Integration of Management Principles in an Open-Ended Community Service Project

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Abstract

The University of Arkansas at Fort Smith has developed a unique engineering project for first year students to experience the business world while gaining an understanding for engineering tasks and how engineers function in the workplace. This project included five "Introduction to Engineering" classes, each tasked with designing, funding, and implementing a synchronized holiday light show which could be received on any automobile FM stereo. To facilitate a better understanding of the current world-wide business environment, this project grouped the students from the five classes into five different plant locations. Each class represented their own physical site with identical departments of project management, facilities and technical areas. As a result of the size and scope of the project, coordination of resources was combined in a cross-functional, cross-site interaction. Students took roles in this business model and were responsible for technical components, planning, logistics, milestones and final completion of the project. This unique project environment gave first year students a realistic insight into the engineer's lifestyle. Additionally, we believe these types of projects will help with student retention by increasing out-of-class interactions between fellow students and faculty as well as allow students to contribute to their community in a highly visible way. The project was well received by the community, with over eight thousand people coming to campus to view the holiday light show. Student survey results also indicate a high level of satisfaction with the project.

1.0 Introduction

The need to incorporate management principles into engineering courses along with other "soft skills" to compete in a global economy[1] is evident in feedback from business leaders. From this feedback, it is also evident there is a disconnection between academia and many firms that hire their graduates. This disconnect does not center on graduates' technical knowledge, but on their inadequate managerial skills and lack of innovative thinking. This has encouraged the development of several approaches in resolving these issues that range from engineering students taking a course in entrepreneurship[2] to projects that demand consistent teamwork and the use of interpersonal skills[3] along with opportunities to create and present original work. Student engineering projects that meet these criteria are difficult to develop and manage due to significant faculty/student involvement, but are essential in conveying the nature and scope of professional requirements after graduation.

Project selection and development should address different learning styles and evaluation metrics; previous experience has shown both to increase class participation. Since many engineering students are inductive learners[4], projects can be tailored to accommodate this learning style; this will allow students to learn at their own pace using a discovery method. Project selection should also address building teamwork and communication skills. Another project selection factor to be considered is campus and community visibility and the incorporation of service learning; this has a very positive impact on student vesting. To ensure a successful project experience, these objectives must be addressed during the development phase of the student engineering project. Our selected project stressed management principles by creating realistic budgets, Gantt charts, fundraising, advertising, and managerial interactions. Likewise, teamwork was encouraged by real-world time demands, task complexity, modern communications, and public visibility.

2.0 Project objectives and outcomes

There were four main objectives considered in selecting the "Holiday Light Show" project which introduced first-year engineering students to the following concepts. 1) Exposing students to communication methods within the global business environment will better equip students for international offices and understand differences in multicultural ethics. 2) The second objective is to encourage creative thinking. As the pace and volume of information and technology increase, engineering students need to apply a more entrepreneurial spirit to problem solving; this will result in new globally competitive products and services. 3) Refining oral and written presentation skills is integral. Quality presentation of original work is vitally important to career advancement in a corporation or self-owned business. 4) Strengthening teamwork between students and faculty helps solve difficult problems while building rapport and a support network. Specifically in the academic setting, the establishment of a strong bond between first-year engineering students and faculty should increase retention rates.

3.0 Project selection and organization

3.1 Project selection

The project concept was introduced to students the first week of semester classes. The concept was to design a Holiday Light Show in which the lights were synchronized to music and displayed on our engineering building. Each class was given one week to produce a creative presentation illustrating their concept of design without regard to feasibility to emulate a scenario in which marketing sells an idea before it is proven possible. The final design was selected by the students using a majority voting process with the restriction of not allowing a team to vote for their own design. After the winning show was determined, each class created a ten week Gantt chart (timeline) for engineering, building and testing the Holiday Light Show. The five timelines were then merged into one comprehensive timeline with buy-off approval from all groups and campus stakeholders. At this point, a logistics team acted as the project manager and was the overall owner of the timeline.

3.2 Project description

To facilitate a real world environment with complications and problems associated with a typical large corporate business, five separate Introduction to Engineering I classes totaling over 100 students which ranged in size between 15 and 24 students each, were broken into five groupings: programming, structures, electrical, logistics, and FM transmitter. The size of each group was determined first by the anticipated workload and second by student interest. Although the five classes were located on the same campus, they simulate our current global environment with each class representing a plant location separated by intracity, intrastate, interstate, and international boundaries. To facilitate better communications between group managers, leaders, and engineering staff, a comprehensive list of email addresses and cell phone numbers was made available to all participating students.

3.3 Organizational structure and responsibilities

The organizational structure of the project was chosen based upon an actual blue chip company and its reporting hierarchy. The four-level organizational structure in which professors and students were placed is shown in Figure 1. The three professors were placed at the highest level of the organizational structure for oversight of one or two interclass "departments" to ensure the project met time and budget constraints. The second-level consisted of student managers that reported directly to their assigned faculty lead; each student manager had five class group leads under his or her purview. These student managers were selected by cohort nomination. Each student manager was responsible for keeping their portion of the project on time/budget and compiling weekly reports submitted to each faculty lead. The third-level consisted of student group leads for each individual class or plant site. These group leads were responsible for organizing and assigning tasks to each group member in their class. The fourth-level was staffed with students working as engineers on assigned tasks. Figure 1 illustrates a complete breakdown for the electrical group.

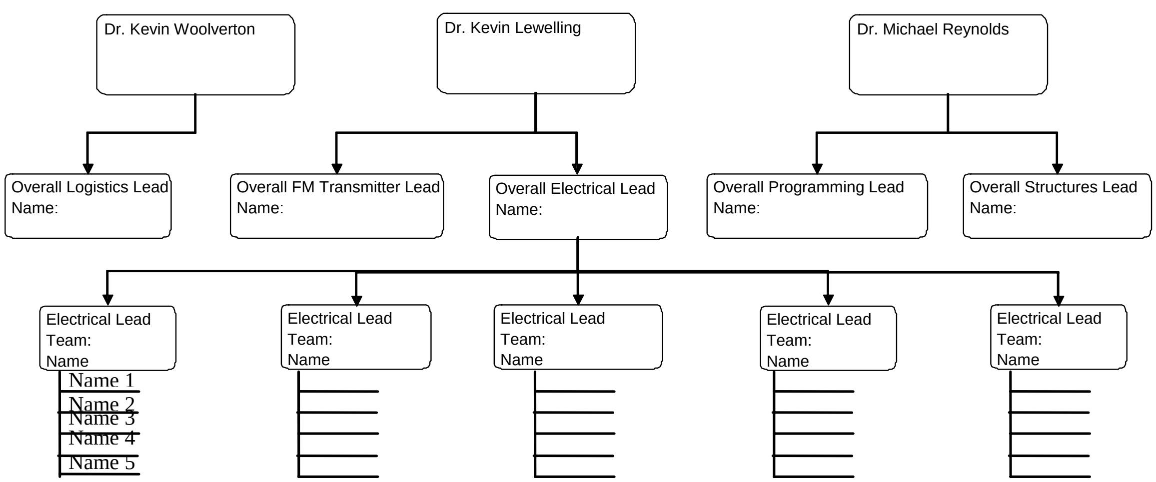

Figure 1: Organizational Structure for the Light Show Project.

The responsibilities of each group are described in this section. The programming group was tasked with programming and synchronizing the holiday lights with the transmitted music; this included learning a new computer program and a functional understanding of the closed local area network. The structures group was tasked with researching, testing, and fabricating the structures needed to support lights used in this display. The FM transmitter group was tasked with researching, fabricating, and testing the low power FM transmitters needed in this display. Additionally, this group had to theoretically and experimentally determine antenna placement to cover a 5 acre parking lot. The logistics group was tasked with traffic and crowd control, project timeline and management, donations, advertisement, and nighttime logistical operations. The electrical group was tasked with power distribution and wiring with associated calculations. This included reviewing national codes, producing electrical schematics, and making physical connections to power supply and computer controllers.

4.0 Project execution

4.1 Timelines

To ensure the project stayed on time, all groups relied heavily on a comprehensive map or timeline. Figure 2 below shows only the electrical group's major milestones of the actual project. The breakdown of each of these major milestones, other group's milestones and the arrows showing the corresponding interactions between the milestones of the complete timeline is exhaustive, lengthy, and will not be shown in this paper.

Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
Electrical	Power requirements identified	Initial wiring layout for power distribution completed including diagnostics	Give electrical equimpment requirements to Logistics for purchase or acquisition	Obtain buy-off on power distribution plan with key players	Installation of power distribution complete	Obtain physical plant buy-off for installed power distribution		Complete system built	System tested and bugs fixed
	Hardware requirements identified with prices given to Logistics	Determine current per channel needed and given to Programming so they can assign channels				Integrated systems built			

Figure 2: Timeline for the Electrical Portion of the Project.

4.2 Teaching the engineering process

The engineering process was taught through a real-world need-to-know environment. Each group had deadlines to meet with many unanswered questions. This provided numerous opportunities for self study and for teaching engineering principles in both one-on-one situations and large groups. Additionally, each group was tasked with researching and informing the other groups about their portion of the project; this fostered a sense of self reliance and ownership of the project.

4.3 Testing project components

As each part of the project was completed, a series of tests was performed to determine if the component functioned properly as a stand alone unit and interfaced with other components being designed and implement by other groups. These tests were noted by strategic markers on the project map to emphasize the "bigger" picture outside of a personal assigned task.

5.0 Project evaluation

To gauge student feedback, a survey was administered at the end of the project. While surveys are an indirect assessment, they can cast light on student attitudes and perceived learning. A total of 97 students were surveyed, greater than 80% of the students involved with the project. Students responded to twelve statements by indicating perception of strongly agree, agree, unsure, disagree or strongly disagree. Some of the survey results can be seen in Table 1.

Table 1: Student survey results.

Statement	% Agree or Strongly Agree	% Disagree or Strongly Disagree
The project helped me learn how to work in a team.	84.5	7.2
Communication through weekly reports was an essential task to the project (not just my grade).	58.7	23.7
I have learned that a good project timeline is necessary for any large engineering project such as this.	88.7	3.1
Community Service was an important part of this project.	62.1	10.5
Because this project is a gift to the community, I have a better idea of how engineers can give to their communities.	80.1	4.2
This project has made me more interested in my future engineering studies.	74.7	12.6
The project required too much time and effort from me and it has affected my grades in other classes.	26.3	48.4

The results suggest that most students enjoyed the project and believe they learned about working in teams, communication and community service. Since engineering teamwork was essential to the project, it was not surprising that 84.5% of students either agreed or strongly agreed that the project helped them learn how to work in a team. The importance of the project timeline was also indicated by the students, with 88.7% of them indicating that it was necessary. It was hoped that more students would realize the vital need for communication through weekly reports, with only 58.7% responding the reports were essential. This result may have been confounded by a portion of students neglecting to read reports regularly as some students failed to send reports in a timely manner and others did not write them effectively.

A majority (62.1%) believed that community service was an important part of the project. The engineering faculty emphasized this project was “a gift to the community” and students were generally receptive to this idea. Over eighty percent of the students indicated they learned ways engineers can give to their communities. This is an indirect measure of the desired outcome that students understand their work should help their community and society. Nearly three-quarters of the students indicated the project made them more interested in future engineering studies. By engaging students in a large, hands-on project with an exciting outcome, a general positive outlook regarding engineering was an expected (but still pleasant) result. The long hours required of all involved parties did take its toll on some students, with over one quarter of the group saying that it affected their grades in other classes. Careful management of a large scope project like this is important to keep workloads manageable. While it is hoped the excitement of the project will help with retention, overworking students could also hurt retention. The overall retention effects are still inconclusive at this time after the project.

5.1 Project grading

Each individual professor was in charge of grading project deliverables and reports as well as assigning weights to each component. The project represented 40-50% of the overall class grade. The project grade was divided into four sections: Reports, Presentations, Peer Review and Participation. The peer review was 30% of the project grade. The other sections had variable weightings among faculty members but were approximately 40% for reports (weekly reports and a final report), 20% for presentations (oral weekly reports and final oral presentation) and 10% for participation.

5.2 Peer review

A peer rank and rating system was modeled after those utilized by real-world companies used to motivate employees. The system used 360 degree feedback which allows most individuals to be ranked by those above his level, those at his level, and those below his level. Each person was evaluated by a total of six peers.

Students at level-four (the lowest level) were evaluated by three reviews at level-four and three reviews from people at a higher level. People at all other levels had two reviews from people at a lower level, two reviews from people at the same level, and two reviews from people at a higher level. The ranking and rating metric gauged the performance of the individual in the following areas: the level of an individual’s ability to be a team player (0 – 5), the level of an individual’s contribution (0 – 5), the level of an individual’s action items completed (0 – 5), and the level of the individual’s overall effectiveness (0 – 5), 0 being ineffective and 5 being most effective.

The six peer review scores for each of the metrics were totaled and then averaged for an overall score which is represented as a percentage. This overall peer review score gives an individual a direct comparison to his peers. The peer review scores were sectioned into quartiles in relation to all participating students. The quartiles represent the grading score obtained from the peer evaluations as follows; a student's score is reflected with the top quartile receiving a full 30%, the second quartile receiving 25%, the third quartile receiving 20%, and the bottom quartile receiving 15%.

6.0 Discussion and summary

The largest and most pervasive problem with the Light Show Project was communication. Even though each student was given tasks and the time for completion, the difficulty of dealing with less motivated individuals and communication failures regarding delays began to appear. Careful explanation of the importance of timely, well-written reports was also critical. The second most apparent problem was personal execution. Just as in the real world, task accomplishment was delayed by various factors, pushing the whole project back in time due to the linearity of task completion or other unplanned factors. The latter was the most pervasive as our project worked with an outside vendor to acquire the materials for the electrical and structure portion, with difficulties in quantity or timing of obtaining the supplies. A project like this also requires a large time commitment from faculty. It is advised that faculty members recognize the large scope of a project like this and plan appropriately.

The response from the community was tremendous with coverage by three local television stations, postings on YouTube.com, Google.com, and over eight-thousand visitors coming to campus to view and listen to the Holiday Light Show. We believe this idea of "bring engineering to the public" will help encourage high school students to select careers in engineering and improve retention rates by making course work applicable and highly visible. We will be tracking these rates over the next few years to confirm these assumptions.

References

[1]Hissey, T. W., Enhanced Skills for Engineers, Proceedings of the IEEE, Vol. 88, No. 8, pp. 1367-1370, August 2000.

[2]Ford, R.M. Goodrich, J.G. Weissbach, R.S., A multidisciplinary business and engineering course in product development and entrepreneurship, Frontiers in Education 34th Annual Conference, Vol. 1, pp. T2E/5 - T2E10, October 2004.

[3]Sullivan, J.F.; Knight, D.W.; Carlson, L.E., Team Building in Lower Division Projects Courses, Frontiers in Education 32nd Annual Conference, Vol. 1, pp. T1A-7- T1A-12, November 2002.

[4]Felder, R.M. and Silverman, L.K., Learning and Teaching Styles in Engineering Education, Journal of Engineering Education, Vol. 78, No. 7, pp. 678-681, 1988.

Bibliographical information

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