graduate student researchers and occurred on a voluntary basis. A total of eight student interviews were done.

Finally, all of the students in the ME39C class completed the on-line Myers-Briggs (Keirsey personality test) profile. The Myers-Briggs indicator has been used in the engineering education research community for a variety of purposes. Specifically, results of the test have been used to create groups that have a diversity of members [10]. In addition results of the Myers-Briggs analysis have been used to establish correlations between personality types and success in the engineering curriculum [11]. Since these specific uses of the Myers-Briggs indicator have implications regarding how the community conceptualizes the student, we chose to examine the utility of this test in accurately capturing the student's 'behavior-type'.

IV. Results

The data presented here will be taken from the four different methods described previously; observations, interviews, SpeakEasy, and the Myers-Briggs questionnaire. Collecting information about the class through these four methods enabled us to form a more comprehensive picture of student interaction and teamwork. We will focus on two specific cases where data collection from multiple methods provided interesting and contrasting results. The first case explores the team dynamics of one of the group projects; the Digital Video Group. The second case compares the results from the Myers-Briggs questionnaire to data obtained from the other three methods for two specific students; Kate and George[1]. Finally we include some of the ME39C student comments regarding the graduate students who participated in the class.

Case 1: The Digital Video Group

The Digital Video Group was composed of three students; Alan, Fred, and Jeff. The goal of the project was to build a web based case study around the use, history, and explanation of digital video. As with all of the other projects, the main task was to design and build a series of web pages to present the case study. Some of the activities involved in the construction of the case study included making decisions about the user interface design, deciding on the look and feel of the environment, and selecting both the technical and multimedia content. Therefore many decisions needed to be made among the group members regarding each of these issues.

In the current paper we chose to focus on this group because some very interesting, and problematic, group dynamics emerged throughout the course of the semester. The group was observed working on their project during class on various occasions and during both team presentations. Two of the group members were interviewed near the end of the semester and all of the group members entered comments to SpeakEasy. Each of these sources, the observations, interviews and SpeakEasy, provided insight into the working of this particular team.

During week 12, about three weeks after the team project started, the students began entering comments into SpeakEasy. One of the SpeakEasy topics that students were instructed to respond to directly addressed team functioning:

[1] Students were given pseudonyms to protect their identity

SpeakEasy Topic: How does your design team function?
Topic Overview: I am interested in learning how a design team functions. Walk me through your project, highlighting any important decisions, critical transitions, etc., that were made by you or your group in each of the following stages: 1) Project Definition and Formation, 2) Getting Things Done (how did your group manage tasks, what problems did you encounter and how did you solve them, etc.) and 3) Wrapping Up (since you may not have done this yet, how do you anticipate to finalize your project in your group)

The following comments were submitted to SpeakEasy during the last three weeks of the course, before the project was due, by members of the Digital Video group:

"It's now rushing time, and our team hasn't got much things done yet. Instead of getting done with the contents, we wasted our time arguing whether to use rectangular or circular buttons. Then the server went down and we all were in a bad mood. It was a Black Friday (5/2) for our team."

"Everyone in our group has their own separate tasks and we plan to get things in our own sections finished. At the end, we will collaborate our work and compromise on our interface to make it unison."

"Since Fred is the group leader in our group, I have complete confidence in him that he will make our case study the best in the end."

These comments do not necessarily indicate any major team problems, but they do suggest that perhaps the team is not communicating or working together very well. Additional comments regarding the group's progress were also made during the interviews and some of these comments are provided below:

"...on our group project we each have our own distinct stuff. We haven't actually collaborated but we've actually done our own pieces progressing satisfactorily."

"We divided our duties because...we went through all the topics and what we were going to discuss, and kind of separated with different people."

The SpeakEasy comments, combined with the interview data, suggest that the team members may actually be functioning as individuals rather than as a team. Apparently they have divided the work and each member is working independently on his 'own distinct stuff'. While this approach may work during portions of the project, eventually the team must combine the individual work and reach consensus on the final layout and design.

In addition, observation of the group's lack of interaction during the class further indicated possible problems with the team dynamics. In fact the group's mid semester presentation, in combination with the later SpeakEasy comments, was a clear display that little or no collaboration had taken place. In contrast to the other groups who interacted with each other during the presentation and mutually shared responses to audience questions, the Digital Video Group appeared to be three separate entities. Each member presented his individual work and there was no cohesion among the three pieces. Each member had a separate user interface design, different backgrounds, different buttons and colors, and different uses of multimedia. The instructors of the class consulted with the group after the presentations and offered feedback for continuous improvement. Specifically, since there lacked a consistency in design, the instructors suggested creating a mutually agreeable user interface design for the final product.

The SpeakEasy and interview comments, combined with classroom observations of the three members happily ignoring one another, could make an excellent opportunity for instructors to construct some type of intervention, possibly improving the chances for better team interaction. Since most freshman and sophomore students are new to working in teams, it is necessary for the class and instruction to provide guidance when problems arise. Providing guidance and intervention will help to avoid the kind of problems that the Digital Video Group eventually experienced as evidenced by the following SpeakEasy comments:

> "I'm going to tell you some interesting but true stories about the dark side of team work...Our team consists of three stubborn people. One is a total dictator who always criticizes other people's works and forces them to change, but never accepts any criticism, or even suggestions, from others. Four words: He just wouldn't change. Another one is the trouble-maker who always initiates arguments. The last one has a "I don't care attitude but changes the team's work without consulting other team members."

> "...I argued that since our case study is for the general audience, we should keep things more simple and general...I urged that he shouldn't write his stuff too technical...then he criticized ME by saying that I don't understand English!!!...Anyway, I told him that if he didn't want to change his style, he didn't need to because nobody should force him to do something that he didn't want to. And I couldn't fall asleep that night."

> "...we had all agreed on the template-yours. However you falsely accused me of using a different template. Wrong, mister...all I did was change the logo..."

The above three comments, in addition to many other similar comments from this group, were submitted at the end of the project just after the final project presentations. They definitely indicate tension among the team members and this outcome was foreshadowed by the mid semester presentation performance and by earlier SpeakEasy and interview comments. Therefore some of these problems may have been alleviated early on in the process by offering more guidance, or at the very least creating a dialogue within the group. However, from the earlier comments it was unclear how serious the communication deficiency in the group was, and we had hoped that the team members would work things out with limited intervention. Unfortunately, as seen by the final comments, the Digital Video Group's problems escalated by the end of the semester.

Ultimately the SpeakEasy discussion initiated by the teamwork topic provided the course instructors and graduate student mentors information about the group dynamics, teamwork and design process that is rarely seen in a classroom environment. Not only does this information allow instructors to improve future course design, but affords instructors the opportunity to intervene at a time when the original learning goals of developing teamwork and communication skills are at risk.

Case 2: Myers-Briggs Data Comparison

In addition to examining the team dynamics of the Digital Video group through multiple methods, we also explored the results obtained from the Myers-Briggs indicator for two specific students; Kate and George. These two students were chosen for analysis because they scored highly on opposite ends of the introvert/extrovert scale. Kate scored 80% on the introvert side and George scored 90% on the extrovert side. Since these were strong scores indicating a particular personality type we chose to focus on how their behavior and personality played out in the classroom, specifically with respect to the team interactions. Since we focus on only a few students, the purpose of the analysis is not to draw generalizable conclusions. Rather, our intention is to examine student teamwork and interaction in depth based on multiple data sources. Detailed results from the Myers-Briggs indicator are given in Table 1.

	Type	Introvert/ Extrovert	Sensation/ Intuition	Thinking/Feeling	Judging/Perceiving
Kate	ISTJ	80%/-	55%/-	75%/-	75%/-
George	ESFJ ENFJ	-/90%	50%/-	-/60%	60%/-

Table 1. Personality type and scores along each dimensions for Kate and George.

Kate's score indicates a strong tendency toward introversion but this score seems to contradict data from classroom observations. From the very first class session she was one of the more vocal students. As the semester progressed she often asked questions, acted as the spokesperson for the group, and seemed quite comfortable being in the forefront. During their group presentations she was often the one who led the discussion and she emerged as the 'decision maker' for the group. It is also noted that she was one of the students who volunteered to be interviewed.

In contrast to Kate, George scored very high on the opposite end of the scale. George scored 90% extrovert on the personality test which indicates a strong tendency toward extroversion. From our observations, George appeared comfortable making presentations for the group but he did not necessarily surround himself with people. On many occasions, during the class time allotted for project work, he spent much of the time alone, in front of the computer, with little interaction with his team mates. Kate, who scored highly introverted, spent much more time interacting with her group and even assumed a leadership role. Therefore, in these cases, the scores from the Myers-Briggs indicator did not provide useful information regarding anticipated student interaction and behavior.

In addition, comments from the interviews provide a broader picture of student behavior and personality type. For example a comment from George is given below:

> ...like I pick my lab partner that I think will be able to keep up the pace, get it done in a decent amount of time, get out of there and, not stumble too much in putting something together because we have conflicting interests or ideas or whatever. For the most part I like to work with people. The only time that I like working by myself is when I'm actually building something...it's, I don't know, usually when I go to build something, I go in the garage and I have an idea in my head and I usually can't have someone else there trying to get into it because that drives me crazy...

The comment suggests a preference to work alone, or with others as long as they don't get in the way or have conflicting ideas. This self description also seems to agree more with his actual behavior in the classroom than with the Myers-Briggs questionnaire result. Therefore the questionnaire data may have limited utility for describing student personality types for the purposes of creating diverse teams. The personality profiles, when compared to other data sources, may not really be indicative of one's actions or behavior.

Finally, we include the following comments made by four of the students during the interviews. These comments raise questions about the validity of the personality test results and hence the usefulness of using the results for education purposes. The comments reveal that the students rushed to complete the test and often had difficulty choosing one option over the other. One student even reported that he may not have answered the questions honestly. Therefore caution should be used when interpreting the results and, particularly, when using the results for classroom purposes.

> Q: What do you remember about the personality test?

"I don't know, I don't think, I mean I tried to go through the questions carefully but I don't think I went through them carefully enough. Maybe I might do a better job at figuring out. But there were some points, its kinda like reading your horoscope where you're looking at it, that could work, but then sometimes you know you're like no that's not how."

"The thing is like some of the questions I remember thinking, that's kind of vague, like I had no idea how to answer it or you kind of feel well like I could go both ways and that wasn't a choice to go both ways.

"It was really like I don't really care what I put... I didn't really care about the questions either way. I mean if there was like a don't know button I'd press it every time... I think I answer as honestly as I can on every survey except for that one [referring to the Myers-Briggs test]... Cause that one was, I don't know, predictable."

"I did it in a hurry cause I was absent in the class and then someone told me to, like, check what you're supposed to do. I did the survey at home and I just print it out in a hurry quick, quick, quick."

Graduate Student Mentors

We also noticed an unanticipated outcome from including graduate students in the classroom. Although the original purpose of allowing graduate student mentors into the ME39C classroom was intended primarily for the benefit of the graduate students, several SpeakEasy and interview comments suggest that the presence of graduate students had positive benefits for the class as well.

"but really, we just got together with and sat with one of the graduate student observers who helped us overcome our silence and begin to get some ideas out on the board of how we thought a case study could be improved..."

"I think the instructors in this class are really supportive. There's always plenty of you guys around, scattered about the room, making sure we're getting this stuff...I feel like I should set up altars to this chummy bunch of profs:)...one of my worries is that I'm not getting all I can out of this group of great instructors..."

"... it's good to have someone coming in and help us out. Especially, like, in a small class. You guys come in like and we can work, we can talk, individually. Cause I'm a person who wants to get more individual attention. So if I can talk to the graduate students one by one or something , I mean it really helped me to gain confidence."

Although the opportunity to have additional help in a laboratory classroom is not a regular occurrence, it is also not a situation that is sought by many instructors. Enlisting interested students to observe and help in a classroom could provide the necessary assistance and guidance needed in initiating and developing individual and team performance.

V. Summary

In order to achieve the learning goals set out by the ABET criteria, many engineering classrooms are changing. As our classrooms change to encourage teamwork, open-ended design skills and improved communication, our standard techniques for evaluating student performance have to change as well. There is a need to look at the process of teamwork and design in addition to the product that results from these processes.

The current paper presented data from four different methods; observations, interviews, SpeakEasy and the Myers-Briggs questionnaire. Each of the methods provided a unique perspective regarding student behavior and team interaction. Taken together, the information obtained from these methods enabled us to construct a more comprehensive analysis of student performance. Some of the methods were more successful than others in revealing actual student teamwork interactions. If the classroom goal is to analyze, teach, and/or evaluate teamwork then a variety of approaches may be necessary to provide a more complete analysis.

In addition, since teamwork inherently requires working together with a variety of people, it is reasonable to expect some level of conflict. It is more difficult though to predict when and where conflicts will arise. Therefore in order to provide appropriate intervention and instruction it is useful to monitor team progress continuously throughout the project. Using only one method for monitoring team progress may or may not provide detailed team interaction information. Therefore a variety of approaches may result in more useful feedback.

While we chose to focus the data analysis on the Digital Video Group which demonstrated problems with team dynamics, we do not want to suggest that all of the teams in the class were problematic. In fact the majority of teams commented positively on the project and class experience. However the purpose of the paper was not to congratulate ourselves on our successes. Rather we chose to explore and present the problems that did arise and hence examine possible ways to improve in the future.

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