Managing Virtual Teams in Senior Industrial Projects

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Abstract

The Industrial Projects course at Tennessee Technological University represents the practical execution of the technological skills and knowledge the students gained from all sources throughout their college career, work experience, and life. This course is the capstone experience that requires both teamwork and individual skills in solving an industrial problem.

Since the students will be working in an industrial setting, wouldn't it be better for them to learn in an industrial setting? With cooperative education agreements, and some industry/education partnerships, this can become more of a reality. The students enrolled in the class are divided to groups of 2-3 students. They are required to solve an industrial project either in a nearby industry or in a special project while they are on co-op. Since the class is not meeting in a regular classroom setting, the class is taught as distance learning class using WebCT®. The students enrolled in the class have access to the course materials at any remote location.

Several research questions have surfaced from this experience: How do you manage the virtual team? Which communication media are students using (i.e., online or face-to-face) when completing group projects? Which media are most likely to be associated with team member satisfaction? Which methods are more likely to be associated with positive group performance? This paper will present our experiences and findings to these questions.

Introduction

Technology and pedagogy are converging in the 21st Century to create a dynamic learning environment replete with opportunities and obstacles. This convergence, known as distance learning, has gained rapid momentum for both the Academy and the Corporation[1]. Distance learning is viewed by both as a means of gaining competitive advantage in the global marketplace but raises many questions about satisfaction and profitability[2-3]. In addition, course delivery either entirely at a distance or hybrid (online and on ground), has advantages and liabilities as far as student access, cost savings, and teamwork[4].

While university administrators, faculty, and students have shown interest in distance learning, there appears to be increased emphasis in Engineering and Business Colleges to "be on-line" (e.g., Auburn, Colorado State, Tennessee Technological University). Engineering and Business faculty are encouraged to teach on-line, offer e-commerce courses, and use enhanced technology in the classroom that simulates global work environments.

This paper presents a collaboration between the College of Engineering and Business in the evolution of an engineering senior industrial team-based project capstone course from on-ground to online using WebCT® technology. By taking the course online, the questions raised are:

1) Which communication media are most likely associated with team member satisfaction?
2) Which methods are more likely to be associated with positive group performance? and
3) How can you resolve team conflict?

Engineering faculty present the course and its evolution online. Business faculty share their processes and research findings to these questions.

Industrial Projects Course

This course is the capstone experience, which requires both teamwork and individual skills in identifying and solving an industrial problem. It requires the application of design; manufacturing processing, project management plan, and public presentation of results.

It is a proven fact that students have the ability to learn, demonstrated by the fact that they have successfully completed the prerequisites of this class. However, very rarely do students have the opportunity to put into practice the skills and knowledge they have acquired during the course of their education in solving real-life industrial problems before graduation. The primary focus of the Industrial Project course is to provide students with an opportunity to apply their skills and knowledge. This course affords students the opportunity to demonstrate that they can translate their learning into worthwhile action by solving industrial problems; and that they understand and are aware of interrelationships among basic knowledge, technical advance and human needs. This distance-learning course is taught differently than any traditional face-to-face course the students have taken during their course of study. This course is a challenging and rewarding experience, with much learning on the student part. The ultimate goal of this paper is to: describe the course, virtual team management rules and conflict resolutions, and discuss the course management using WebCT®.

Course Description

The Industrial Projects course represents the practical execution of the technological skills and knowledge the students have gained from all sources throughout their personal experience, college and professional careers. It is the capstone experience that requires both teamwork and individual skills in solving an industrial problem. The students are taking the course during their senior year and only when they are prepared for it. Upon completion of this course, the student will be able to: 1) apply the principles and skills in solving a real-life industrial problem, 2) analyze an industrial problem by breaking it into component parts, each of which can be studied separately as well as in the context of assembly, 3) differentiate between the various stages in the design process and describe the total process in general terms, and 4) individually design or make significant contributions to the group performance of the following tasks:

- Problem identification and definition,
- Product research, analysis and decision-making,
- Design and drawing refinement, and implementation,
- Model and prototype construction, and
- Develop a technical report and visual presentation of a product and /or system design.

General Course Characteristics are: 1) instructor coordinated independent study, 2) few reading assignments, much reference work expected, 3) fundamental knowledge of problem solving and skill is prerequisite, 4) professional looking end-product and presentation expected, 5) team(s) of students work on a complex project, 6) instructor is a general resource person, and specialists will need to be consulted, and 7) distance learning using WebCT® course management engine.

The Industrial Projects

Using WebCT®, the students are divided randomly into teams of two or three students. Each team will research and develop a design problem from the identification phase through the presentation phase. Some individuals may propose problem solving, others may investigate economic factors, research the materials, draft the plans, develop technical reports, etc. Therefore, each team of students is responsible for finding an industrial project for the course. Each group of students may get an industrial project from a local industry, get a project from their workplace, or get a project from the company they work for while on co-op. This project could be related to a product design, process design or system design**.** Each team will go through: 1) definition of the problem, 2) conduct literature review, 3) brainstorming to generate ideas, 4) systematic problem-solving procedure and 5) propose a feasible solution to that problem. Before beginning work on the project, both the faculty advisor and the industry advisor should approve the proposal and the approved proposal becomes a binding contract. The problem selected must have a solution that requires the use of/or development of a computer program, designing a product, development of a process, or developing a manufacturing system. The solution to that industrial project will be presented virtually during the finals week before an audience of students, faculty members and an industrial counterpart. Each team is required to deliver fully narrated and animated PowerPoint presentations using Impatica® to essentially any Internet device without plug-ins and even at normal modem speeds. All presentation participants are requested to evaluate each group member and the group as a whole. A survey evaluation form was designed specifically for this purpose using Respondus® software and uploaded to WebCT®. The instructor works as a moderator during the presentations and the student presenters sign-up from any remote location in vclass room using the Elluminate® virtual classroom at Tennessee Technological University.

Team Building

A single individual seldom performs industrial projects. They are rather performed by a number of people working together making individual contributions to the total process. Effective team building is a key for the success of the project[5]. The successful team members are able to work together and function at their maximum potentials when solving an industrial problem. The success of the team depends on: 1) each team member understanding his/her function within the organization of the team, 2) members of the team agreeing upon the goals of the project, 3) team members agreeing on a set of procedures for getting things done, 4) team members developing effective interpersonal relationships, and 5) defining the team leader roles. The ability to work in teams does not happen by itself. The team skills must be taught with coaching, practice and feedback[6]. This course is designed to achieve three major objectives: 1) to enable students to participate in many of the tasks associated with product design and development, 2) to learn how to be a team player, and 3) to improve students' written and oral communication skills. Basic

competencies will be developed in the performance of these objectives. In order to obtain these types of learning experiences, the class is divided randomly into teams of students using WebCT® group generator.

Several web-based courses were developed by engineering and engineering technology faculty[13-19]. The commercially available course management software standardized the development process and made it more manageable to develop such courses. The University Administration and Faculty chose WebCT® course management software as the engine to develop TTU's web based courses. The following figure shows the home page for the Industrial Projects course.

Method of Instruction

There are scheduled vclass periods for discussions among each group's members or communicating with the faculty as a resource person using chat room or whiteboard, and group presentations. There are some instructional presentations based on the project's need or students' request. The remaining time is devoted to project work. Scheduled class meetings are vital for completing project assignments and team member interaction on the industrial project. It also provides an opportunity for the faculty to assist students and observe their performance. Because of this, each student is expected to be punctual and regular in attendance. Attendance is monitored periodically during the class period using webCT course management tools. All students should

log in at least once per week. Additionally, they should attempt to remain current with the course calendar. If a student does not login during a week (defined as Sunday midnight to Sunday midnight) or if the student is two weeks behind the calendar on Sunday midnight, then that week will count as an absence. Two unexcused absences will result in the lowering of the course grade by a letter grade; five will result in failure of the course.

Individual assignments are communicated to the group members via email, or using the calendar, or take place during virtual class meetings. The assignments are usually: reading assignments, product research and/or report preparation.

Informational sources are at the discretion of each individual and the group. Resources and references could be worldwide web materials, libraries, consulting with an expert or a friend, personnel from industry, universities, as well as state and federal agencies.

Leadership will be rotated among the team members and change according the schedule listed below:

- First Leadership Period - first four weeks of the semester.
- Second Leadership Period - second four weeks of the semester.
- Third Leadership Period - third four weeks of the semester.
- Fourth Leadership Period - fourth four weeks of the semester.

A copy of the leader's weekly reports is to be emailed to the faculty on Monday prior to the group scheduled weekly virtual meeting. The weekly report is to include the following information:

- When and how long your group meetings lasted.
- What was accomplished last week? (Be specific).
- What the goals of the group are this week.
- What the goals are for next week.
- Job assignments and performance appraisal of each of the subordinates.
- Financial Statement/Report:
  1. Weekly report, and
  2. Detailed Final report - to be part of the leaders last report before turning the leadership to the new leader.

Project & Team Management

The term "project" is universally used in engineering practice as a "unit of work, usually defined on the basis of the client"[7]. Mills develops this definition further by stating that "almost every task undertaken" and the time allotted is in relation to the project. While tasks and timetables are emphasized in engineering team based projects, relational factors such as creating relationships, building trust, and resolving conflicts are critical to project success especially when the team is virtual. These relational tasks frequently occur in face-to-face communication in on ground teams. Face-to-face communication provides rapid verbal, non-verbal, and tonal feedback for this personal work. It is viewed as a relatively rich or "hot" means of communication. Historically, it has been the medium for both instructor-student and student-student communication in the traditional classroom.

In contrast to face-to-face communications, WebCT® technology provides a "cold" means of communication using e-mail, virtual chat rooms, and whiteboards which are applied to a wide range of tasks from simple information exchange to complex problem solving. At times, the problems requiring solutions call for a resolution of conflicting positions to arrive at a preferred alternative[8]. The technology allows instructors and students to document and contribute uninterrupted, anonymous, and simultaneous comments in the resolution of conflicts.

While WebCT® technology allows for the documenting of processes, various researchers[9-10] suggest that a richer "hot" form of communication is more effective than a lean "cold" medium when resolving issues that are ambiguous, subjective, involve values and feelings, and require judgmental tasks. Forming teams, building trust, and resolving conflicts involve values, feelings, dealing with ambiguity, and require judgment.

Several online courses in the College of Business have recognized that while "hot" forms of communication are effective in resolving team management and conflict issues, the boundaries of distance online learning do not easily lend to face-to-face communication. The issues of team management and conflict resolution in these online business courses have been addressed through the use of autonomous self-managed virtual teams. The randomly computer selected team is responsible for the "whole project". Team members hold collective responsibility to manage the process of forming, storming, norming, and performing[12] through progressively complex assignments. Disciplinary action policies are agreed upon in virtual chat sessions between team members and the instructor. Electronic signatures of each team member agreeing to the policy are archived. The team is empowered to hold themselves and each other accountable for the process. If a member or members are not performing to the agreed upon norms, the team implements a "due process" to ensure compliance.

The following process and guidelines are discussed in virtual chat, and electronically agreed upon to assist in managing a fair and equitable process if the team is confronted with a dysfunctional member:

- The group members discuss the issue (i.e. non-attendance at meetings of a member, etc.)
- The group members discuss how to handle the situation.
- If disciplinary action is decided upon by the group, the group members inform the team member by providing an oral reminder (via phone) that serves as the initial formal phase of the process to identify to the member what problems the group is having. This reminder is designed to correct the problem (i.e. not attending virtual meetings, not contributing a task on time, etc.)
- If the oral reminder is unsuccessful and the group decides that a more formalized version is needed, the group drafts a written reminder of what the problem is and what corrective actions the group expects. Furthermore, specific timetables, actions, and consequences for failing to comply are included.
- If the written reminder is unsuccessful and the group chooses to terminate the team member from the group, they are required to submit to the member a written summary outlining the problems, actions taken to date and their final recommendation-termination. Termination means that the terminated member will not receive a grade for the group work.

- If the terminated member wishes to appeal, he/she must do so to the instructor in writing within 7 days of receiving the termination document from the group. A copy of the written appeal must be submitted by the terminated member to each group member as well as the instructor. Upon receipt of the written appeal to the team members, the team members are to provide the instructor with a copy of the Written Reminder and the chronology of the disciplinary action taken.
- The instructor will review both documents (appeal and the written reminder), interview team members, and make a final decision.

In the past 18 months, the policy has been consistently applied to 45 self-managed project teams (approximately 210 students). Five students have been terminated based on the above policy guidelines. One student appealed the termination within the allotted timeframe. A review of the written appeal and accompanying documentation did not justify a termination reversal.

Communication Among Students

As the Industrial Projects course moves from a pure face-to-face format to a more virtual format, many questions arise. Because of the "colder" nature of virtual communication, the relational aspects of group performance may be more difficult for team members to negotiate among themselves. This section will attempt to summarize what College of Business faculty have learned from their transition to virtual student teams.

Over the last two years, faculty from the College of Business have measured various aspects of group process in student work teams. These aspects include transitional activities (e.g., establishing group rules and guidelines), action processes (e.g., coordinating the actions of group members), and interpersonal processes (e.g., working through disagreements). As we transitioned from on-ground teams to virtual teams, we also measured the extent to which these activities and processes were handled via face-to-face communication or via electronic means (e.g., email, discussion boards). A recent survey of the students in the Industrial Projects course allows us to compare and contrast the communication patterns of engineering and business students. A sample of business and engineering students responded to a survey using Likert-type scales ranging from 1 (not at all) to 5 (a great deal). The data in Table 1 shows the extent to which various communication media are used (for any purpose) by students in virtual teams.

Table 1 – Extent to which various communication media are used by students.

Communication Medium	Business (n = 11)	Engineering (n = 8)
Face-to-face	3.23 (1.34)[a]	3.59 (1.06)
Phone	1.36 (0.90)	2.69 (1.23)
Email	4.09 (0.51)	3.23 (1.22)
Chat	2.27 (1.05)	1.75 (1.05)
Written	1.24 (0.59)	1.82 (1.30)

[a] Mean (Standard Deviation)

These data show that engineering students were somewhat more likely to use face-to-face, phone, and written communication. Business students were more likely to use email and chat rooms. Interestingly, business students in purely virtual teams still seek out face-to-face contact.

Likewise, engineering students are more likely to use face-to-face communication than any other medium.

Table 2 shows the total amount of communication (across media) devoted to each process for business students and engineering students.

Table 2 – Total amount of communication devoted to each process.

Group Process	Business (n = 11)	Engineering (n = 8)
Transitional Processes	2.62 (0.52)	2.68 (0.86)
Action Processes	2.53 (0.60)	2.66 (1.00)
Interpersonal Processes	2.52 (0.86)	2.60 (0.87)

These data show very little difference between the amount of time devoted to transitional, action, and interpersonal processes. This is true within as well as across disciplines. The lack of any differences suggests that the group process model used by Business School faculty may be generalizable to engineering projects.

The purpose of Table 3 is to determine if particular media are used for different purposes by students from different disciplines. Perhaps the most interesting result in Table 3 is the fact that engineering students use email to the same extent to complete transitional, action, and interpersonal tasks. Business students, on the other hand, are apparently more reluctant to use email in dealing with interpersonal issues than they are in dealing with transitional and action processes.

Table 3 - Particular media used for different purposes by students from different disciplines

Communication Medium	Business (n = 11)	Engineering (n = 8)
Face-to-face		
Transitional	3.44 (1.72)	3.75 (1.03)
Action	3.05 (1.47)	3.50 (1.07)
Interpersonal	3.15 (1.65)	3.47 (1.37)
Phone		
Transitional	1.41 (1.06)	2.75 (1.23)
Action	1.28 (0.70)	2.66 (1.38)
Interpersonal	1.38 (0.94)	2.66 (1.19)
Email		
Transitional	4.25 (0.63)	3.30 (1.16)
Action	4.27 (0.47)	3.28 (1.47)
Interpersonal	3.70 (1.04)	3.28 (1.18)
Chat		
Transitional	2.26 (0.96)	1.66 (1.10)
Action	2.17 (1.06)	1.75 (1.09)
Interpersonal	2.39 (1.34)	1.86 (1.07)
Written		
Transitional	1.24 (0.51)	1.77 (1.39)
Action	1.25 (0.79)	2.04 (1.45)
Interpersonal	1.28 (0.79)	1.68 (1.11)

Finally, it may be interesting to know if the factors associated with overall group satisfaction are similar across disciplines. Table 4 shows differences that may be worth pursuing in future research with larger samples. The correlations in Table 4 show the relationships between overall satisfaction and the extent to which each communication medium was used. For example, the correlation between overall satisfaction and total face-to-face communication for transitional processes among business students is .58. The same relationship for engineering students is -.49.

Table 4 - Differences worth pursuing in future research with larger samples

Communication Medium	Business (n = 11)	Engineering (n = 8)
Face-to-face		
Transitional	0.58	-0.49
Action	0.49	-0.57
Interpersonal	0.45	-0.45
Phone		
Transitional	0.18	-0.41
Action	0.19	-0.40
Interpersonal	0.22	-0.46
Email		
Transitional	-0.12	-0.59
Action	0.04	-0.47
Interpersonal	-0.32	-0.59
Chat		
Transitional	-0.53	-0.94
Action	-0.71	-0.91
Interpersonal	-0.66	-0.88
Written		
Transitional	-0.30	-0.96
Action	0.22	-0.82
Interpersonal	0.17	-0.93

Even with a small sample, these correlations show an interesting pattern. Among the engineering students, more communication (using any media for any purpose) is associated with lower group satisfaction. Among the business students, there is much more variability. Business students were more satisfied if they used more face-to-face communication. They were less satisfied, however, if they used chat rooms more often. It may be interesting to pursue these differences to discover their origin and their consequences for actual group performance.

Suggestions for Future Research Work

The data collected thus far offer several potentially fruitful avenues for further research. In both of these groups, students appeared to seek out face-to-face communication. In this particular setting, students could easily meet with each other if they so desired. More interesting, however, is the fact that the authors have observed this same phenomenon in virtual teams that were geographically separated. The interesting question that needs to be pursued is: What function does face-to-face communication serves that is not met by online methods? A second avenue for future research concerns the validity of the model used above. The model has been validated in

business settings and the limited data available suggest that the model may be useful in engineering settings as well. Additional research could help determine the links between group processes and group outcomes in engineering settings. Finally, future research should continue to explore the differences suggested above as well. The results imply that amount of communications and group satisfactions are positively correlated among business students. Among engineering students, however, communication is negatively correlated with group satisfaction. Future research should examine the causes of this relationship. Are there personality differences that produce this relationship? Do engineering and business students communicate under different circumstances? The answers to these questions would help determine the boundary conditions for the group process model when applied to engineering settings.

Conclusion

This paper presents the initial collaboration between the College of Engineering and Business in the evolution of an Engineering senior industrial team-based course from on-ground to online using WebCT® technology http://webct.tntech.edu/SCRIPT/MIT462000103S/scripts/serve_home. Questions about communication media, team member satisfaction, and team member conflict were raised. The results of this initial dialogue and findings provide promise for avenues of fruitful research and working relationships across disciplines.

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