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Agricultural and Biosystems Engineering capstone course evolution at North Dakota State University

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Abstract. The approach to the department's capstone design course has changed considerably since the 1960s. The general evolution of the course has proceeded from extended laboratory exercises to individuals working on self-defined projects to team-based projects. Interactions between the capstone course and other courses have been attempted with varying success. This paper presents the development of the NDSU Agricultural and Biosystems Engineering Department's capstone course and thoughts on possible future modifications to the course.

Keywords. Capstone design, integration, presentation

INTRODUCTION:

Development of the capstone design course evolved from term projects in the senior level farm machinery course. Increasing size and scope of the projects ultimately lead to the development of a separate capstone course sequence within the Agricultural Engineering (later renamed Agricultural and Biosystems Engineering, ABEN) program. The capstone course has evolved over the years incorporating various methodologies and approaches during the approximately 40-years since the capstone sequence became a separate course offering within the department.

The capstone course sequence evolution has gone from predominately individual projects, to large team projects involving a hierarchy of sub-teams, to the current approach involving team projects with generally between 2 to 4 students. Project sources have predominately changed from student proposed projects to solicited projects provided by local industry, government, and university cooperators. The goal of the capstone sequence, from its inception, has been to provide students with meaningful design experiences intended to enhance their academic and professional careers. In addition, the capstone design sequence is part of the required design experiences for departmental accreditation.

Student demographics, accreditation requirements, employer expectations, and student outcomes have provided input and direction to changes in the capstone sequence over the years and will continue to do so. This paper will discuss the development, changes, and future considerations for the ABEN capstone design sequence.

CAPSTONE DESIGN ORIGINS:

Historically, early Agricultural Engineers were "farm mechanics." This filled the needs of agriculture at the time. But later, as the profession diversified into specialty areas, the farm mechanics group became the "Power and Machinery" (PM) specialization.

Starting in the early 1930s, at North Dakota Agricultural College, NDAC; later renamed North Dakota State University (NDSU) the PM specialization was filled with students possessing an extensive mechanical and farm background. Combining the background of these students with the academic program produced students well prepared for industrial positions.

As the PM specialization became more complex due to many advances in mechanization, it was apparent educational development beyond studying textbook engineering principles was needed. The senior level farm machinery course was changed to include field trips to farms, local manufacturers, and equipment dealers.

In addition, a special term project was incorporated into the course. Students selected or were assigned (individually or as teams) a term design project. The objective of the term project was to solve a particular problem using research including textbook principles, working with local company personnel when possible, and standards, journal articles, and

other sources. For example, a current machine or machine component would be studied to learn its historical origins, the progress and design changes made to the present time, and then consider modifications to meet future needs. These changes included increasing capacity, durability, cost, safety, or any aspect as suggested by the cooperator.

The special projects were well received by students and cooperators. This activity did help bridge the transition from typical classroom activities to the first job.

One limitation of the special projects was that the projects were part of an elective course in the PM specialization of the ABEN program. While this course was popular and taken by a significant number of students, it suffered two limitations:

- not all students took the course and
- it was limited to machinery.

Large open-ended term projects had shown their value in the PM specialization as discussed earlier. The desirability of extending this concept to the other specializations of the ABEN major lead to the development of a three quarter capstone design project sequence required of all students majoring in the ABEN program in the 1960s.

INITIAL CAPSTONE DESIGN PROJECT SEQUENCE:

The Accreditation Board for Engineering and Technology (ABET) has defined engineering design as (Anon., 1993):

"...Engineering design is the process of devising a system, component, or process to net desired needs. It is a decision making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The engineering design component of a curriculum must include most of the following features: development of student creativity, use of open-ended problems, development as use of modern design theory and methodology, formulation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, production processes, concurrent engineering deisng, and detailed system descriptions. Further, it is essential to include a variety of realistic constraints, such as economic factors, safety, reliability, aesthetics, ethics, and social impact."

Initially the capstone design project sequence started in the spring quarter of the third academic year with students learning design principles and discussing open-ended projects. Students selected their projects for the course. Most frequently, projects were self-defined by students either from personal interest projects or with cooperators the students had approached individually. The instructor also had a few projects available for students who did not have a project of their own, although this was relatively uncommon. Many projects involved farm based projects or company projects where students had co-op experiences. The majority of the projects were individual projects.

During the fall quarter of their fourth year, students continued developing their projects. Progress reports were required. However, most work was independently done outside a classroom setting as design options were explored and evaluated. If possible, a prototype of the project was constructed and evaluated during the second and third quarters.

During the winter quarter, the projects were completed and project presentations made. The presentations frequently included presenting the project at the annual Agricultural Engineering Show held during mid-February which was near the end of the winter quarter. In addition, an oral presentation of the project and a written report, including calculations and drawings for the project was required.

The general format of the course was used by various instructors from the 1960's into the late 1980's. During the 1980s, the course offering was changed so the sequence started in the fall quarter and was completed during the spring quarter of the student's fourth academic year. One effect of this change was few capstone design projects where shown during the Agricultural Engineering Show, as the show now occurred about 2/3 of the way through the project progress on the prototypes or models was not sufficient for public display.

One author of this paper (Bon) joined the faculty in the fall of 1989. One of the assigned teaching components included the capstone design sequence. The capstone design sequence had five primary objectives (Bon, 1992):

- engage students in a comprehensive design project from design objectives to a model or prototype, if possible;
- expose students to current industry design;
- develop and enhance communication skills;
- provide experience in the iterative nature of design; and
- promote professionalism.

During the 1989-1991 academic years, the capstone design project sequence was conducted primarily using the methods described in the previous sections. Most students worked on individual projects that they had proposed, often through a cooperator.

CHANGING TO TEAM PROJECTS:

The Institute for Business and Industry Development (IBID) contacted the ABEN department looking for potential engineering input for local economic development projects in 1991 (Bon, 1992). Potential projects would be proposed by local industries, student initiated designs, government agencies, and university faculty. Qualifying projects would be eligible for potential grants from the Small Business Institute (SBI). SBI provided some funds for report preparation and presentations (Zetocha , 1990; Haut, 1990). IBID was a source of several potential capstone projects during the years that the economic development project through the 1994 academic year.

One consideration was whether to have several projects each year or one a large project that involved the entire class, such as a focused industry design project. One large project for a single cooperator had the advantages of allowing greater design detail to be explored in areas such as engineering analysis and depth in exploring alternative designs (Coddington, 1989). The small team approach would allow a greater number of projects-allowing more opportunity for students to do a capstone design project in their academic area of interest.

A small team approach was used with the IBID projects and any other project. Teams generally consisted of 2-4 students. The transition to small teams was motivated by the scope of the project being proposed being too large for one individual. In addition, industry was encouraging team projects for students to assist the student in making the transition to their post-graduate careers where most would involve teams (Braham, 1992).

During the 1992-1993 academic year, NDSU transitioned from quarter academic sessions to semester academic sessions. The three course capstone sequence was changed to a two semester sequence with three semester credits and renumbered to the current Design Project I – ABEN 486 and Design Project II – ABEN 487 (1 credit and 2 credits, respectively).

The Accreditation Board for Engineering and Technology (ABET) evaluated the NDSU ABEN program in 1994. After the program had been successfully accredited for another six years, brainstorming sessions were held between Instructors Backer, Bon, and Steele, to consider how the information compiled during the evaluation might be further used to improve the department curriculum, particularly courses taught by them (Bon et al, 1996).

During these years, the capstone instructor (Bon) and other instructors within the department observed that some students had difficulty making the transition to open-ended problems. Often the students were concerned with finding the "right" answer to their design project as was the case in many basic mathematics and engineering science courses. Another concern was that many students wanted to bypass the planning and consideration of alternative solutions and begin working on a solution to the problem (Bon, 1995; Bon et al., 1996)

DEVELOPING INTEGRATED DESIGN:

Integrated design was defined as incorporating design experiences through the undergraduate curriculum to enhance student learning by integrating engineering science and engineering design (Bon et al., 1996). Searching the literature indicated several possible methods for consideration. Shaeiwitz et al. (1994) described a holistic curriculum incorporating open-ended term projects in all courses after the first year. Projects increased in complexity and detail each year and included interdisciplinary elements. Starkey et al. (1994) described the use of a second year design course providing introductory instruction in design principles and term project to prepare students for their later capstone design project. Isgrig (1993) developed a capstone

course incorporating multidisciplinary teams working on a large project. The capstone class defines, organizes, and manages the project but subcontracts portions of the work to other classes within the major. No single method was seen to be dominate.

After examining the literature and brainstorming, the following objectives were developed by Bon et al (1996):

- enhance lower division student awareness of the capstone design course,
- reduce anxiety of students starting a capstone design project,
- allow lower division students to contribute to the success of the capstone design projects and develop a greater ownership in the ABEN program,
- improve student understanding of the design process, and
- help students relate design components used in ABEN classes to the overall design process.

Four courses were initially selected for the integrated project by the three involved instructors. These included the capstone design sequence, ABEN 486 and 486 – Design Project I and Design Project II, the first year introductory course, ABEN 110 – Introduction to Agricultural and Biosystems Engineering, and the second year analysis course using computer based software, ABEN 255 – Computer-Aided Analysis and Design. .

INTEGRATED DESIGN IMPLEMENTATION:

Ideas from Starkey et al. (1994) and Isgrig (1993), as well as ideas developed by the three instructors were selected as the basis to develop the integrated design. The integrated design (Bon et al., 1996) is discussed below.

Plans were made to have the capstone design students, ABEN 486, meet with the students in the first year introductory course, ABEN 110. Before the joint meeting of the two classes, the capstone student teams had selected projects and the teams had developed their project definition statements. Developing the project definition statements was required to provide a knowledge base for the teams to present the projects to the ABEN 110 class.

The class period before the ABEN 486 and ABEN 110 meeting, the ABEN 110 instructor would discuss the principles of design and brainstorming to prepare the students for a brainstorming session. In the first period of the joint class session, the ABEN 486 students would make 3-5 minute presentations of their project objectives and goals. The ABEN 110 instructor would then divide his class into roughly equally sized sections, somewhat based on interest, and pair his class teams with the ABEN 486 teams. The joint teams would meet at various corners of the classroom and nearby conference room. Teams would brainstorm ideas for their project with the ABEN 110 class charged with doing the brainstorming and the ABEN 486 teams charged with answering questions and recording ideas.

The next class period would start with approximately half the class period used for additional brainstorming of any new ideas student may have developed during the time between the classes. For the final half of the class period, all the students in both classes would meet together as a large group and representatives from each ABEN 486 team would summarize the ideas developed with the ABEN 110 students in their group. This provides a method for the ABEN 110 students to hear a description of all the capstone projects being completed that academic year and also hear brainstorming ideas that were developed for each of the capstone projects.

A different role was developed between the ABEN 486 class and the ABEN 255 class. The model was a variation of Isgrig's (1993) concept of subcontracting work from the capstone class to a lower division class. The ABEN 486 teams were offered the opportunity to propose a computer based portion of their project using either spreadsheet analysis or AutoCAD drawings to the ABEN 255 class. If more than one project was proposed to the ABEN 255 class, the class instructor (Steele) would select the project his class would do as a term project. The instructors of the two classes would also work with the team(s) to help develop a proposal deemed acceptable for the ABEN 255 class.

The ABEN 255 students were then divided into teams to do the subcontracted work. The appropriate work would be done and a final report was written by each team. The instructor would evaluate the reports and deliver a copy of the best report, with student names remove, to the ABEN 486 team that had subcontracted the work. Information from the ABEN 255 work was usually then incorporated into the final written report for that capstone project.

In addition, all undergraduate students in the ABEN program were invited to the final oral presentations of the capstone presentations held in the spring semester during the capstone design class' second semester, ABEN 487. Attendance by lower division students ranged from 3 to 15 students per presentation and continues in this range to the present time.

INITIAL STUDENT FEEDBACK:

ABEN 110 course evaluation in 1995 included questions concerning their brainstorming interaction with the ABEN 486 class. The question was, "The brainstorming session with the senior design class stimulated my interest in engineering?" Out of thirty-seven students responding, sixteen students strongly agreed, eighteen students agreed, and three students had no opinion. No students disagreed or strongly disagreed. In response to a general response question on the evaluation form, "What in the course was of particular benefit?", several students mentioned the brainstorming sessions with the capstone students (Bon et al, 1996).

Student evaluations in the 1995 ABEN 255 class (Bon et al. 1996) indicated students felt the subcontracted projects were quite intensive given the time constraints on the work. Several students expressed frustration with the open-ended data that often had ranges

rather than just being told how to do the work. The next year, ABEN 255 students were given a longer time period to do the project (Bon et al., 1996).

Exit interviews with graduating seniors by the department chair indicated all students rated the major favorably or very favorably, with several mentioning the capstone course as beneficial. Open discussions with the capstone class by the instructor (Bon) at the class evaluation pizza party indicated the students generally enjoyed the capstone projects and felt working with other classes was beneficial to those classes although they did not always consider the interaction directly beneficial to their teams.

Students becoming aware of capstone projects and following a project has at times increased student involvement. One student provided the following response, in an assignment at the start of his capstone design experience as why he wanted to work on a particular project as follows:

"The project has intrigued me for the last two year years. I have attended the spring senior design seminars for the last two years. These seminars have been extremely interesting to me in the past. I am excited at the chance to work on this project with my peers. I am sure that if given the chance I will excel in this project because I truly want to work on it."

"I have much to offer to this year's broccoli harvester project. Through my information gathering over the last two years (attending seminars and talking with project personnel) I have learned much about the difficulties of harvesting broccoli. On 13 SEP 1996 I made a special 100 mile trip to see last year's design perform in actual field conditions. Through my actions in the past and in the last week, I know that I possess the information and knowledge needed to significantly contribute to this project...(Soltman, 1996)."

CAPSTONE DESIGN TO THE PRESENT:

ABEN 255 accepted one project from the capstone design class each year for five years. The projects were as follows (Bon et al., 1999):

- economic estimates to compare a mechanical harvester versus manual labor for harvesting broccoli,
- evapotranspiration estimates as part of an irrigation system design,
- a hitch design modification for a broccoli harvester,
- design of an open channel for conveyance of water away from a small watershed, and
- a barn layout drawing.

For the 2000-2001 academic year, the ABEN 255 course offering changed from the fall semester to spring semester. Due to this change, the capstone design course schedule did not work well with ABEN 255 and the interaction was discontinued.

The interaction between ABEN 486 and ABEN 110 continues to the present and is now in its eleventh year. Capstone design student response to the interaction has remained

positive over the years. Some informal comments from capstone design students indicate they enjoyed the interaction when they were in the ABEN 110 class, but considered their capstone participation as paying thire "dues" to continue the interaction. Students response in the ABEN 110 class have been very positive to the senior design interaction. Table 1 shows the results of class evaluations for selected academic years. Only one year of ABEN 110 results are included as the course change instructors at the start of the 2004-2005 academic year. Capstone design students rated the question, "Working with lower division classes was a positive experience." The ABEN 110 students rated the question, "The brainstorming session with the senior design class stimulated interest in engineering."

Table 1. Responses to the interaction questions*

Class	Year	Total Responses	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
487	97-98	13	6%	44%	50%	0%	0%
	98-99	14	21%	50%	22%	0%	7%
	02-03*	12	8%	25%	58%	8%	0%
	04-05**	14	21%	43%	21%	7%	0%
110	04-05***	22	41%	18%	9%	0%	0%

* do not add up to 100% due to rounding to the nearest whole percent

** percentages rounded and one student did not respond to the question.

*** percentages rounded and seven students did not respond to the question.

Other innovations to the capstone design class sequence include the following:

- inviting potential project cooperators to present their projects,
- inviting more outside speakers to the class,
- requiring a team poster session during the Agricultural Engineering Show,
- move the final oral presentation from near final week to March,
- require a second draft of the written report be turned in at the final oral report,
- incorporate peer evaluation into the team grading to promote individual accountability,
- incorporate a cooperator evaluation of the team as part of the grade,
- include student evaluations of their cooperator as part of the course,
- attending the Engineering Futures, and
- include an informal session (pizza party) for off the record course discussion.

Cooperator's presentation of potential projects:

All cooperators who have proposed potential capstone design projects are invited to come to the class and make short presentations about their potential projects to the capstone design class. Potential cooperators also answer student questions concerning their projects and leave contact information if students may wish to ask questions later. Presentations occur during the first two or three weeks of the semester.

After all the presentations of potential projects are completed, the students are assigned to rank their preference of the projects in order and the write an explanation of why the student should be allowed to work on their top three project selections. The instructor considers this information in forming the teams for each year's projects. Teams are typically 2 to 4 students based on the estimated scope of the project presented. After teams are formed the instructor informs the cooperators whose projects have been accepted and whose projects have not been accepted.

Often one project captures the number one interest of far more students than there are positions for the team. Here is where the explanation by the students is used to select the students who will work on the project and which students will be working on a project they ranked second or third. The instructor is the final judge in these decisions.

Cooperators who have provided projects include TerraMarc Industries, Bobcat, Amity Technology, K2S Engineering, NRCS, Crystal Sugar, Trenton-Buford Irrigation District, CNH Global, North Dakota State Parks, North Dakota State University, and others. The use of real-life projects is seen as fulfilling ABET Educational Objective 1 c and 3 l: design a system, component, or process to meet desired needs and apply engineering skills to agricultural systems , biomaterials systems, or environmental systems.

Outside speakers:

Outside speakers have been invited to the fall semester ABEN 486 course since approximately 1997. The purpose has been to provide a better bridge between the academic and "real life" practices found in industry and engineering firms. Each year one speaker from a local manufacturing firm has been invited to explain the product development/design process in their organization. Companies of different sizes have been invited as scheduling allows.

"Communication through engineering drawings" is presented by another industry speaker who spends the majority of his time working with suppliers producing components from drawings. The speaker provides numerous examples where inadequate drawings have caused confusion, rejected component shipments, caused conflicts between suppliers and purchaser, and resulted in monetary losses.

Another speaker is a local industry person/inventor who currently as over fifteen patents. He speaks on the reasons for obtaining a patent, the pros and cons of obtaining a patent and the process and approximate costs in obtaining a patent.

On occasion, either an alumni from the department or a local lawyer has been invited to present a talk on engineering and liability. This talk has not occurered in recent years due to scheduling problems but is seen as a topic that should be re-incorporated into the course.

Obtaining the outside speakers is seen as contributing to ABET objectives 2-f , 2-g, 2-i and 2-j: an understanding of professional and ethical responsibility, an ability to

communicate effectively, a recognition of the need for lifelong learning, and a knowledge of contemporary issues.

Poster presentations:

Poster sessions for the ABEN 487 class were introduced as a requirement in the early 1990s. The first two years the poster sessions were conducted during class periods with faculty and students invited to attend the sessions. Each student team produced a poster presenting the background, objectives, and progress-to-date on their project. Using a poster session provided experience in presentation and discussion of ideas in an informal setting compared to a class room and in communicating with small groups with a changing audience.

After the first two years, the poster presentation was incorporated into the annual Agricultural Engineering Show held in February each year (Figure 1). Changing from class room presentations to the Agricultural Engineering Show provides a larger and more diverse audience for student teams to interact and explain their project and work.

Figure 1. Example of a capstone design team and their poster at the 2005 Agricultural Engineering Show.

Additional benefits include the general public being able to see what students do in Agricultural and Biosystems Engineering and providing more varied communication experiences. The ABEN 487 poster session has evolved into its own Caspstone Design division of the Agricultural Engineering Show and also has a small scholarship for the best team. This is seen as contributing to ABET objective 2-g, an ability to communicate effectively.

Moving the final oral presentation date earlier:

Originally, the final oral presentation of the project was given by the student teams one or two weeks before spring semester final exams. Students were under stress not only from their upcoming capstone design presentation, but also often had other project deadlines in the same time period. In addition, a comment that had frequently been made by students during the pizza party was they would appreciate being pushed to accomplish more work on the project earlier in the sequence. The project presentation was moved to the two week period before spring break during the 2002-2003 academic year.

Advantages to moving the presentation to approximately mid-semester provided more incentive to complete the design earlier in the academic year and, in addition, provided time for feedback on the written report which will be discussed in the next section. However, student feedback indicated that having the presentation before spring break was a little too early. A compromise, in the 2004-2005 academic year, was to have the final presentation and draft written report due at the end of March, after spring break, to provide more time for work on the presentation and report.

Requiring a second draft report at the time of the final presentation:

Some observation by the instructor (Bon) and the departmental committee that evaluates the written capstone reports for outcome assessment were as follow:

- evidence of having been hastily written often appeared to be first drafts,
- were incomplete in details to allow work to be reproduced, and
- did not adequately reflect the effort that students had obviously was obvious done during the project..

The final written report often appeared to be an afterthought or a hoop the students needed to jump through to graduate. Typically, final written reports were turned at or shortly after the final oral presentation. Therefore, no time was available for possible comments by the instructor and for rewriting the report.

Requiring a second draft report and the edited first draft has allowed time for the instructor and cooperator to examine the report and make comments. Capstone design teams are then expected to address the comments and rewrite the report. Ideally, additional levels of editing should occur before turning in the final draft for grading. This effort is also seen as contributing to ABET objective 2-g and 2-j the ability to communicate effectively and knowledge of contemporary issues.

Peer Evaluation:

During the second semester of the capstone design project, all work and reports are team efforts. Typically, students are asked to evaluate each other twice during the semester. The first evaluation is before mid-semester and is primarily used to spot problems on teams and address them. The second evaluation is expected to be turned in before the end of the semester.

Since all work the second semester is team based, the evaluation is used to allocate the team grade to the team members. A team member can either obtain a higher or lower grade than the team grade. Typically, the entire team receives the same grade, although there have been occasional exceptions. Appendix 1 is a copy of the peer evaluation sheet.

Cooperator evaluation:

Cooperators are asked to complete an evaluation form (Appendix 2) near the end of the project. The cooperator is also asked to grade the team. The cooperator's grade is weighed as 20% of the team grade for the ABEN 487 course. Students are provided with a blank copy of the cooperator's evaluation form as they start to work in their teams so they know the basis of evaluation.

Student evaluation of cooperators:

Students are provided the opportunity to comment on their assessment of how well they felt the experience was with their cooperator. This feedback is used to assist in retaining cooperator contacts for possible future projects and improving student design experiences. Appendix 3 is a copy of the form students use to evaluate their cooperator.

Engineering Futures:

Tau Beta Pi is a national engineering honor society. Part of the organization's objectives is to assist engineering students gain the "soft" skills necessary to be successful in the workplace. Sessions are moderated by facilitators who have been in industry for several years. Sessions have included People Skills, Team Chartering, Analytical Problem Solving, and Group Processing (http://www.tbp.org/pages/whatwedo/EF.cfm accessed 9/23/05). Students attend two of the sessions offered during the day. This has been required of ABEN 486 students since 2001. This is seen as contributing to ABET objectives 2-i and 2-j, a recognition of the need for and an ability to engage in lifelong learning and a knowledge of contemporary issues.

Informal session-pizza party:

Starting in 1995, the instructor (Bon) introduced an informal evening session to collect student feedback from the year's capstone projects. Using this format, the students are free to make any comments concerning the instructor, cooperators, and course. Comments are used to evaluate if changes should be made to the next year's schedule and also allows a response to specific topics or procedures that may be of concern to students.

CONSIDERING THE FUTURE:

The first year student and capstone course interaction has continued for approximately 11 years. Students in ABEN 110 have a positive response to the brainstorming interaction

with the capstone design teams. Student exposure to the ABEN 486-ABEN 110 interaction, Agricultural Engineering Show presentations, capstone final oral presentations, and probably the normal student interactions, has reduced increased student awareness of the expectations in the capstone design sequence. While they do not know the full scope of the capstone design course, they are not paralyzed by inertia and unable to get started.

Looking ahead at the future of the ABEN 486/487, several items will need to be assessed in the future. Currently the course is a two semester sequence. However, many students are involved with internship experiences during the academic year which moves them out of course sequence. These cases are dealt with by using independent study credits which has some students complete their capstone design in one semester. Should the capstone sequence be a one semester course? Should both courses be offered each semester? These are questions that the ABEN Department will be addressing in the next several years.

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APPENDIX I

Rater's Name: _____

Team Member: _____

Team Name: _____

Complete a separate peer evaluation form for each member of your team, other than yourself. Turn your evaluations in as instructed.

The purpose of this form is two – fold:

1. to provide the instructor with feedback of how the team is functioning and possible feedback to the team. Comments and specific examples are strongly encouraged and
2. to gather information to make any grade adjustments needed based on exceptional or insufficient contributions by individuals on the team, so you should be sure that your feedback is consistent with your overall assessment of the team member's contributions

	Not Really	At times	Generally	Consistently
Contributed intellectually To achieve the team's Project objectives, both in And out of team meetings	1	2	3	5
Did high quality work	1	2	3	5
Was reliable and completed Tasks on time	1	2	3	5
Contributed to managing Team activities, maintaining good communications and improving the team process	1	2	3	5
Took initiative to solve Problems, including learning New skills or doing research, as needed	1	2	3	5
Worked efficiently with others In the group, including Respecting different skills and Supporting others' efforts	1	2	3	5

Overall, how would you assess this individual's contribution to the group's achievements in this evaluation period? If at least half of your team (other than yourself) agrees that you did exceptional or insufficient/problematic work, your grade might be adjusted upward or downward by as much as 15%. If at least half your team (other than yourself) indicate that you did not participate or contribute in any meaningful way, your grade may be lowered without limit at the instructor's discretion.

_____ Exceptional work – contributed significantly more than his/her fair share; may apply to at most 1 or 2 people in the group

_____ Very good work – did his/her fair share effectively and reliably

_____ Good work – did his/her fair share with only minor problems

_____ Insufficient or problematic work – did not do his/her fair share or did not accomplish key tasks effectively

_____ Completely inadequate work – did not participate or contribute in any meaningful or substantial way to the team's efforts

Please write a sentence or two giving specific examples of strengths and suggestions to justify your assessment of the individual's work and for overall improvement of the team's process.

APPENDIX 1
Cooperator Evaluation Form for ABEN Capstone Design Projects

Instructions:

Please assign a value to each question using the following rating system, 1 - excellent, far exceeded expectations; 2 - very good, above expectations; 3 - average, met expectations; 4 - poor, below expectations.

A space is available for comments. Comments are very useful and appreciated.

Rating:	Item
_____	The team met or attempted to meet with you or your representative on a regular basis to share information on project progress, ask questions, check on details, etc.
_____	The team members were prepared for meetings with you.
_____	A complete project description was developed to your satisfaction
_____	Satisfaction with the design
_____	The team explored alternatives to accomplish the design project.
_____	The team quickly understood and applied new techniques or concepts to the problem
_____	The team used available and appropriate information sources and standards
_____	Written communications were clear and effective
_____	Oral communications were clear and effective
_____	The team worked well with each other and you as the cooperator

Summary: (please use an extra sheet of paper if necessary to include all your comments)

A. Team Strengths:

B. Areas Needing Improvement:

C. General Comments:

_____ Grade you would give the team overall (A, B, C, D, F)

Signature: _____ Title: _____

Company Affiliation: _____ Date: _____

APPENDIX III

ABEN 487 – Team evaluation of cooperator

1) Company/Individual cooperator: _____

2) Positive aspects of working with the cooperator.

3) Negative aspects of working with the cooperator.

4) Item with the project/cooperator interaction that could be constructively improved.

5) Would you recommend using this cooperator again in the future? Please explain either a positive or negative reply.