Experiential Learning and Engineering Management Effectiveness: A Leadership Class Case Study

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Abstract

With increased electronic communication and global, virtual teams, the requirement for skilled engineering managers has received increased focus in technical organizations. This paper provides observations regarding the effectiveness of graduate students completing a hands-on engineering task in the classroom. The exercise simulates a workplace challenge an engineering manager could face on a typical day. The study is an assignment with pre-task and post-task questions, completed in one 90-minute session of an M.S. in Technology Management/MBA Leadership and Change Management class.

Results demonstrated to students that effective management was as important to a task as the specific knowledge and skill in the technical aspects of the assignment. From learning-by-doing, students understood the value of management practices. This case study showcases the learning of technical management skills, and it is presented so that others may adapt the study to their own courses and classrooms. This study does not presume that a manager will have a technical background. Therefore, there is applicability to use the teaching method in a variety of situations from academic to corporate learning programs.

Introduction

An experiential learning exercise conducted in a leadership class with business and technology management masters students demonstrates the importance of basic management practice. Successful engineers are frequently promoted to engineering managers. In management roles, the skills that served individuals well as engineers often do not provide a substantial organization effectiveness benefit. A new set of skills must be learned. The capabilities that support the mainstay of these new skills are different from those of technical engineering roles and require practice for mastery.

This paper identifies some influences on the effectiveness of graduate students completing a hands-on task in the classroom. The exercise simulates a workplace challenge of an engineering manager. Students were given pre-task and post-task questions, to complement the 20-minute task. The setting is an M.S. in Technology Management/MBA Leadership and Change Management class with 37 students enrolled. The task was to construct a structure from the materials provided (craft sticks) with specific requirements and constraints simulating a workplace project. Four groups were tested: a control group, a group receiving instruction on the leadership model only, a group allowed to communicate electronically, and a group with both instruction and electronic communication.

This paper provides the results of this simulation exercise with recent literature on success in engineering management. Results demonstrated that effective management of the task was more important than specific knowledge and skill in the technical aspects of the assignment. Student feedback was very positive regarding the learning achieved and the relevance of the exercise to their understanding of leadership and team development.

Literature

Experiential learning projects (ELP) in business have been considered as valuable as internships to meet AASCB accreditation standards due to pedagogical benefits and reduced resource requirements.[1] Managing technical projects in industry requires not only business and technology skills, but also flexibility and emotional intelligence.[2] There is opportunity for further exploration with respect to a holistic model to expand work by Günsel and Açikgöz beyond software development projects to engineering projects in general.

The measure of engineering management effectiveness used in this paper is the completion of an assigned task to meet a set of specifications within a provided time constraint. The paper investigates two variables: awareness of team development stages[3] and use of electronics. Tuckman's work regarding team development in small groups is simple to explain, well known and well cited. Thus it is considered an appropriate choice for a classroom experiential learning exercise. With students today being inseparable from their technology of choice, the researchers were also curious as to whether the presence or absence of electronics would impact task completion or effectiveness.

Software development teams and their capacity to learn are discussed widely in academic research.[4] Agile practices force learning within project teams to apply new engineering and management practices, technical and non-technical skills, and lessons learned. Mobile technologies facilitate learning in an agile, virtual instructional setting. Self-adaptation using mobile technology is presented in the literature as a solution to mitigate risks, seek resources, and prevent failure.[5] The design of our experiential learning exercise in this paper contains an electronic technology component to assess whether this research can be applied to engineering management in a collaborative team environment.

Straus and McGrath[6] found that the productivity of student groups was much better when working face-to-face rather than working in a computer-mediated format. When tasks required a high level of interaction, the use of electronic media inhibited student productivity.

Different industry sectors place significantly different levels of importance on six dimensions of project manager competence including "1) industry-specific and generic skills…; 2) project management knowledge/expertise…; 3) (senior) managerial skills; 4) (positive) personal traits; 5) project management methodology experience and professional qualifications; and 6) risk management…".[7] Engineering education typically has little emphasis on learning skills required in the workplace beyond the technical realm.[8] Gaps are often highlighted between what industry needs and what education delivers, in software development for example.[9] Students may prefer projects of personal relevance to projects of professional relevance. When education can exploit personal learning as a tool to enable professional expertise valued by industry, a win-win outcome is possible. Engineering managers have a responsibility to be well versed in this competence to achieve organization goals while enabling efficient and effective delivery teams.

Methodology

A master's level class dually listed as 'Leadership in Technical Enterprises' and 'Leadership, Teams, and Managing Change' was the setting for an experiential learning exercise for aspiring technology managers. Collecting questionnaires from the students in the class before and after the experience was intended to enable comparison of the responses. Data were collected with pre-task questions as shown in Figure 1, and post-task questions as shown in Figure 2. Questions were designed to focus on four elements of engineer traits: temperament, curiosity, persistence, and focus. There were 32 students attending class on the day of the exercise. Data collected were entered in an Excel spreadsheet and analyzed using basic descriptive statistics.

1. Gender: Male Female
2. Age: <22 22-25 26-30 30+
3. English native language: Yes No
4. Academic program: MBA MS TM Other

On a scale of 1-5 (5=most), rate your answers to below questions:

- If given a choice, would you prefer to do the task alone?
- Do you enjoy working in groups?
- Do you believe the task can be completed successfully?
- Is completing the task successfully important to you?
- Do you care to complete the assigned task if it is challenging?
- Do you care to complete the assigned task if it is a quick win?
- Are the task assignment instructions clear?
- If you are challenged to do the task, are you likely to give up?

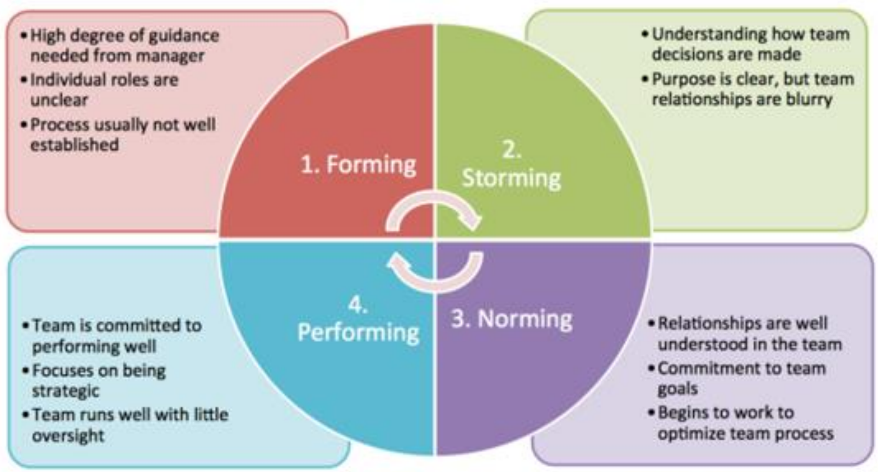
Figure 1. Pre-task Questions.

On a scale of 1-5 (5=most) or N/A, rate your answers to below questions:

- Did instruction influence your participation in your group?
- Did instruction influence your team in completing the task?
- Did use of electronics influence participation in your group?
- Did use of electronics influence your team task completion?
- How strong was your preference to complete the task alone?
- How much did you enjoy working in your group?
- How well did your group complete the task?
- How important to you was winning the contest?
- How challenging was the task?
- How challenging was working in your group?
- How clear were the task instructions?
- During the exercise, how much did you want to give up?

Figure 2. Post-task Questions.

The class was divided in four groups and given a 20-minute interactive in-class team assignment. Each team selected a project manager. Two of the team project managers were provided brief instruction on Tuckman's team development model[10] at the beginning of the assignment per Figure 3. The other two teams received no instruction to enable comparing results of task completion and whether understanding the model helps teams complete the task more efficiently or effectively. Additionally, two teams were advised that they should complete the exercise technology-free. The other two teams were allowed to use technology if they wished and a list of allowed devices was shared. The device list included laptops, tablets, smartphones, calculators, and other electronic items. Thus, the breakdown of the four groups was as shown in Figure 4.



https://www.google.com/search?q=tuckman's+stages+of+group+development&biw=1366&bih=651&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMI2abT1dLWyAIVyR0-Ch3OIg5T&dpr=1#imgrc=4Nvyz4LbYcXwCM%3A
Tuckman, 1965. Added 5th stage – Adjourning, in 1977 with Jensen.

Figure 3. Instruction: Team Development Model

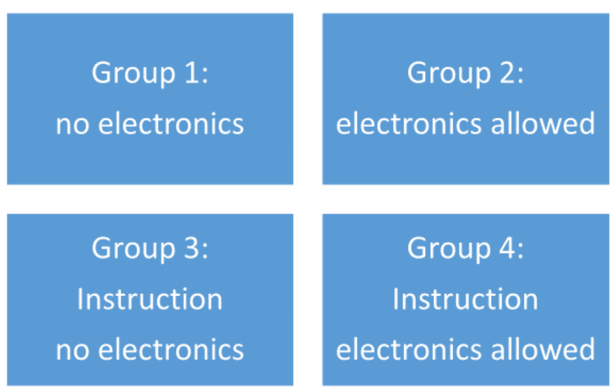


Figure 4. Experimental groups

The class leader explained the common task to the teams. They were to build a structure with the provided 10 craft sticks. The structure dimensions were constrained to a maximum 12" x 6" x 4" size and a minimum 1" height per Figure 5. The objective of the structure build was to support the weight of ten US quarter coins. Moreover, the task was tested prior to the class activity with a high school AP science student to demonstrate that it was feasible to complete within the timeframe planned, with her solution shown in Figure 6. When teams asked the class leader for advice during the exercise, the response was to defer to the team project manager. One team member was designated as an observer/recorder and requested to share the team experience with the class during debrief after the exercise. Three of the four teams shared written observations.

- This is a timed 20 minute contest.
- Each group must have a project manager and an observer/recorder.
- Team must build a structure with only the craft sticks provided.
- Structure maximum 12” x 6” x 4” size, and minimum 1” in height.
- The structure must support the weight of 10 stacked quarters.

Figure 5. The Task

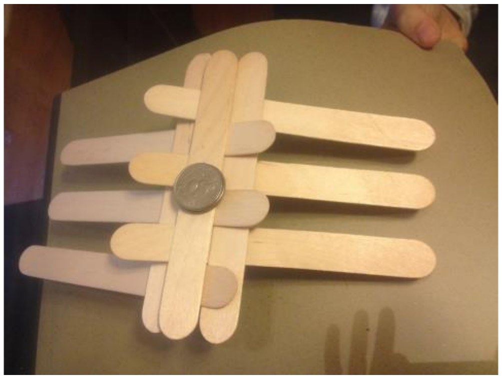


Figure 6. One Solution

Team 2 Summary

– Team of 5 men and 4 women gave equal contributions
– First idea did not meet the measurement requirements but could balance all the coins
– Next idea was to break the sticks, but this was rejected
– Successful 3-level structure used all 10 sticks: ground level used two sticks for support, next level added two sticks to complete the foundation, and remaining sticks provided a coin platform

Team 3 Summary

The task was completed in 12 minutes
Step 1: understand requirements
Step 2: identify member experience and strengths
Step 3: solicit inputs from all members
Step 4: test design to ensure criteria were met
Step 5: project manager kept team to task and time
Step 6: decided to innovate (break sticks) to be successful
Step 7: reviewed lessons learned and implemented for subsequent design iterations

Team 4 Summary

– PM was clear on instructions to divide the team
– Group were excited to get the task done and showed strong team spirit

– PM worked as part of the team and at the end took over the task because of different ideas
– Used phones to lookup information, but it wasn't that useful
– Decided to build the structure on the carpet to give it more support
– Went 2 minutes over time and the size was 6in x 9in x 1.5in
– Cut through the sticks to make the structure stand

Results

The winning team was the team which was provided with instruction on team development and did not use any electronics. That team was the only team to complete the task in less than the provided 20 minutes. However, when the exercise was extended by 5 additional minutes, all teams did complete the task. The winning team used an iterative development approach with their first solution done in 12 minutes, then used the remaining time to improve their work. The project manager of this team was initially observed to have taken the instruction he received and share it with the team members. The team most swiftly progressed through the forming, storming, and norming phases, and was able to perform the task most effectively.

The control group team with no instruction and no electronics took a risk to break the sticks to complete the structure and was the 2nd place finisher. They were focused on task and frequently sought validation from the facilitator during the exercise. They also used an iterative approach to testing the capability of the structure to support the required number of coins and sought to improve their design as a team. They also worked diligently without eavesdropping on the other teams which either had had instruction or were allowed electronic usage.

Allowing electronics appeared to have a negative effect on task completion. The team with no instruction and allowed electronics initially used their smartphones then quickly abandoned them based on lack of value added to the task. Interestingly, they seemed to be least inclined to stick to task and tried many options for the structure that clearly did not meet the stated requirements. Some team members seemed to be paying as much attention to other teams efforts as their own team and were not completely engaged. Did the opportunity provided to use electronics, although not leveraged in the team's final solution, provide distraction? One student was seen texting another student, who was standing 5 feet away, rather than simply talking. The electronics may have inhibited people working as an effective team.

The last team which had both team development instruction and electronics used their smartphones extensively. They determined that moving the structure building from a class lecture hall desk to the carpeted floor may provide friction for a more stable structure. While creative, this did not do the trick. This team not only placed last in the exercise completion time, but also was observed to operate in the least coordinated manner. Despite the project manager having shared instruction on expectations for how the team would progress in its maturity during the course of the exercise, team members were distracted by their electronics. They did not attend to each other and the coordinated completion of the task until the other teams all finished building the assigned structure. If the exercise were repeated, it may be a noteworthy to learn if the two poorest teams both used electronics is a coincidence or an indicator of a task inhibitor.

Discussion

The students in the class study technology management and business. Of the 32 students who participated in the four teams, most students were age 22-30, and all students reported not being native English speaking. Students’ belief in the project success and importance was above the mean before and after the task. There was a lower score and higher standard deviation regarding enjoyment of group work after the task. The average score on caring to complete a challenging or quick win task was higher initially than post-task, yet the standard deviation of responses increased. Of all the questions, when asked post-task about being challenged and wanting to give up, students reported the lowest score (1.19, std dev .54) compared to any other pre- or post-task questions. The survey results are shown in Table 1. The limited number of responses and the fact that students discussed their answers collaboratively negates the statistical significance and the validity of this data. However, the exercise of designing the study, collecting data, and analyzing it shows promise. With sizeable data and statistical rigor, reliable conclusions might be drawn from future study.

There were interesting instructor observations providing value to the exercise as a model for future study. The instructor observed that teams having instruction in the task improved appearance of individual participation and team task completion. This may not have been due to the instruction as both these teams were seated at the front of the room, and the teams without instruction were comprised of individuals who chose seats at the back of the room. It was also observed that electronics had little or no effect on participation or team task completion. Teams using electronics sat on the right side of the room (front and back) and as the exercise proceeded, the individuals abandoned their device, typically a smartphone, and engaged with teammates.

The main body of questions on both the pre-task and post-task assessment were aligned with four different traits typically associated with engineers: temperament, curiosity, persistence, and focus. The first two questions represent temperament with respect to the student’s nature to want to work alone or in a group. The second two questions represent curiosity and ask for a confidence and importance score. The third two questions represent persistence and assess if the student is accepting of the task challenge and will keep trying regardless of whether or not a quick win is achievable. The last two questions represent focus using the task instructions and dedication to completion without giving up.

Pre-class

	Prefer task alone?	Enjoy group work?	Believe in task success?	Task success is important?
AVG	2.84	4.66	4.74	4.91
MIN	1	3	4	4
MAX	5	5	5	5
STDEV	1.02	0.65	0.44	0.30

	Care to complete challenging task?	Care to complete task if a quick win?	Task instructions are clear?	If challenged, will you give up?
AVG	4.75	4.34	4.00	2.56
MIN	3	2	2	1
MAX	5	5	5	5
STDEV	0.51	0.87	0.62	1.79

Post-class

	Prefer task alone?	Enjoy group work?	Believe in task success?	Task success is important?
AVG	2.22	3.69	4.81	4.72
MIN	1	1	3	2
MAX	5	5	5	5
STDEV	1.48	1.79	0.47	0.73

	Care to complete challenging task?	Care to complete task if a quick win?	Task instructions are clear?	If challenged, will you give up?
AVG	3.81	2.75	4.45	1.19
MIN	1	1	2	1
MAX	5	5	5	3
STDEV	1.01	1.14	0.81	0.54

Table 1. Questionnaire results

Learnings

The leadership class case study described herein may provide a methodology to learn more about engineer personality[11] and the Tuckman's process[3] for team development. Indeed, while there has been significant work in education and instructional design and groundbreaking achievements in technology and its availability, there are also some constant tenets as to how a technology manager can be effective in the workplace. Through experiential learning in this research, though limited in sample size, further work can be undertaken with broader, more diverse technology management students. Personal traits can be assessed with multiple tools, such as the Myers- Briggs type indicator[12] and others. Engineering management effectiveness can be measured by designing experiments with various team sizes and task complexities.

This study was not intended to focus on project manager competence nor the effect of technology on productivity. Each of these questions have a wide body of knowledge independent of the breadth or depth of this paper. However, if modeling future classroom experiments with larger numbers of students, there could be research designs that control for these variables and draw conclusions of value in many settings, particularly for business. This case study is a call to further explore project manager influence on team success and technology impact on team productivity. A much larger research effort would be required to produce valid results and draw reliable conclusions on these topics.

The methodology described can be extended with more sophisticated quantitative analysis providing simulations for workplace tasks. The effort may provide value to students, educators, and researchers. For students, participation in experiential learning helps not only with skills development and application of academic work, but also provides a reference point to evaluate future employment opportunities. For educators, experiential learning demonstrates how much students have assimilated the course material presented and how successful they are at applying what has been learned to live scenarios. For researchers, aggregating data from a significant number of the same or similar exercises will enable more widely applicable conclusions to be drawn. The next generation of technology managers will certainly face challenges. When students have positive classroom experiences with the opportunity to practice skills that will help them to overcome challenges and learn to work in effective teams, it can be a win for both the individuals and for the organizations which will employ them.

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