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Strengthening Senior Technology Capstone course experience for agricultural and industrial technology students

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Abstract
The Technology Capstone I/II are required Agricultural Systems Technology and Industrial Technology courses at Agricultural and Biosystems Engineering (ABE), Iowa State University to prepare students for workplace application of learned practices. Instructors are challenged to create a strong and rigorous learning experience in the final year of a typical degree program. Past experiences with Technology Capstone course weaknesses could be summarized as follows: (1) projects were often "made-up" problems, i.e., contrived to meet academic requirements, lacking real-world business client and associated professional/business-world expectations, (2) student engagement was low and affecting other team members, and (3) instructors lacked sufficient information for assessing performance and awarding final grades. This paper describes how the Technology Capstone course was strengthened to address these major weaknesses. The objectives of this paper are to: (1) overview the significant parts of Technology Capstone at ABE and how they contributed to course weakness; and to (2) share the experiences strengthening student experience and course outcomes through student based project selection process, team member accountability and weighted team member evaluations. Major improvements were made that focused on the following areas: (1) project identification, (2) team selection process, (3) team member evaluations, (4) written and oral communication, (5) facilities improvement and programming changes, and (6) faculty mentors. Several measures were put in place to strengthen team success, student accountability, and expected team member performance: (1) quality and quantity of work; (2) team meeting attendance, (3) preparation and participation; (4) team task deadlines; and (5) collaboration and effort.

Keywords
Education, technology, management, course, practices

Disciplines
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Comments
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Strengthening Senior Technology Capstone course experience for agricultural and industrial technology students

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Abstract. The Technology Capstone I/II are required Agricultural Systems Technology and Industrial Technology courses at Agricultural and Biosystems Engineering (ABE), Iowa State University to prepare students for workplace application of learned practices. Instructors are challenged to create a strong and rigorous learning experience in the final year of a typical degree program. Past experiences with Technology Capstone course weaknesses could be summarized as follows: (1) projects were often "made-up" problems, i.e., contrived to meet academic requirements, lacking real-world business client and associated professional/business-world expectations, (2) student engagement was low and affecting other team members, and (3) instructors lacked sufficient information for assessing performance and awarding final grades. This paper describes how the Technology Capstone course was strengthened to address these major weaknesses. The objectives of this paper are to: (1) overview the significant parts of Technology Capstone at ABE and how they contributed to course weakness; and to (2) share the experiences strengthening student experience and course outcomes through student based project selection process, team member accountability and weighted team member evaluations. Major improvements were made that focused on the following areas: (1) project identification, (2) team selection process, (3) team member evaluations, (4) written and oral communication, (5) facilities improvement and programming changes, and (6) faculty mentors. Several measures were put in place to strengthen team success, student accountability, and expected team member performance: (1) quality and quantity of work; (2) team meeting attendance, (3) preparation and participation; (4) team task deadlines; and (5) collaboration and effort.

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Introduction

Problem Statement

Many technology programs instructors are challenged to create a strong and rigorous learning experience in the final year of a typical degree program. Past experience with Technology Capstone course weaknesses could be summarized as follows:

(1) Projects were often "made-up" problems, i.e., contrived to meet academic requirements, lacking real-world business client and associated professional/business-world expectations.
(2) Lack of student engagement. Minimal (or no) participation by some. Engaged/functioning students not empowered to hold non-engaged members responsible. Lack of timely feedback to instructor regarding non-performing members.
(3) Insufficient information for assessing performance and awarding final grades.

In addition, teaching the Senior Capstone course sequence is especially difficult since the students are expecting to follow a typical course experience that that have been accustomed to through Freshmen-to-Junior curricula that does not necessarily create open-ended projects. Students are also not accustomed to team project environments where individual performance is measured by industrial standards. Students are also accustomed to being given a well-defined project as opposed to be needing to find an opportunity to work on a project for a real industrial partner. Students are also not necessarily used for the industrial setting expectations, coping with setbacks, team members, and professional level of communications.

This paper describes how the Technology Capstone course was strengthened to address its major (1) through (3) weaknesses.

Technology Capstone Courses: Catalog Description

The Technology Capstone I/II are required Agricultural Systems Technology and Industrial Technology courses at Agricultural and Biosystems Engineering (ABE), Iowa State University to prepare students for workplace application of learned practices. The first of a 2-semester course sequence (TSM 415, 1 cr.) focuses on:

> *'identification and proposal development of a current technological problem in agricultural or industrial systems. Formation of project teams and selection of faculty project mentor in preparation to complete project'.*

The 2nd semester (TSM 416, 5 cr.) focuses on:

> *'continued team development, communications, and responsibilities. Development of alternate solutions using creativity, critical analysis, and planning techniques. Selection of promising potential solutions to technology problems for development and analysis by student teams. Presentation of project through oral presentations, written reports, and working prototypes'.*

First semester activity is at first individual and then transitioning to team effort. The Senior Capstone sequence prepares students for first job success. The Senior Capstone course bridges traditional technology curriculum problem solving with post-degree employment performance expectations. The course objectives assist students in 'connecting the dots' of their coursework in an industry-sponsored, team-based, applied problem-solving setting. The Senior Capstone courses are strongly supported by the department, faculty, and departmental external advisory committee (EAC). Employers continue to emphasize that the employees they value the most are those who have had experiences (1) working in multidisciplinary teams, and in (2) planning and managing technology projects.

Technology Degree Options

There are currently two Technology degree programs and four options requiring senior project diversity to represent agricultural and biosystems management, machine systems, manufacturing and occupational safety. The degree programs are:

> *Agricultural Systems Technology (AST) program graduates have the ability to apply science and technology to*

problems related to agriculture; they manage complex agricultural systems for sustainability. They find careers within a variety of agriculturally related industries, businesses, and organizations, including: agricultural machinery, environment, government, farm builders, grain, feed, seed, fertilizer, chemical, food, bio-renewable resources, and production agriculture.

Industrial Technology (ITech) program graduates understand commonly-used manufacturing processes, lean manufacturing principles, continuous improvement, quality management, safety, regulatory issues affecting manufacturing, and the properties of manufacturing materials. They find careers within a variety of industries, businesses, and organizations focusing in manufacturing (e.g., quality control, production supervision, and process and facility planning) or occupational safety (e.g., development, management, and evaluation of safety programs and systems; and hazard identification and mitigation).

Objectives

The objectives of this paper are to:

(1) Overview the significant parts of Technology Capstone at ABE and how they contributed to course weakness.
(2) Share the experiences strengthening student experience and course outcomes through student based project selection process, team member accountability and weighted team member evaluations.

Supportive of the instructor goals to provide project focused 'real-world' learning with high value student outcomes, this paper addresses successful methods for:

(1) Project identification and selection;
(2) Team member engagement and ownership; and
(3) Tools for improving written and oral communication.

Methods

This section describes historical experience with the Technology Capstone course at ABE with specific emphasis on major weaknesses.

(1) Common Problems with Project Identification

Senior Capstone projects allow students to demonstrate and apply core learned curriculum, demonstrate participation in successful team based problem solving, and communication of root cause, methods, measurable outcomes, and data based conclusions. Failure to define sufficient diversity and high-value 'real-world' projects results in low value student experience, unmet student learning expectations, and low instructor performance reviews. Senior Capstone project identification historically allowed (1) 'students defined' project, or (2) 'instructor sourced'.

Student defined projects resulted in low-quality or 'made-up' projects. Experience with made-up project revealed that without industrial client expectations, the resulting project quality proved unacceptable for a Senior in a technology program.

Instructor sourced projects have hindered the desired project diversity due to limited or narrow industry contacts (e.g., new faculty members to the geographical region or narrow instructor expertise), or time. Furthermore, instructor-sourced projects place the instructor in the role of a project 'champion' that raises concerns about a conflict of interest. Finally, narrow industry contacts can create a situation where multiple teams place a high load on the company. Multiple teams can be at risk in the event of sponsor withdrawal.

(2) Common Problems with Team Selections Process

Allowing students to select their own team does not serve well Senior Technology Capstone course. Students tend to select partners they know and have worked well with in prior courses. That can create limitations to team's performance as some skills are over and underrepresented, decisions are made based on collegiality. Students may also be drawn to projects with well-known regional employers. Random team selection by instructor can work as long as skills represented are distributed fairly.

(3) Common Problems with Team Member Evaluations

Student ownership and balanced, fair team member load and efforts are key to meeting student learning objectives and project outcomes. The time wasted on underperforming or unengaged team members quickly consumes the team's resources resulting in poor project performance. The structure of the course requires participation of a team. Removal from a team results in failure in the course. The last 5 years of teaching this course (Snell) provided evidence that can be summarized the following three types of team member behavior.

> *Type 1*, the high-performing team member. Achievement driven, desiring only the best grade possible 'an A'. This student type will, if necessary, do all of the work necessary to bring the project completion.
>
> *Type 2*, the passing-grade team member. Effort beyond passing grade is not exerted. This student may reduce effort at the project beginning or end, sometimes to the point of non-participation, while maintaining an appearance of effort. The sum of their individual efforts merits a 'B', 'C' or 'D', i.e., a passing grade.
>
> *Type 3*, the non-performing team member, i.e., 'coat-tailer'. The coat-tailer tests the boundaries of team tolerance to little or no participation. Coat-tailer will show up to team meetings. However, his/her participation and workload is minimal, effort on project tasks are poor, and there is no effort committed to team success.

The perception of many students is that teams are rarely failed. Furthermore, individual's grade adjustment/weightings are rarely severe enough to cause course failure. Students also know team members are unwilling or unable to critically evaluate them or ask for removal. The instructor without powerful data is also reluctant to remove team members from the course. Often, the instructor only knowledge of Type 3 member performance is at the project's end, through a team member survey. A team with a Type 3 team member will suffer in completing a high quality project as team members' waste significant time discussing Type 3 team member.

Finally, without an ongoing evaluation method, team member voice and awareness of achievement or under performance team does not exist, i.e., change is deemed necessary. The instructor is also unaware of team dynamics, preventing the accurate timing to provide team or individual instruction and guidance. In the event of a team member removal, waiting for the peer students to request teammate removal is unacceptable method as students consider this as a negative behavior.

(4) Common Problems with Written and Oral Communication

Overcoming written and oral communication deficiencies can be a real challenge especially if it is not integrated well in the curricula. Students are not challenged to communicate technology problems well. Their preparedness from freshmen level English does not prepare students for the type of communication needed for technology problems, i.e., short, concise, logical, easy to understand, focused on solving a problem. Communication is an integral part of the course that involves communication with the client, faculty mentor and instructors, written course deliverables such as inter-team development activities, project constraint and criteria development, midterm paper, poster, and final paper.

(5) Common Problems with Facilities and Programing

Student feedback indicated need for a dedicated space to be used for team meetings, meetings with client and faculty mentors, and instructors. Feedback to original offering as a 4-credit course (TSM 415, 2 cr.; TSM 416, 2 cr.), from student exit surveys highlighted the significant effort and time required in the second semester that was not aligned with the course credit weighting.

(6) Common Problems with Faculty Mentors

Faculty mentors play key role in maintaining high value and rigor to Technology Capstone courses. Faculty mentoring of Capstone team was not accounted as impact on Annual Reports. Mentoring TSM 415/416 teams is a commitment that not every faculty can make. Faculty participation in Capstone presentations occurring at the end of semester was also not coordinated well with other departmental functions and schedules.

Results and Discussion

Specific examples of measures used to strengthen the Senior Capstone experience are summarized. All these are the result of continuous improvement that was based on student feedback on learning outcomes, instructors' evaluations, instructor and mentor faculty input, EAC feedback, and exit/post exit formal and informal interviews. The Senior Capstone courses are results of multiple years of experience and multi-instructors effort. Several measures were implemented in the Senior Capstone course sequence to strengthen student experience and achievement of course outcomes. Specific main measures are as follows:

(1) Strengthening project identification – student find project through internship
(2) Strengthening team selection process
(3) Strengthening team member evaluations
(4) Strengthening written and oral communication
(5) Facilities improvement and programming changes
(6) Strengthening the role of faculty mentors.

(1) Strengthening Project Identification

To address weaknesses associated with student-identified and instructor-sourced projects the following project identification process was put in place:

1a. Project identification: defining the project requirements, IP issues, budget

Strengthening Senior Capstone project required defining what constitutes a great team project for technology students. The bachelor technology degree curriculum is bounded between vocational-technical degree and engineering degrees in the application of fundamental mathematics and science. Projects expecting technology students to perform fundamental research puts teams at risk for failure and client disappointment. Similarly, a project not requiring any problem solving, creativity, mathematics, fundamental science and technology is more representative of a lesser technical degree or high school student teams failing to demonstrate adequate skill. Thus, the following are the goals for senior capstone project technology student:

(1) The project must be a 'real-world' technology problem that needs student skills and a technology solution.
(2) It must have a 'client' who will define the project need, and help the team to set realistic project goals (final outcome the solution is intended to solve), acceptance variables (measures the success measures of the solution), and constraints (boundaries the team work within).
(3) Each project must have an ABE faculty consultant, i.e., 'faculty mentor', during second semester, who agrees to meet regularly (weekly) with team members, clients, and TSM 415/416 instructors. The mentor assists the team in identifying and demonstrating up-to-date technology concepts and methods leading to innovative problem solutions.
(4) Project must involve application of math, science, and technology concepts from ABE AST and ITech curriculum; analysis of existing or collected data that will support data-driven solutions; development of several solution options; and delivery (by oral presentations and written reports) of the best solution to the client.
(5) Projects need not involve building of prototypes. Thorough plans and specifications for building a project solution may be a required as deliverable, actual construction is often quite expensive, time consuming, and beyond the scope and capabilities of some university facilities. If the project client desires a built solution, then the project definition should include plans and a budget for sponsored funding of prototype construction. Modeling a simulated solution provides verification of a student team's solution with simple materials (e.g., 3D printing) has proven beneficial to both the team and client.

All projects are non-confidential. Confidentiality agreements can become legal contests and delay the project starts. Furthermore, legal negotiations consume valuable faculty and university resources, and restrict open learning between team projects required during class or lab activities. In the event a student team develops patentable material, the instructors move the project into a confidential state. This most likely occur during the second semester. In the event an intellectual property solution is developed, the company retains the intellectual property. Students sign a release to intellectual financial rights, but retain the rights as inventors. There are no upfront charges. Some clients are willing to provide necessary funds for student travel and project expenses. In addition, ABE has introduced $600 per team budget to be used for project expenses. Funds come from differential tuition

surcharges for technology students. Potential pitfalls to this course management style are as follows: (a) loss of client support, (b) team fired by client, (c) legal liability discoveries, and (d) patentable discovery, moving to confidential status.

1b. Project identification: Role of internships and steps improving student learning experience

Success of the project identification begins in the ABE's requirement for technology degree program students to complete an Internship in Technology (TSM 397) course after the fifth or sixth semester. The internship/co-op has proven to be an invaluable source of Senior Capstone projects, eliminating the student made-up projects or relying on the instructor–sourced projects. The foundation to this success is this existing working relationship, i.e., the project 'champion' is an industrial client/company and student with an existing relationship. Student awareness of the forthcoming Senior Capstone project requirement may discuss such opportunities with their internship company prior to the start of the TSM 415 course. Projects developed from internships ensures that at least one team member has strong ownership and understanding of company structure and culture.

Student project 'problem' identification is an important learned skill. A technology student's undergraduate degree program mostly includes 'canned' problem-solving. The problem statement and facts are given, and the student solves to a required (correct) answer. Therefore, problem solving typically equates to equation manipulation based on fundamental theorems. Finding project for a technology team is challenging this practice. The following specific steps were developed and implemented to help students with identification and selection of capstone projects.

1bi. Industry Contact and Communication

Students build on their industry contacts and are required to identify a minimum of three potential industry contacts for which they intend to contact when the TSM415 starts. Students are provided with three documents to assist potential project clients review course, department, and university expectations and to standardize communication to clients. Over the years words were removed to further assist potential clients in understand the student's project needs. The 'design' was removed, as problem solving and the implementation of technology may not require the design, but merely the analysis of the problem, and evaluation of potential pre-existing solutions. The following is a list of the basic requirements for a Senior Capstone project. No official documents are signed prior to project selection. The three documents are as follows:

a. Introductory Letter to Potential Project Sponsors – Defining a Project (see Appendix)
b. Sponsor Acknowledgement Form (see Appendix)
c. Special Intellectual Property Agreement Form (see Appendix)

Development of three per student projects concepts with their industrial clients occurs early in TSM 415 semester. This format enables students to further develop communication skills, and 'buy-in' into proposed projects. During the initial six week project identification period, students provide weekly updates of project search activities until one final project concept proposal is submitted. This format enables technology students to learn and practice communication and networking, student ownership of project concepts, and forces self-evaluation of their skills and competencies. This process forces students to formulate skills and competencies needed in the team in order to solve a problem. Instructors intervene and provide support for some students (typically10 to 25% of class) unable to identify an industry partner. No student can submit a project that is a family sponsor. This is due to the fact the industry sponsor will be providing a 25 to 33% input of final project grade in TSM 416 (see Appendix for example of client feedback form).

For example, in Fall 2014, approximately 234 potential clients were identified, 78 final projects were submitted, 58 were posted to the student 'fair' (see section below), and 19 project teams were formed.

1bii. Project Concept Submission

The TSM 415 course requires each students to define and submit one final project problem statement with identified industry clients, defined skill and vetted projects for high alignment with core curriculum skills, skills required, and project outcomes. Instructors developed and implemented template for project concept (see Appendix). The template forces students to respond to standardized questions and help them to communicate clearly about the business case (problem to be solved), project goals, project outline,

opportunities and project scope. Template was built around the 'what', 'why', 'how' – type of questions. The same template is also the basis of the follow up deliverables in the course, i.e., progress and final reports.

(2) Strengthening Team Selections Process

Students submit one final Capstone Project proposal. All project proposals are then opened up for peer-review and signups based on self-identified skills and expertise. Each student records his/her preference on top 3 ranked projects of choice. Client names are not disclosed at this stage to minimize bias towards well-known regional employers. Instructors select best developed projects with high probability of success based on project proposals, the match the student's ranking and coalescing sets of skills self-identified by students. Resulting teams are not self-selected. Each project team consists of 3 (minimum) to 4 (optimal) students.

2a. Skill Match

Vetting submitted projects for high core and technical skills needed in potential team members is a responsibility of instructors. Students engage in a class activity resembling a 'fair', where their projects are posted and they solicit team members. Students use affinity diagrams and brainstorming tools to reduce large project pool to required number of approximately top 25% final projects. For example, in the Fall of 2014, the total of 19 capstone projects were selected from 18 different companies. These companies represent a healthy mix of global, regional and farm-based enterprises.

2b. Student Skills Alignment

Course instructors verify the validity of project with future clients. Students submit a personal skills evaluation with project skill required. Students who submitted final project concept are automatically a team member (and project 'champion'). Capstone projects with a student champion, i.e., co-op/internship experience, allows rapid project ramp-up.

(3) Strengthening Team Member Evaluations

A system peer-review and team member evaluation system was established to (a) generate data that empowers the instructor to exercise removal from the team/course option, (b) give students feedback on their own performance, and (c) practice industrial setting performance evaluations. The formal checks-and-balances minimizes the impact of negative learned behavior on team's performance and morale.

(3a) Team-Defined Team Member Evaluations

Team member develops personal criteria for '*Meets Expectation*' performance. In addition, teams then define their own standard of '*Meets Expectation*' that is recorded and can be used as a reference. Team member evaluations are developed by teams (see Appendix for examples) as part of their class activity. Team members define expectations by responding to the following question in the following criteria:

Are my team members meeting my expectation for the project?

Expectations criteria:

(1) Quality and quantity of work
(2) Meeting attendance, preparation, and participation
(3) Meeting team task deadlines
(4) Collaboration, and
(5) Effort.

(3b) Course Management using Team Member Evaluations

The key element to course management are team member evaluations. Annual performance reviews result in advancement, continued employment, and probation and/or termination in industry. Instructors attempt to emulate this model in Capstone course. Weekly administered assignment captures team member evaluations as '*Below-*', '*Meets-*', or '*Exceeds Expectations*'. Team member evaluations are based on a single student perspective. Timely submission of team member evaluations are student's responsibility and commitment to course, instructors, and

the team. The instructors frequently recommend that students review their team member evaluation scores and modify performance, and if necessary, contact the instructors for support.

Student response are awarded 6 points for '*Below-*', 8 points for '*Meets-*', or 10 points for '*Exceeds Expectations*' for each of the five expectations criteria. A maximum and minimum score per evaluation is 50 and 30 points respectively. It is expected that most of the time team members will '*Meets Expectations*', except in extraordinary instances will students be '*Below-*' or '*Exceeds Expectations*'. Students not submitting a weekly evaluation automatically receive a score of 30 points and are removed from the team average calculations. Individual team member scores and a team average is then calculated. Individual scores are adjusted based on normalizing to team scores. Team averages are normalized to the class average and the student's score is adjusted by this value. This prevents teams from giving everyone '*Exceeds Expectations*'.

The compiled results, i.e., 3-week moving average and 3-week mean value promotes: (1) high student engagement throughout the semester; (2) validation of student effort for Type 1 and Type 2 students; (3) self-correction of Type 3 student performance; (4) early intervention opportunity for the instructor; and (5) final grade performance adjustments. It has been the practice in Senior Technology Capstone course to use3-week moving average and the threshold of 108 points as an action trigger. The threshold of 108 points represents 'D-' grade level performance based on the last 3 years of student scores in this course. Students falling below 108 point threshold can be either (1) asked to develop and complete self-correcting contract, or ultimately, if that step did not work be (2) removed from the course.

Table 1 summarizes the 3-week moving average scores for individuals ranked from highest (top) to lowest (bottom) The 3-week average (far right column) is used to weight students final project grade. Several cases of Type 1, 2 and 3 students are evidenced in Table 1. Also, evidence of correction from non-performing (Type 3) to high-performing (Type 1) as well as calculated change of performance from Type 1 to Type 3 towards the end of the semester is highlighted in Table 1. Instructors are empowered with team performance data to intervene and (if needed) remove student from the course (bottom row in Table 1).

(4) Strengthening Written and Oral Communication

Several measures were implemented to strengthen the course. Poster and oral presentations are prepared, rehearsed, and presented on a designated Capstone Day that is one of the key dates for the whole ABE during a semester. Faculty and client participation is highly encouraged as it projects professional expectations to teams. Final course exams are team-based and often involve revising and finalizing course deliverables. Teams that have developed timelines for key deliverables and adhere to them do well on final exams. Teams which take advantage of writing help (e.g., both ISU-based tutoring available to undergraduate students and specialized software enhancing writing also do well on final exams.

Students are encouraged to develop graphical abstracting skills and visual aids that are integral part of project poster, final project presentation and final project report. Besides graded assignments, several additional feedback opportunities were introduced. These include peer-evaluation of 'elevator' speeches and poster drafts in TSM 415, peer-review of mid-point progress report, and peer evaluations of practice oral presentations (the latter offered on voluntary basis). Templates for reporting and examples of outstanding deliverables from prior years are readily available to teams.

(5) Facilities Improvement and Programing Changes

Student feedback resulted in development of four dedicated Senior Capstone teaming rooms used by both Technology and Engineering programs at ABE. Teaming rooms are used for required team defined weekly (TSM415) or bi-weekly (TSM416) meetings. These team meeting are established to support meetings with client and faculty mentors, and instructors. Each room provides large screen television, video communication camera, and computer hookups. Students are encouraged to use cloud computing-type storage of files that are shared with team, faculty mentor, client, and, if needed with course instructors.

Programing changes were made to validate students' course experience and feedback. These required redefining course credits to match the students' effort and the departmental expectation. The change resulted in the current 6-credit course (TSM415, 1 cr.; TSM416, 5 cr.).

Table 1. The 3-week moving average scores for individuals ranked from highest to lowest. The 3-week average (far right column) is used to weight students' final project grade.

Team/Member	1-3	2-4	3-5	4-6	5-7	6-8	7-9	8-10	9-11	10-12	11-13	12-14	3-Wk Average
T5 m2	123.18	119.39	123.01	123.43	125.18	123.38	123.01	122.73	124.61	123.40	122.81	120.38	124.34
		123.72	125.34	122.76	122.35	121.38	122.67	123.89	124.30	123.90	122.98	124.71	123.49
		120.05	121.01	121.43	121.68	123.04	122.50	123.05	122.63	123.74	123.65	123.71	122.24
		120.72	122.18	122.09	122.02	121.21	121.50	121.72	123.13	123.07	124.15	123.21	122.17
T1 m4	121.02	119.72	120.68	120.59	122.85	122.71	123.84	122.72	124.30	123.40	122.81	120.38	122.08
T18 m2	128.68	125.05	113.55	111.30	111.73	122.21	123.17	125.88	126.96	126.74	124.15	123.21	121.89
T15 m3	123.02	124.55	124.18	121.59	119.52	120.21	121.34	121.72	122.30	121.07	120.81	119.71	121.67
T2 m2	120.35	119.72	120.68	119.93	121.52	123.37	122.50	122.05	120.96	122.74	122.81	123.04	121.64
T13 m2	121.02	120.39	120.68	119.43	119.52	119.04	120.67	121.39	123.80	124.40	124.31	122.88	121.46
T10 m3	122.85	123.05	123.34	121.59	121.18	120.88	121.17	122.55	124.96	126.90	115.13	113.86	121.46
T12 m3	121.02	121.39	122.84	122.76	121.68	120.88	121.01	121.06	121.80	121.24	121.15	120.54	121.45
T7 m2	107.77	107.80	110.09	121.59	122.85	123.55	123.84	125.56	127.13	128.40	128.65	128.71	121.33
T10 m1	120.18	121.05	122.68	121.59	120.52	120.21	121.17	121.22	122.96	122.90	121.65	119.71	121.32
T8 m4	121.35	121.22	121.51	121.26	121.18	121.54	121.01	121.22	121.96	121.90	121.48	119.71	121.28
T3 m1	119.85	118.72	120.34							123.90	122.98	125.71	121.11
T6 m1	119.68	119.05	121.34							121.74	120.98	120.38	120.92
T18 m4	113.42	124.39	125.01							120.40	121.48	119.88	120.87
T6 m4	121.02	121.72	122.01							123.74	122.98	121.04	120.81
T2 m1	120.35	120.39	121.34							118.74	117.48	116.38	120.64
T12 m4	121.02	119.39	120.84	119.43	120.35	119.55	121.01	121.06	121.80	121.24	121.15	120.54	120.61
T19 m4	120.02	119.39	120.51	120.09	120.52	120.21	120.68	120.72	121.70	121.47	121.21	120.48	120.58
T3 m3	120.52	120.05	121.01	120.76	122.18	122.38	121.68	119.56	119.96	120.57	120.98	117.04	120.56
T17 m2	121.18	121.39	120.18	117.26	116.68	117.71	120.84	121.05	122.96	122.74	122.31	121.88	120.51
T17 m4	122.18	122.05	123.51	124.59	124.68	124.04	123.17	124.05	123.63	112.50	110.74	110.97	120.51
T19 m1	120.02	119.39	120.51	120.09	120.52	120.21	120.68	120.72	121.20	120.97	120.71	120.98	120.50
T19 m3	120.02	119.39	120.51	120.09	120.52	120.21	120.68	120.72	121.20	120.97	120.71	120.98	120.50
T19 m5	120.02	119.39	120.51	120.09	120.52	120.21	120.68	120.72	121.20	120.97	120.71	120.98	120.50
T8 m3	120.02	119.22	121.18	120.26	120.85	120.21	121.01	121.22	121.30	120.57	120.15	119.04	120.42
T9 m3	122.85	111.42	115.21	112.79	123.35	118.87	120.17	120.88	125.13	126.24	125.65	122.21	120.40
T1 m2	121.02	120.05	119.84	118.43	119.68	119.21	120.18	119.72	120.46	120.40	122.81	122.54	120.36
T12 m2	120.02	118.39	119.84	120.76	121.68	120.88	119.68	119.72	120.46	121.24	121.15	120.54	120.36
T4 m1	120.02	119.39	120.51	120.09	120.35	119.88	120.34	120.55	121.30	121.07	120.65	120.21	120.36
T4 m4	120.02	119.39	120.51	120.09	120.35	119.88	120.34	120.55	121.30	121.07	120.65	120.21	120.36
T3 m2	108.58	119.39	121.01	122.09	122.18	121.71	123.68	122.89	123.30	120.57	119.65	119.04	120.34
T11 m1	109.10	108.30	110.59	123.43	123.02	122.04	120.67	123.89	125.63	125.90	125.65	123.38	120.13
T15 m4	122.35	123.89	123.51	123.59	122.52	119.21	118.34	117.72	121.30	122.07	111.63	114.53	120.06
T1 m4	118.35	119.39	119.51	119.76	120.35	121.21	121.51	121.65	119.89	119.74	118.81	119.21	119.89
		118.72	119.68	120.09	120.35	117.71	117.84	118.38	121.30	121.07	120.31	120.38	119.63
		119.39	119.68	120.09	119.85	120.38	119.68	120.06	119.96	119.07	119.15	118.54	119.56
		117.72	117.34	117.59	119.68	120.55	121.84	121.22	120.30	117.74	117.65	119.04	119.20
T8 m1	118.68	117.89	117.18	117.59	118.18	118.21	119.68	119.22	120.63	119.90	120.15	119.04	118.86
T16 m4	121.02	120.89	111.89	110.47	110.23	120.05	120.51	120.72	121.30	121.07	123.31	124.71	118.85
T13 m4	122.35	111.75	112.71	109.46	119.52	119.71	122.01	123.39	123.13	120.40	119.65	120.21	118.69
T15 m1	122.35	123.89	123.51	121.59	119.52	121.21	122.34	122.72	120.30	109.83	109.58	106.47	118.61
T11 m4	119.18	117.72	118.01	116.76	117.68	118.71	120.01	118.55	118.96	117.90	118.98	118.04	118.38
T14 m2	120.35	120.05	121.01	120.76	121.02	110.89	111.02	110.90	120.63	120.40	120.98	121.71	118.31
T3 m4	109.92	119.39	119.68							119.24	119.65	119.71	118.12
T4 m2	120.02	119.39	110.59							121.07	120.65	120.21	117.83
T7 m3	122.18	121.55	122.51							117.74	114.65	112.04	117.82
T19 m2	109.60	108.97	110.09							120.97	120.71	118.48	117.69
T2 m3	118.35	117.72	119.34							119.40	120.15	121.71	117.53
T16 m1	119.68	118.22	117.34	107.26	109.02	110.71	121.18	120.72	121.30	121.07	121.31	120.04	117.32
T11 m3	117.52	117.39	117.68	117.43	119.02	118.71	119.34	116.56	116.30	116.57	115.65	115.38	117.29
T12 m1	107.60	107.97	108.09	117.43	118.35	119.55	121.01	121.06	121.13	120.57	119.81	119.88	116.87
T14 m4	119.68	118.72	110.22	107.97	108.89	119.37	121.50	120.72	120.63	119.07	118.31	115.71	116.73
T5 m4	118.85	109.42	109.71	109.46	119.85	120.38	120.34	120.06	119.96	118.40	117.15	116.54	116.68
T9 m2	115.52	117.55	117.68	116.26	116.02	116.54	116.17	116.88	113.80	116.90	116.31	119.54	116.60
T18 m3	117.68	116.39	107.55	108.64	109.73	119.55	120.51	119.22	119.63	118.74	119.48	119.21	116.36
T9 m1	110.43	108.47	99.47	111.80	112.89	123.87	122.84	122.22	123.13	120.90	120.31	118.88	116.27
T7 m1	118.85	108.25	98.42	101.50	114.06	123.88	122.84	119.89	121.13	119.74	122.65	122.04	116.10
T6 m3	119.68	119.05	121.34	110.93	112.35	101.39	112.02	110.74	120.96	121.07	121.65	121.04	116.02
T13 m3	119.02	108.42	110.04	111.46	122.85	121.71	120.67	120.72	111.74	111.68	111.59	122.21	116.01
T8 m2	120.02	119.22	111.05	110.14	110.73	120.88	110.54	110.76	110.83	121.90	121.48	123.71	115.94
T4 m3	120.02	109.42	100.42	100.00	110.89	121.21	121.68	121.22	121.30	121.07	121.31	120.88	115.78
T10 m2	119.52	119.05	110.22	109.80	110.06	119.21	120.17	119.55	120.96	120.24	110.47	109.86	115.76
T9 m4	120.85	108.75	108.21	98.46	109.68	111.55	123.51	122.89	123.13	120.24	120.98	120.88	115.76
T13 m1	117.68	117.05	118.68	110.09	110.18	110.38	119.34	117.39	116.13	117.40	117.31	116.21	115.65
T16 m2	109.08	119.55	121.68	121.59	121.35	110.23	110.69	100.46	110.86	110.63	121.31	120.71	114.85
T16 m3	119.68	118.89	121.01	110.93	111.35	110.05	120.51	110.28	110.86	110.63	117.31	116.04	114.80
T1 m3	108.27	107.97	99.97	109.97	109.89	119.21	119.51	120.39	121.80	121.07	117.48	116.54	114.34
T10 m4	106.92	114.39	115.68	117.26	120.18	110.73	110.36	109.74	116.30	114.24	115.65	117.71	114.09
T17 m3	117.52	116.72	118.18	108.59	110.02	100.23	110.02	108.24	118.30	118.40	120.65	120.88	113.98
T7 m4	110.43	109.14	110.09	118.93	118.85	108.73	109.69	109.40	117.80	118.40	117.31	118.71	113.96
		109.42	109.71	107.46	117.18	117.71	119.68	120.06	110.24	108.01	108.09	111.21	113.74
		117.39	120.18	109.93	110.68	109.04	118.84	109.28	109.86	109.97	119.31	117.54	113.38
		111.72	115.68	116.76	107.12	108.15	108.45	108.45	108.19	107.97	118.15	119.21	111.63
		105.22	70.72 Removed from Course										92.56

Type 1 students

Type 2 students

Type 3 students

Evidence of correction from Type 3 to Type 1 team member

Evidence of performance change from Type 1 to Type 3 team member

(6) Strengthening the Role of Faculty Mentors

Several measures were implemented to improve faculty participation. Faculty mentoring of Capstone team is accounted as one of the criteria on Annual Report. TSM 415/416 instructors recognize value of faculty time. Thus, every attempt is made to advertise selected projects and teams at the end of the first semester, seek faculty participation and feedback during Poster presentations, and involve many faculty member as mentors in the second semester, effectively sharing the mentoring load to one-faculty-one team. Selection of faculty mentors is on voluntary basis. Faculty mentors participate in weekly meetings with teams, often setting their own expectations that are more stringent than the course. Faculty mentor feedback counts as part of the grade similarly to the feedback from client (see Appendix for an example of Faculty Mentor Feedback form).

Acknowledgements

The authors would like to thank industry clients for their continued support in providing project opportunities. Special thanks go to previous ABE TSM 415/416 Senior Technology Capstone course instructors Dr. Charles Schwab, Dr. Carl Bern, and Dr. Tae Huyn Kim for their valuable contributions to develop end strengthen this course as well as many ABE faculty and instructors who have mentored teams.

Conclusions

Several major improvements were made to strengthen the Technology Capstone I/II courses to prepare students for workplace application of learned practices. Instructors aimed at creating a strong and rigorous learning experience in the final year of ABE Technology degree programs. Past experiences with Technology Capstone course weaknesses were addressed. Major improvements were made that focused on the following areas:

(1) Strengthening project identification. Students build on their industry contacts and are required to identify a minimum of three potential industry contacts for which they intend to contact when the semester starts.
(2) Strengthening team selection process. Focused on self-identified skills, skills match and skills alignment
(3) Strengthening team member evaluations. Weekly administered assignment captures team member evaluations as '*Below-*', *'Meets-*', or '*Exceeds Expectations*'. Scores are totaled on rolling average basis enabling self-correction. Instructors are empowered with team performance data to intervene.
(4) Strengthening written and oral communication. Templates and examples of outstanding deliverables are readily available. Graphical abstracting, use of writing enhancement software is encouraged. Peer feedback is used. Exams are designed to be major part of key course deliverables.
(5) Facilities improvement and programming changes. Dedicated teaming rooms with modern communication technology were created. Credit value was increased to be consistent with student load and departmental expectations.
(6) Strengthening the role of faculty mentors. Participation as faculty mentor is now accounted for as part of the teaching load. Capstone Days are integral part of departmental calendar.

Appendix

Example of Introductory Letter to Potential Project Sponsors

Capstone course adds value!

Employers of TSM graduates continue to emphasize that the employees they value the most are those who have had experiences working in multidisciplinary teams, and in planning and managing technology projects. The goal of TSM 415 and 416 is to provide opportunities for you to gain an initial project experience.

What is a great Capstone Project?

A great project is one that provides your capstone project team with opportunities to:

1. define the potential root cause of the customers what;
2. analyze a multidimensional open-ended agricultural/industrial technology problem;
3. identify alternative solutions;
4. evaluate and "refine" a final solution using student and client defined measurable criteria;
5. present the "best" alternative solution to a business client (orally and in writing);
6. develop the "best" alternative to a usable solution; and
7. defend WHY the recommended solution is the best solution.

The following is a brief list of basic requirements for a capstone project.

1. The project must be a real-world technology problem that needs your skills and a technology solution. It MUST have a "client" who will define the project need, and help the team to set realistic project goals (final outcome the solution is intended to solve), acceptance variables (measures the success of the solution), and constraints (boundaries the team work within).
2. Each project must have an ABE faculty consultant "project mentor", during second semester, who agrees to meet regularly with team members, clients, and TSM 415 instructors. The mentor assists the team in identifying and demonstrating up-to-date technology concepts and methods leading to innovative problem solutions.
3. Project must involve application of: math, science, and technology concepts from your TSM curriculum; analysis of existing or collected data that will support data-driven solutions; development of several solution options; and delivery (by oral presentations and written reports) of the best solution to the client.

Get started NOW with your project!

TSM students have identified that getting an early start on their capstone projects is beneficial. Therefore, in approximately 4 weeks every TSM 415 student must develop and submit and industry supported, "real" project idea with the support of a potential sponsor. Furthermore, prior years have shown the diversity of project proposals submitted by students greatly exceed the resources of a single professor.

In the past, capstone students have found that the most rewarding capstone projects are identified by getting in touch with current or former internship or summer employment contacts. To assist you in thoroughly defining a potential project, we have attached the 'TSM 415/416 Project Development Form' that identifies important initial information you should gather as you interview and discuss a potential project with an industry partner.

Please note that TSM 415 instructors will **not** accept projects that require non-disclosure or confidentiality agreements. The reason for this policy is that confidential projects prevent open discussion of projects in class and with faculty. If your industry contact inquires about confidentiality, please provide her/him with the attached 'ISU College of Engineering Capstone Design Sponsor Agreement' which outlines Iowa State University's position on student project confidentiality.

Please also note that project need not involve building of prototypes. Thorough plans and specifications for building a project solution may be a required deliverable, actual construction is often quite expensive, time consuming, and beyond the scope of the university facilities. If the project client desires a built solution, then the project definition should include plans and a budget for sponsored funding of prototype construction. Modeling a simulated solution provides verification of a student team's solution with simple materials has proven beneficial to both the team and client.

Example of Introductory Letter to Potential Project Sponsors (continued)

Project timeline, submission, and project selection procedure

From the table below you will see we are on a very tight schedule.

Thursday, Sept. 25	All students must submit: 1. 2014-2015 TSM 415-416 Project Development Form 2. Project Proposal Summary 3. Project Search Activity Report
Friday, Sept. 26	Evaluation of proposals for resources required and alignment with learned core curriculum. Identification of 22 project finalist
Tuesday, Sept. 30	Student personal skills evaluations
Friday, Oct. 3	Tentative project and student alignment
Week, Oct. 6-9	Verification of projects; instructors will conduct conference calls with the potential client and the submitting student to verify the projects potential.
Friday, Oct 10	Instructors will have identified the top project opportunities, and the class will then align their skill with potential projects they wish to work on. The faculty will then assign students to teams based on this evaluation.
Monday, Oct 13	Instructors will email clients and outline of the course timeline, objectives and expectations from student teams.
Friday, Dec 5	Senior Capstone Day, Poster Presentation by team (In our new facility)

Unfortunately, not all projects are selected. This semester two 3-member and eighteen 4-member teams will be developed from 78 project proposals. Please contact the instructors if you which to provide additional information about your project.

For additional information contact instructor(s)

Example of Project Proposal Froms for Clients

PROPOSED PROJECT TITLE:	
CLIENT FIRM & CONTACT INFORMATION:	Firm Name: Address: City: State: ZIP: Project Contact Person: Job Title: Phone #: Email:
PROJECT CONSTRAINTS: *List project "MUSTS," such as maximum implementation cost, minimum performance capacity, etc. that the final project solution MUST meet.*	1. 2. 3. 4. *(add as required)*
DATA: *All project decisions and recommendations MUST be data driven. Please list the types of data that are currently available or that can be collected to support technical decisions and recommendations.*	1. 2. 3. 4. *(add as required)*
DELIVERABLES: *List at least 5 significant technology tasks, products, or outcomes items (e.g. performance testing, prototypes, manufacturing specifications, safety analyses, etc.) that the client wants the project team to deliver. More may be defined as the project proceeds to completion.*	1. 2. 3. 4. *(add as required)*
PROJECT BUDGET: *List estimated costs for items that will be needed to complete the project.*	
Sponsor Review of Capstone Design Agreement Documents **1.** *Special Intellectual Property Agreement Form* **2.** *Sponsor Acknowledgement Form*	____ check here that sponsor has reviewed the ISU Capstone Design Sponsor Agreement. Signatures are not required until project is selected.

Example of Sponsor Acknowledgement Form
Undergraduate Student Project

This Sponsor Acknowledgement Form is required for each project involving external sponsors. It is to be completed after the faculty departmental contact and the Sponsor have defined the essential details of the project.

Department: Agriculture and Biosystems Engineering; Agricultural Systems Technology and Industrial Technology degree programs.

Active Semesters:

Faculty Contact:

To be completed by project sponsor

Project title:

Project description (Brief)

Organization name:

Address

City

State

Zip

Project coordinator:

Title

email

Phone

1. Thank you for your interest in supporting a student project in connection with a course at Iowa State University. These courses are designed to provide our students with real-world experience in their chosen discipline. In return for your support of and participation in this student project, the University will provide you with a copy of the project results, including as appropriate, any data, analysis, hardware and/or software (referred to as student project results) provided you complete and sign this form.

1A. Please understand that this undergraduate course is educational in nature and intended to facilitate student learning and students may make mistakes as a natural, expected, and appropriate aspect of the educational process. Therefore, student project results are provided "AS IS" WITHOUT ANY REPRESENTATION OR WARRANTIES WHATSOEVER, WHETHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT NECESSARILY LIMITED TO ANY WARRANTY AS TO FITNESS FOR PARTICULAR PURPOSES, MERCHANTABILITY OR NON-INFRINGEMENT. All student projects are performed by University students and are not subject to peer review or independent verification of results. You hereby agree to hold harmless the University, the State of Iowa, the Board of Regents of the State of Iowa and their agents, employees, students and volunteers for any and all harm, loss, liability, claims or damages which may arise from your use of the student project results in whatever manner or form.

1B. For purposes of this agreement, there shall be no export controlled information disclosed by any party. Further, it is understood that foreign nationals may be part of the student group working on this project.

Please check the box below:

☐ **I agree.**

2. While it is the University's preference that sponsors make a reasonable effort to avoid the inclusion of confidential information into a student project which takes place in an open and collaborative academic learning environment, it is understood that there may be situations where a Sponsor wants to share information that is to be held in confidence. It is the responsibility of the sponsor to determine if any confidential information will be involved in this project and to sign a separate confidentiality form (Non-Disclosure Agreement) if this is the case.

Example of Sponsor Acknowledgement Form (continued)

Please check the appropriate box below:

☑ I WILL NOT be sharing any confidential information during this project and will not need to sign a confidentiality agreement.

☐ I WILL be sharing confidential information during this project and have signed a separate confidentiality agreement.

3. While the University encourages sponsors to permit student participants to retain their intellectual property rights related to the project, it is understood that there may be situations where the Sponsor wants to obtain ownership rights from participants.

Please check the appropriate box below to indicate how you desire to proceed regarding this issue:

☑ **Sponsor Retains IP** - I desire to obtain ownership rights from the participants and I have signed the Special Intellectual Property Agreement Form that clarifies the ownership of the intellectual property.

☐ **Student/University Retains** IP - Student project results provided shall be used solely for your internal review and analysis. Any and all rights to the student project results, including all intellectual property rights, if any, shall remain the rights of the individual student participants as appropriate under the law regarding rights to and ownership of intellectual property unless there is a separate written agreement addressing the ownership of intellectual property. Prior to any commercial use or subsequent transfer of any student project results, you must obtain the appropriate rights from the respective owners.

4. The student project results are not the work of the University and any references either internally or to third parties shall clearly identify the source of the student project results as an undergraduate student project performed at the University without subsequent independent evaluation.

5. A facsimile or scan of any original signature transmitted by one party to the other party is effective as if the original was sent to the other party.

Please check the box below:

☐ I agree.

I AGREE TO THE ABOVE TERMS AS CHECKED IN THIS DOCUMENT:

Signature: _____ **Date:** _____

Printed Name: _____

Example of Special Intellectual Property Agreement Form

I understand that my rights and responsibilities regarding intellectual property I create as an undergraduate student at Iowa State University include the following:

General Rule. Any intellectual property created by undergraduate students at Iowa State University including copyrights (such as original homework assignments, papers, artwork and theses authored/created by the student) and patent rights (such as, inventions, discoveries, creations and new technologies conceived or first reduced to practice by the student) as a work product of a course (including, laboratory experiments, special and independent study projects) will be owned by the undergraduate student. The University does not claim ownership of such intellectual property, but does have the right to use the intellectual property internally for the educational mission of the University.

Special Situations. Situations may occur in certain courses where students are presented with the opportunity to participate in projects or activities in which the ownership of any resulting intellectual property must be assigned either to the University or to a sponsoring entity (such as a company) as a condition of the student's participation. Students are never obligated to participate in activities that require the assignment of the student's intellectual property to the University or to another entity. In these situations students will always be presented with an option of an alternative activity to participate in that does not require the student to assign their intellectual property to another entity.

Assignment of Rights.

I agree as a condition of my participation in _____TSM415/416 Senior Capstone_____ , in

[Course number]_____, to

[Identification of project/activity requiring assignment of intellectual property]

assign, and do hereby assign, to _____

[Entity name, hereafter referred to as Sponsor]

all intellectual property rights (including, but not limited to, copyright and patent rights) that I may acquire in copyrightable and/or patentable documents, inventions, or discoveries that are created, authored, conceived or first actually reduced to practice by me as a result of my participation in this course. I agree to inform Sponsor of any intellectual property that I may develop and to cooperate with Sponsor, at Sponsor's expense, to obtain a patent and/or register a copyright as the case may be regarding my intellectual property.

Right to Receive Royalties. I understand that if I assign my intellectual property rights to Sponsor, then Sponsor will manage the intellectual property and shall be solely responsible for patenting and commercialization of the intellectual property. Sponsor shall have the sole right and responsibility to determine the extent of United States and foreign patent prosecution, maintenance, enforcement and defense relating to the intellectual property.

I understand that if I assign my intellectual property rights to Sponsor, then I will not receive any financial benefit, licensing or patenting assistance, or other financial compensation from the University for that Intellectual Property. Any financial benefit would have to be agreed to in a separate agreement with Sponsor.

Cooperation with Patenting Process. I agree to make myself available to patent attorneys, to sign all papers, take all rightful oaths, and perform all acts which may be necessary for fulfilling this assignment and for securing and maintaining patents to the intellectual property in any and all countries and for vesting title thereto in Sponsor. The Sponsor understands that, since I am an inventor, I will be included as an inventor in any resulting patent sought by the Sponsor. I understand that my responsibilities to cooperate in the patenting process under this agreement will continue after completion of the course and possibly even after graduation from the University.

This agreement is effective upon latest date of signature. A facsimile or scan of any original signature transmitted by one party to the other party is effective as if the original was sent to the other party.

Sponsor
Signature:_____
Printed Name:_____
Title: _____
Date: _____

Student
Signature:_____
Printed Name: _____
Non-ISU email address:_____
Date:_____

Agreement Acknowledged:
Faculty Instructor
Signature:_____
Printed Name: _____
Date: _____

Example of Client Mentor Evaluation Feedback Form

Team Communication: (during the period January - May, 2014) How satisfied were you with the frequency, clarity, and professionalism of the project team's communication with you or others in your firm? Did the team appear to be organized and prepared when it met with you?
Professionalism: Does the final project report meet your expectations for a technical project completion report? Does it look professional? Is it well organized with a table of contents and section headings that help you find the information you need quickly? Are mathematical models clearly explained and documented? Are the grammar and spelling acceptable?
Task Summary: Are the tasks that the project team completed adequately described? Is it clear what they did and how they did it? Are the tasks completed aligned with the original contract and/or written/oral adjustment of project scope expectations?
Recommendations: Are the team's final recommendations clear? Are they believable….are they adequately backed up with data, calculations, and clear logic?
Deliverables: Are all project deliverables that were developed and submitted at the beginning of the project accounted for? Were all items that were committed to actually delivered? If so, is it clear where these items are located and when/how they will be delivered? If certain deliverables were not supplied, is an adequate explanation given?
Implementation: Did the team provide useful information (parts lists, drawings, vendor contact info, etc.) and suggestions for implementing their recommendations?
Graphics: Were supporting graphics high quality, useful, and adequately explained in the text?

Project Concept Template (to be submitted in early TSM 415 course) one per student.

(Your Name, major, ISU e-mail, phone)

(Date)

Project Concept Template: Project Name

Instructions: use this template to complete a 2-page summary document of your proposed project. Respond to the questions using short, informative sentences. Instructions in Italics should be deleted for the final, submitted version to save space and limit response to 2 pages. Respond to all questions listed below as uppercase letters, e.g., A, B, C, etc…

Business Case (*respond to A, B, C, D and E*)

The business case statement describes the "why" of undertaking the improvement initiative. The problem statement should address the following questions:

A. **What** *is wrong or not working? (or)* **What** *is the need?* (or) **What** *needs to be solved*?
B. **How** *extensive is the problem?*
C. **When** *and where do the problems occur?*
D. **Why** *does it make strategic sense to address this problem? (or)* **Why** *is this problem an opportunity?*
E. **Who** *cares about the problem? (or)* **Why** *should anyone (e.g., your potential project partners) care about this opportunity?*

Goal Statement (*respond to A, B, and C*)

The goal statement defines the objective of the project, and is S.M.A.R.T.

- ***S****pecific (in addressing the Business Case)*
- ***M****easurable (or modeled)*
- ***A****ttainable (considering constrains)*
- ***R****elevant (to technology-oriented curriculum)*
- ***T****ime-bound (for the Fall and Spring semester commitment)*

This is your vision of the future outcome(s) if things go according to plan.

A. **What** is the improvement the team will be seeking to accomplish?
B. **How** will the improvement success be measured?
C. **What** (respond to at least one of the questions below)
o specific parameters will be measured or modeled?
o tangible results deliverables (e.g., reduce cost, cycle time, minimize risk, reduce environmental impact, improve performance, preventing injury, saving lives, creating jobs, etc.)?
o intangible deliverables/results? (e.g., improving the quality of life, improving public relations, improving company image, improving ABE image, etc.)
o will be possible when the project outcome is implemented?

Project Plan/Outline *(Respond to A, B, C, D, and E)*

*The project plan describes the high level tasks, skills, resources, and time that will be required to complete the project. Transforming the "**What** is wrong?" and the Objective listed in the **Goal Statement** into a logical sequence of steps that will be required to complete the project. Use bullet/short sentence format and write a project outline below. Follow the key parts of the Plan and address questions such as examples below. Address at least one question in each **4 bolded** categories in E.*

A. Problem Statement
   - *What is generally known?*
   - *What is not known about the problem?*
   - *What is not known about relevant issues related to the problem?*

B. Objective
   - *What are you going to do about the problem?*

C. Rationale
   - *What will be possible when the problem is solved?*

D. Methodology/Approach
   - **Data collection**:
     - *How will you gather information, facts, and skills to eliminate the root cause?*
   - **Skills**:
     - *What needs to be learned to understand the problem?*
     - *What kinds of skills are needed in the team?*
     - *Which classes, material and competencies will come particularly useful?*
   - **Solutions**: *How will you develop proposed solutions?*
     - *How will you measure/evaluate/model which solution or parts of the proposed solutions are better?*
     - *How will you develop a metric to evaluate which solutions and parts of solutions is better?*
   - **Organization:** *How and how often will you meet/communicate with the project sponsor/industrial client?*
     - *How do you propose to organize work for the team?*
     - *What will be the major milestones for your project?*

E. Results/Deliverables
   - *What will be your deliverables?*
   - *When will they be completed?*
   - *What is the timeline for deliverables?*

Opportunity Statement *(Respond to either A, B, C, D or E)*

The opportunity statement delves into the nature of the problem. Broadly speaking, the Opportunity is a description and analysis of your potential market.

A. Who experiences the pain? Who cares?
B. Severity of the pain?
C. Trends affecting the source of pain?
D. How people are currently addressing the pain (both substitutes and competitors)?
   - Work around(s)
   - Risk avoidance

E. How much people are willing to spend to alleviate the pain?

Project Scope *(Respond to A, B, C, D, and E)*

The project scope defines the boundaries of the business opportunity.

A. **What** are the boundaries, the starting and ending steps of a process, of the initiative?
B. What parts of the business are included?
C. What parts of the business are not included?
D. What, if anything, is outside the team's boundaries?
E. Why something potentially obvious is not included?

Example of project search activity report to be submitted during initial weeks of TSM 415 semester

Project Search Activity Report

TSM415 F2014

Student Name
Submission Date
Revision Number:

Project Contact Number: 1

Project Name (3 words max.):

Status Select Project Status Probability Probability of submitting project

Company Name:	
Contact Name:	
Title:	
Address:	
City:	
State:	
Zip:	
Phone:	
Email:	

- *Instructors will not contact anyone listed in your Project Search Activity Report*

Select Date	**Activity Documentation (email communications, phone call or personal visit summary outline)**
Date	*(For more rows, select this row, then use Table Tools>Layout>Insert Above)*
Date	…
Date	…
Date	…
Date	…
Date	…
Date	*4th Activity Entry Here*
Date	*3rd Activity Entry Here*
Date	*2nd Activity Entry Here*
Date	*Enter first contact notes here.*

Special Notes or Comments:

Examples of team-based, team-developed peer evaluation criteria

Quality/quantity of Work

- Team CNR
  Team members are expected to strive for a quality of work expected of a graduating senior, ensuring to maintain a professional demeanor in both written and verbal communication, including presentations, emails, documentation, and feedback. (Cab Noise Reduction)
- Team ECT
  1. Work load is evenly distributed
  2. Meets individuals skill set to the best of their abilities
  3. Work is related to the project
  4. Work is completed at a professional level
  5. Work is a product that all members can be proud of
- Team SEE
  Team members are expected to do their share of the work while putting forth an honest effort that is of their skill level.

Meeting Attendance, Preparation, and Participation

- Team CNR
  Team members are required to attend all meetings agreed upon by the group, on time and with the expected amount of work completed, unless an emergency arises or prior notice is given; these meetings should be treated with a level of industry professionalism, and members should stay focused and productive.(Cab Noise Reduction)
- Team ECT
  1. Attending all team meeting (unless extenuating circumstances)
  2. Always be prepared for team meetings
  3. Inclusion of all team members in team discussions
  4. Proper notification to team members before absence occurs
  5. Meetings are informative and have plan of action
- Team SEE
  Team members are expected to show up prepared and to contribute their full attention and effort while in team meetings.

Team Task Deadlines

- Team CNR
  All team members are expected to complete their tasks prior to the deadline with enough time to allow for peer review and communicate if a deadline is going to be missed, or if they need assistance with completing the work on time. (Cab Noise Reduction)
- Team ECT
  1. Task are completed on time
  2. Individual members complete work agreed upon by team
  3. As a team set deadlines for the project tasks
  4. Team deadlines are set unless extenuating circumstances
  5. Team deadlines can be changed if the whole team agrees
- Team SEE
  Team members should complete deadlines on schedule, set appropriate deadlines, help team members meet a deadline, and effectively communicate when deadlines are

Collaboration

- Team CNR
  Everyone on the team will work together to ensure the work is split evenly, and within everyone's skill sets, as well as ensuring they assist others, while asking for assistance as required. (Cab Noise Reduction)
- Team ECT
  1. All members are included in conversation and decisions
  2. All thoughts and ideas directly related to the project are shared
  3. All members utilize their developed skills and knowledge on the project
  4. Constant communication on project development is kept
  5. Each member brings outside resources available to the team

- Team SEE
  Team members should always contribute to the conversation as well as listen to, and build upon other team members ideas.

Effort

- Team CNR
  Each person on the team should strive to devote the necessary time and energy required to complete the project to the highest attainable caliber expected from a graduating technologist. (Cab Noise Reduction)
- Team ECT
  1. Each member shows dedication in completing project to the entire team's goal
  2. Team members work collaboratively to complete tasks efficiently
  3. Tasks are completed in a timely matter to the best of the team/individual's ability
  4. Each member presents themselves in a professional matter for the wellbeing of the team
  5. Project obstacles are looked upon as a challenge to improve the team
- Team SEE
  Team members should do each assignment to the best of their ability, help other team members solve problems, and should respond and be a part of team communications.

Example of Faculty Mentor Evaluation Feedback Form

Team Communication & Responsiveness: How satisfied are you with the frequency, clarity, and professionalism of the project team's communication with you ? Did the team keep you advised of project needs, objectives, and progress; and listen to and consider your technical advice?
Project Problem Statement: Does the scope overview problem statement accurately and clearly summarize the project problem and client constraints; and does the team appear to thoroughly understand the problem?
Project's Variables and Constraints: Is the team's identification and description of key project variables and constraints clear and logical, and does their final solution address these variables and constraints?
Academic Application: Does the final solutions proposed by the team reflect application of university level knowledge taught in the TSM curriculum?
Project's Solution: The team's final project recommendations was clearly and logically developed from the client's problem statement, defining a root cause, variables and constraints definition with data, and verified thoroughly after the final solution is completed? Does the team's identify the magnitude of change or improvement?
Project Outcome: Does the project solution represent a viable problem solution?
Written Report: Does the language and grammar of the written report meet your expectations for a pre-professionals technology student team? Is the quality of supporting graphics (charts, tables, sketches, photos) what you would expect for professionals reporting to a business client?