Unifying Assessment of Freshman Design Teams With Team Project Management

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Abstract
This paper discusses efforts to unify the assessment of first-year engineering design project teams with the project management skills and techniques employed by the teams. Assessment of the performance of *individual* design project team members is always a difficult task- especially in large classes such as Introduction to Mechanical Engineering. Project management is also a difficult challenge for both the instructors and the students- again even more so since we are dealing with first-year students. This paper presents a methodology for addressing both of these challenges in one cohesive project management effort. The result has been increased team productivity, a better experience for the students, increased student retention, and valuable data for the instructor that enables the assessment of the performance of individual team members within the context of large engineering design project teams.

Course Overview

In 1997 a major overhaul of the introductory experience to Mechanical Engineering at Florida Tech was initiated. The purpose of this overhaul was to develop an experience that would serve to: (1) prepare students for the ME curriculum, (2) motivate students to complete their studies, (3) provide students with academic success skills, and (4) introduce students to the engineering profession. The format chosen to realize this goal is a yearlong sequence of two courses that freshmen take entitled Introduction to Mechanical Engineering I (MAE1022 Fall, 2 credits) and II (MAE1023 Spring, 1 credit). This sequence is a project-motivated experience inspired by traditional capstone design courses. In the fall students are taught basic academic success skills such as time management, study skills, working in study groups, self-motivation, and goal setting. Next, a major team-based design project is assigned. This is immediately followed by an introduction to basic design theory and methodology including brainstorming techniques. Students then learn the skills they need in order to complete the design: computer-aided design via Pro/ENGINEER, basic machine shop skills, generating dimensioned

production drawings, project management including timelines and Gantt charts, project budgeting, and documentation. The major assignment in the fall course is the design proposal that each team prepares. In the spring course student teams complete their designs, fabricate functioning devices, and demonstrate these devices to the campus community.

The reconstructing of the Introduction to Mechanical Engineering experience at Florida Tech was motivated by a recognition that more could and should be done for our students. It was decided early on that a traditional introductory course that provides an overview of ME technical subject areas was not desirable. Such an overview approach does not serve the needs of the freshmen students nor does it prepare them for their future course work. These technical topics are most effectively covered in detail in the traditional engineering sciences courses (e.g. statics, fluids, thermo). Instead, a thorough review of the state of the art in pedagogy [1-23] identified some basic themes that would be adhered to in formulating a new Introduction to Mechanical Engineering experience. These themes are evident in the following citations that had a profound influence on the outcome of this effort:

- ***"Lead the participants from a relatively dependent status to as independent a status as their competency warrants" (NSF Research Experiences for Undergraduates Site Program 03-577).***
- ***Marshall Lih, then Director of NSF's Division of Engineering Education and Centers, wrote in ASEE Prism [7] "engineering schools should help students develop the following leadership traits- knowledge, know-how, judgment, and character" and "that engineering curricular should be eclectic and integrative".***
- ***In 1997, the Deputy Director of NSF Joe Bordogna in "Next-Generation Engineering: Innovation through Integration" [2] stated "Participating in the entire concurrent process of realizing a new product through integration of seemingly disparate skills is an educational imperative."***
- ***"Sink or Swim" is on its way out and we are in the process of a shift from that paradigm to one of "student development." Engineering colleges all across the nation are revising their freshman year curricula with the primary goal of enhancing student success. R. B. Landis, "Studying Engineering: A Road Map to a Rewarding Career" [21].***
- ***NSF Sponsored Chautauqua Short Course by Prof. Landis (May 1998). Goal: "To develop and document an Introduction to Engineering course designed to enhance student success by addressing five primary themes: community building; professional development; academic success strategies; personal development; and orientation to the university and the engineering program."***

These themes have lead to the development of a curriculum that is based upon providing a foundation ***cornerstone*** design experience to first year students. This cornerstone experience lays the foundation for the engineering sciences and the capstone design experience of mechanical engineering students. The course objectives are to produce students that: (1) are motivated to pursue their chosen educational and professional goals, (2) have a working knowledge of who an engineer is, (3) have an appreciation of the various engineering disciplines, (4) have a working knowledge of the engineering design

process, (5) can plan and manage design project teams, (6) can prepare a written engineering project proposal, (7) can prepare and present an oral and written engineering project report, (8) understand the concept of features based solid models, (9) can conceptualize, create, and build simple 3D geometries with a focus on mechanical parts and assemblies, (10) have a working knowledge of and ability to perform basic machine tool manufacturing operations (e.g. drilling, milling, turning, finishing), and (11) have an understanding of the relationship between detailed drawings and manufacturing processes. ***The course is structured as a project motivated learning experience modeled after traditional capstone design courses***. Students are assigned to teams, write project proposals, generate design concepts, perform analyses, generate detailed production drawings, attend design reviews, and manufacture functioning physical prototypes.

Currently, the project is the ASME Student Design Contest. Moreover, throughout the experience focus is placed upon the success of the whole student. As the process gets underway students recognize the need for learning design theory, computer-aided design, machine shop skills, project & time management, technical writing, etc. As the students recognize these needs they are taught to them in a "just-in-time" fashion. Efforts are made to integrate the course schedule with the capstone design schedule such that interactions between the first and senior year students are maximized.; e.g. design reviews, machine shop access, project presentations. These interactions facilitate knowledge transfer from seniors to freshmen and the youthful energy of the freshmen serves to motivate the seniors. The remaining sections of this document summarize the design project and present the unified project management and design project team member performance assessment tools created to enable the successful implementation of this curriculum at Florida Tech.

The Design Project

Since 1997, when the revision of the introductory mechanical engineering experience began, the design project has been the ASME Student Design Contest (www.asme.org/students/Competitions/designcontest/index.html) or a project based on the contest. The competitive nature of the ASME contest serves well to motivate the students and also serves to introduce them to their professional organization- ASME International. The few times the exact contest has not been used are when, in the author's opinion, the contest's level of difficulty was inappropriate for the freshman students. In these cases a simplified version of the contest was created. In the middle of the fall semester students are assigned to project teams of 4-6 members. Students are assigned to teams to maximize diversity among team participants. The measures of diversity used include: academic strength, gender, ethnicity, machine shop experience, cad experience, as well as personality types as all students in the course take the Keirsey Temperament Sorter II (www.advisorteam.com/temperament_sorter). The fall project assignments are: to select a team leader, to conduct formal brainstorming sessions and generate design concepts, to undergo a formal design review, and prepare a formal written design proposal.

At the beginning of the spring semester the commented design proposals are returned to the project teams. Teams are provided a nominal budget of $30 from the Dept. that they

are allowed to supplement with another $30 via donations- students are not allowed to fund their own projects. Teams may solicit an unlimited amount of material donations to their projects. Team members are told of the exact requirements for the completion of their projects. Grading is based as follows: websites (10%), progress reports & timesheets (15%), oral design presentation (25%), written design report (25%), and performance of the design (25%). The performance grade is objective and is solely based upon the team's score per the ASME Student Design Contest scoring formula- the top team receiving a perfect score. A heavy emphasis is placed throughout on project management, budgeting, and production drawings. No physical hardware (e.g. raw materials or piece parts) may be purchased until completed production drawings for all piece parts to be manufactured have been completed.

Project Management & Assessment Overview

There is a prescribed sequence of project management techniques that are taught to the students in a just-in-time fashion with respect to their design project. The pedagogy employed here utilizes known proven tools from industry to both manage teams and to assess the performance of individual members of design project teams. We now summarize these project management tools:

- Election of Team Leader- immediately after the assignment of the class design project teams are required to meet and submit within seven days a hardcopy memo signed by each team member declaring whom the team has selected to be their team leader. The Team Leader serves as the primary point of contact for team with the Professor, teaching assistants, technicians, and accounting staff of the University.

- Creation of Team Website- after submission of the Team Leader memo teams are require to create a team website. The website must include links to the course BlackBoard™ website [24], links to each team member's personal web site, a description of the design project, and email buttons for each individual team member as well as one button to send an email to the entire team. The purpose of the website is to publicize the team's work. Students often take great pride in their work and how it is presented on their team's website.

- Project Progress Reports- weekly progress reports must be posted to the team's website that are brief summaries of all of the efforts of the team each week. For each activity the progress report summarizes w^5: *who, what, when, where,* and *why.* These reports serve to publicize the effort or lack thereof of individual team members. The result is increased peer pressure on all team members to contribute and *carry their share of the load*.

- Gantt Charts, Project Timelines, and Organizational Charts are required to be posted and updated weekly to the team's website. These tools have proven to facilitate the resolution of conflicts within a team. These clear statements of the team's administrative structure and the assignment of responsibility for each task

are used by the teams themselves and by the Professor to resolve power struggles and other conflicts that arise within teams.

- Design Project Proposal- upon completion the team's design project proposal must be posted to the website. This serves to publicize the team's plan for completing the project on time and on budget.

- Photos, videos, and data of prototype testing are posted to the team's website as they are gathered. Students take pride in displaying their progress which in turn increases peer pressure on those teams that are lagging behind.

- Weekly Time Sheets- each week team members must complete a formal time sheet that details their efforts and activities with respect to the project, see appendix 1. The time sheets are submitted in hardcopy to the team leader for their signature. These time sheets have proven to be very useful as an intra-team tool to communicate team member effort and time on task- or lack thereof.

- Formal Project Design Review- two formal oral project design reviews take place- one each semester. These reviews provide the teams with formal guidance and feedback from the Professor and the teaching assistants.

- Written Design Project Report- Electronic and hardcopy of formal design reports are required of each team at the end of each semester. These written reports record the design completed by the team and are inserted into each student's personal professional portfolio as examples of their work and capacity to work effectively within a team setting.

- Oral Design Project Report- at the end of each semester a formal design project presentations is required of each team. Presentation day is an exciting event on campus. Local high school students are invited as well as the entire campus community. Often the Dean and Department Head attend as well. These presentations provide the students with an opportunity to present their design and to express their pride in their work. Students know in advance that the audience is large and have expressed that they feel a large amount of peer pressure to make the best presentation possible.

- Design Project Team Member Evaluation Forms- at the end of each semester written design project team member evaluation forms are required, see appendix 2 and [10]. Each student must complete an evaluation of each of their team members including themselves. These forms seek to assess the contributions of each individual team member as viewed by their peers. The forms inquire as to the contributions of the individual toward the team management, attendance at team meetings, oral and written reports, prototype manufacturing & testing, etc.

All of these project management tools have proven to be effective in helping the freshmen manage their design project teams. Moreover, they provide the instructor with

sufficient data to effectively evaluate the efforts and contributions of each individual within a design project team, even in courses in which there are more than 15 teams, without requiring a lot of the instructor's time or energy. The teaching assistants tabulate and record the data from the timesheets and design project team member evaluation forms in a spreadsheet. Next, the Professor identifies large variations of time on task or member evaluation scores within a team for subsequent closer examination. If warranted, the Professor may meet with each team member individually to discuss the data and to receive their input. Moreover, the Professor may consult with the teaching assistants and the campus technicians to better ascertain the performance of the individual(s) in question.

Teams are assigned nominal scores on their website, oral design presentation, written design report, and design performance. Individual are scored for their progress reports and timesheets. The assessment and team management data (e.g. timesheets, design project team member evaluation forms, progress reports, etc.) are used to modify the nominal scores to arrive at grades for each individual team member. For example, two years of data are reported in the table below that shows the final grade for each student in the spring MAE1023 course for 2004 and 2002. Grades that differ from the team's nominal grade are shown in red. Often each team member within a team receives the same grade. However, by having the project management data available, the Professor is well equipped to assign varying grades within a team. It is interesting to note that there is more variation in the grades in 2004 than in 2002 and that the teams in 2004 were larger than the teams in 2002. Although conclusions cannot be drawn from this one data point the idea is interesting and future trends in the course will be analyzed and reported upon in the future.

Team Number	2004 Grades	2002 Grades
1	C,C,C,C	F,F
2	B,B,B,B,B	A,A,A
3	D,A,A,A,A	A,A
4	A,A,A,A,A	A,A,A,A
5	A,A,A,A,A	A,A,A
6	C,C,C,C,C	A,B,A
7	B,C,B,B,B	A,A
8	D,D,D,D,D	A,A
9	A,A,A,A,A	A,A,A
10	C,B,D,B,B	B,B
11	D,D,D,D	C,C
12	C,C,C,C	B,B
13		C,C
14		A,A
15		C,C,C

Closing Remarks

A revision of the Introduction to Mechanical Engineering experience at Florida Tech has created a two semester long sequence that is structured as a project motivated learning experience modeled after traditional capstone design courses has been created. Key to the successful implementation of this new curriculum has been the unified team project management and learning assessment techniques presented here. The new sequence has proven to be a success at Florida Tech and our hope is that similar experiences can be created at other institutions. It is important to note that the success of the course would not have been possible without the support of the entire mechanical engineering faculty and the administration of the College of Engineering. Moreover, implementing this freshman experience has required the coordination of several campus resources including- technicians, computer labs, the Mechanical & Aerospace Engineering Department's (MAE) support staff, and the student machine shop. Finally, we believe that first-year students must be provided with a meaningful design experience so that they are well prepared for a curriculum that has design integrated throughout. And, we believe that effective project management and assessment of the performance of individual team members are crucial components in this type of introduction to engineering experience.

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Biography

Prof. Pierre M. Larochelle, P.E. is an Associate Professor of Mechanical Engineering at the Florida Institute of Technology. He is currently the ASME Region XI Assistant Vice-President for Education and the Chair of ASME Design Engineering Diviion's Stduent Affairs Committee. He is the recipient of the Florida Tech College f Engineering Walter M. Nunn Jr. Award for Excellence in Teaching (2004).

Prof. Larochelle is a recognized leader in the research and creation of computer-aided design theory & software for robotic mechanical systems. He has lead the development of: the world's first computer-aided design software for spherical mechanisms (SPHINX), the first computer-aided manufacturing software for spherical mechanisms (SPHINXCAM), the first computer-graphics based program for designing spatial four-bar mechanisms (SPADES), and the first computer-aided design software with the capability of designing spherical mechanisms for spatial tasks (OSIRIS). The National Science Foundation, the SME Education Foundation, and automation and robotics companies have supported Prof. Larochelle's research.

Appendix 1

MAE 1023 Team Member Time Sheet

	Wed.	Thr.	Fri.	Sat.	Sun.	Mon.	Tue.
Task							
Start							
End							
Task							
Start							
End							
Task							
Start							
End							

Start Date of this Time Sheet is: Wednesday the _____ of _____

Total Time on Project during this Time Period is: _____ (hours)

Team Number: _____
Team Member Name (print): _____
Team Leader (signature): _____

Appendix 2

MAE-1023

Engineering Design Project
Group Member Evaluation Form

An evaluation form is to be completed for each group member *including yourself* and turned in on or before: Monday April 26th, 2004

Team Name & Number: _____

GROUP MEMBER NAME(print): _____

GROUP MEMBER(signature and date): _____

This is an evaluation of the performance of(print name): _____

1. Was this member present at all group meetings? (YES/NO)
   If NO, please comment:
2. Was this member an active participant in the group? (YES/NO)
   If NO, please comment:
3. Would the group's success have been diminished if this person had not been a member of the group? (YES/NO)
   If NO, please comment:
4. Rate the member's performance on a scale from 1 to 10; 1 = very poor, 10 = excellent.
   (a) ORAL COMMUNICATION SKILLS:_____
   (b) WRITTEN COMMUNICATION SKILLS:_____
   (c) ORAL PRESENTATION SKILLS:_____
   (d) BRAINSTORMING SKILLS:_____
   (e) OVERALL CONTRIBUTION TO THE PROJECT:_____
   (f) FLEXIBILITY AND COMFORTABILITY WHEN WORKING WITH OTHERS: _____
5. This member should receive a project grade which is(circle one):
   - higher than the average grade of a member of this group?
   - the average grade for a member of this group?
   - lower than the average grade of a member of this group.
6. What letter grade would you give to your group? (avg. mem. grade)_____
7. What letter grade would you give this member?_____
8. This member contributed to: designing your device, manufacturing your device, preparing the written design report, and preparing the oral presentation? (YES/NO)
   If NO, please comment: