Session 2525

Evaluating Multidisciplinary Design Teams

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Abstract Many program look for ways to simulate "real" design experiences. At Purdue University, the EPICS - Engineering Projects in Community Service – program does this through long-term team projects that solve technology-based problems for local community service organizations. The program currently has 24 project teams with approximately 450 students participating during the 2002 academic year. Each EPICS project team consists of ten to 20 students, a local community service organization that functions as its customer and a faculty and/or industrial adviser. The teams are multidisciplinary; they are composed of students from 20 majors across engineering and the university. The teams are vertically-integrated; each is a mix of freshman, sophomores, juniors and seniors.

A key concern with any real design experience, where the purpose is to expose students to open ended problems and multiple solution paths and to encourage creativity, is the evaluation of student performance. This is especially difficult with multidisciplinary and vertically integrated experiences. This process can be further confounded when the projects are driven by an external customer, making it difficult to predetermine the expected outcomes.

The EPICS program has developed a series of methods to help assess student achievement and assign grades in an equitable manner. They cover a variety of attributes that each student brings to the team based on his or her discipline and academic year. These methods include automated weekly report and peer evaluation systems, design notebooks, self assessments, and an evaluation matrix. They are used in a dry run grading period near the middle of the semester to help calibrate students in their performance. This paper will provide an overview of these methods and how they have been applied in the context of the EPICS program.

Introduction The importance of significant design experiences to prepare undergraduate engineering students for engineering careers has been well-documented[1,2]. These experiences should emphasize the application of the technical skills in the classroom as well as the "softer" skills such as communication, working as a team and customer interaction[3-5]. The need for such experiences has spawned many innovative approaches to senior capstone design courses[6,7] as well as design courses for underclassmen[8-11]. The most common model for these courses has been a one semester experience intended to give the students an intense exposure to the design process.

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The model that guided the creation of the Engineering Projects in Community Service (EPICS) curriculum was to involve each student for several semesters or even years on the same long-term project, so that each student would experience varying roles over the course of the project. This emphasis on long-term projects was combined with a goal of undertaking projects that would ultimately be deployed by the customer.

This led to the choice of local not-for-profit organizations as the customers. Community service agencies face a future in which they must rely to a great extent upon technology for the delivery, coordination, accounting, and improvement of the services they provide. They often possess neither the expertise to use nor the budget to design and acquire a technological solution that is suited to their mission. They thus need the help of people with strong technical backgrounds. Moreover, the community service agencies will ultimately deploy the teams' systems -- an important final step that few commercial partners would take.

Through this service, the EPICS students learn many valuable lessons in engineering, including the role of the partner, or "customer," in defining an engineering project; the necessity of teamwork; the difficulty of managing and leading large projects; the need for skills and knowledge from many different disciplines; and the art of solving technical problems. In working with community agencies, the students are exposed to these agencies and thereby become more aware of the community needs and how their professional expertise can be used to meet those needs. This awareness of the community comes as a natural byproduct of fully understanding their customer, a critical piece of the design process.

A challenge for EPICS as well as many design courses is the evaluation of individual students. The purpose of the realistic design experience is to expose students to open ended problems and multiple solution paths and to encourage creativity. These attributes of the experience can become confounding aspects when evaluating individual student performance. This is especially difficult with multidisciplinary and vertically integrated experiences as is the case for the EPICS program. This process can be further confounded when the projects are driven by an external customer over multiple semesters. In any given semester, it is difficult to predetermine the expected outcomes for an individual student based on the phase of the project and their role in that phase. To address these concerns, the EPICS program has developed a series of methods to help assess student achievement and assign grades in an equitable manner. They cover a variety of attributes that each student brings to the team based on his or her discipline and academic year and have been used over several years. This paper will highlight these procedures and processes.

Curricular Structure of the EPICS Program EPICS was initiated in the School of Electrical and Computer Engineering at Purdue University in Fall 1995, with 40 students participating on five project teams. The program has grown steadily at Purdue both in size and breadth. In the 2002-03 academic year, over 500 students participated on 24 teams, addressing problems ranging from data management for social services to mitigation of agricultural pollution and from designing learning centers for local museums to developing custom play environments for children with disabilities. EPICS spans engineering disciplines at Purdue and includes students from over 20 departments across the university.

Each EPICS project involves a team of eight to twenty undergraduates, a not-for-profit community partner – for example, a community service agency, museum or school, or government agency and a faculty or industry advisor. A pool of graduate teaching assistants from seven departments provides technical guidance and administrative assistance.

Each EPICS team is vertically integrated, consisting of a mix of freshmen, sophomores, juniors, and senior and is constituted for several years, from initial project definition through final deployment. Once the initial project(s) is completed and deployed, new projects are identified by the team and community partner allowing the team to continue to work with the same community partner for many years. Each undergraduate student may earn academic credit for several semesters, registering for the course for 1 or 2 credits each semester. The credit structure is designed to encourage long-term participation, and allows multi-year projects of significant scope and impact to be undertaken by the teams.

Each student in the EPICS Program attends a weekly two-hour meeting of his/her team in the EPICS laboratory. During this laboratory time the team members will take care of administrative matters, do project planning and tracking, and work on their project. All students also attend a common one-hour lecture each week. A majority of the lectures are by guest experts, and have covered a wide range of topics related to engineering design, communication, and community service. The long-term nature of the program has required some innovation in the lecture series since students may be involved in the program for several semesters. This has been addressed by rotating the lecture topics on a cycle of two to three years and by creating specialized lecture supplements called skill sessions that students can substitute for lectures they have already seen. Example skill session topics include learning to operate a mill or lathe, developing effective surveys, and tutorials on multimedia software. We have found that students use the skills sessions as a way of gaining specific expertise needed for their projects, and also as an opportunity to broaden their experience for example, a computer engineering student learning to use a lathe or a mechanical engineering student learning web programming.

Phases of EPICS Projects The curricular structure of EPICS enables long-term projects. Over time, each project has five phases: establishing project partners, assembling a project team, developing a project proposal, system design and development, and system deployment and support.

Phase 1 Establishing Project Partnerships: The university-community partnership is at the heart of any service-learning program. In the context of EPICS, this entails exploring the technology needs and aspirations of local not-for-profit organizations.

When planning for the EPICS Program started in 1994, we were able to contact many different service agencies by making a presentation about the envisioned program and its goals to the directors of all local United Way agencies. This single presentation led to many discussions with individual agencies and a long list of potential collaborations. The community partners, designated *Project Partners*, have been selected based on four key criteria:

1. *Significance* not all projects can be undertaken, so partners whose projects should provide the greatest benefit to the community are selected;
2. *Level of Technology* projects must be challenging to, but within the capabilities of, undergraduates in engineering;
3. *Expected Duration* projects that will span several semesters offer the greatest opportunity to provide extensive design experience on the academic side and to address problems of potentially high impact on the community side. It has also proven valuable to achieve a mix of short- (one semester to one year) and long-term (multi-year) projects, in that the short-term projects build confidence and help establish the relationship between the student team and the community partner;
4. *Project Partner Commitment* – a crucial element of the program has been the commitment of individuals in the partner organizations to work with the students to identify projects, specify the requirements, and provide ongoing critical feedback.

Each year, EPICS has added new teams using the significance, level of technology, expected duration, and Project Partner commitment criteria. Since the first round of projects that grew out of the United Way presentation, the source of new projects has been varied. Faculty have initiated some projects; students have suggested others. As the program has become known in the community, several projects have been proposed by local community organizations. From five initial teams in Fall 1995, the program has grown to 24 teams.

Phase 2 Assembling a Project Team: Once a project and Project Partner have been identified, a student team is organized. This is done through discussions with and mailings to academic counselors, advertising the projects each semester in an evening callout and in undergraduate classes, and on the World Wide Web. Eight to twenty students are chosen for each *Project Team*, with the assignment of students managed by the EPICS Student Advisory Council, on which each team has a representative. Depending on the needs of the project, a team may include students from multiple engineering disciplines as well as non-engineering disciplines. Over 20 academic majors have been involved in the program, including Electrical, Computer, Mechanical, Civil, Aeronautical, Biomedical, and Industrial Engineering, Computer Science, Sociology, Psychology, Education, Audiology, English, Nursing, Visual Design, Forestry and Natural Resources, Chemistry, and Management. Vertical composition – the mix of freshmen, sophomores, juniors, and seniors – is also a factor in team assignments. Teams need both technically advanced members (typically juniors and seniors) to spearhead technical progress and (academically) younger members to carry the projects into future semesters. The combination of a vertically integrated team and long-term student participation ensures continuity in projects from semester to semester and year to year. Projects can thus last many years if new students, especially freshmen and sophomores, are recruited for the project to replace graduating seniors.

Phase 3 The Project Proposal: During the first semester of a project, the Project Team meets several times with its Project Partner and the team's EPICS advisor to define the project and determine its goals. During this phase the Project Team learns about the mission, needs, and priorities of the Project Partner. A key aspect of this phase is identifying projects that satisfy three criteria: they are needed by the Project Partner, they require engineering design, and they are a reasonable match to the team's capabilities. This process of project definition culminates in a written proposal and presentation. The proposal must be approved by the EPICS advisor and accepted by the Project Partner.

Phase 4 System Design and Development: Following acceptance of the proposal, the Project Team's goal is to produce a prototype of the proposed system or service. Regular interaction with the Project Partner continues in order to ensure that the products being designed and developed are as desired. The formal portion of this interaction includes written progress reports, periodic design reviews, and presentations. This phase of a project lasts as many semesters as necessary for the team to complete the project to the satisfaction of the Project Partner.

Phase 5 System Deployment and Support: The ultimate goal of each Project Team is to deliver a product or service to the Project Partner. The team must train representatives of the partner, collect feedback, and make any reasonable changes requested by the partner. One of the hallmarks of the EPICS Program is that the systems designed and built by the students are deployed in the field, where they provide real, needed service to the community. It has been our experience that after a team fields a project, the team and Project Partner work together to develop new project ideas, in order to continue the relationship. The students on the team in future semesters assume responsibility for supporting and maintaining the fielded projects. This structure not only provides the local community with useful projects, but also provides a long term technical support resources for the local agencies and organizations.

Sample EPICS Projects For the 2002-2003 academic year, there are 24 EPICS teams. A description of each team can be found on the EPICS web site at http://epics.ecn.purdue.edu. The teams work in four areas of the community, access and abilities, education, social services and the environment. A sample description of a team from each area is presented below.

Access and Abilities:

Wabash Center Industries (2 Teams)
Project Partner: The Wabash Center Children's Services.
Facts: First team began in Fall 1995; second in Fall 1996.
Mission: Develop computer-controlled toys for children with physical disabilities. Develop an artificial sensory environment to provide multi-sensory stimulation and a sense of control to children with physical disabilities. Provide ways for physically disabled children to control their motion and to play with peers.
Delivered: Doll-house kitchen and bath with electronically controlled refrigerator door, lights, swimming duck, lighted mirror, and sounds. Track-based dump truck with large-format four-button wireless control. Custom cap and RF controller to monitor posture. A four-button phone adapted for children with disabilities. Modifications to a commercially available electric car to allow safe use indoors and provide back support for disabled children. Modified toy record player with easy-to-use handle. Custom multimedia software for play-group activities and interactive software for American Sign Language. Internet access, custom web page, and tutorials on computer use for the clinic.
Technologies: Motors, electronics, electromechanical systems, computer based controls,

multimedia software, structures, actuators, ergonomics, and safety.
Disciplines: CompE, EE, MSE, ME, CS, Nursing.
Impact: Expanded capabilities and control of their environment for children with physical disabilities.

Environment

Constructed Wetlands
Project Partner: Purdue Department of Forestry and Natural Resources.
Facts: Began in Fall 1998.
Mission: Work with the Purdue Department of Forestry and Natural Resources to develop and construct a test wetlands area to clean up runoff from cattle, dairy, and swine farms and to treat creek water.
Technologies: Environmental engineering, surveying, hydrology, botany, instrumentation.
Disciplines: CE, EE, Environmental, Chem, Bio.
Impact: Improved water quality. New techniques for mitigating agricultural runoff.

Education

Happy Hollow Elementary School
Project Partner: Happy Hollow Elementary School.
Facts: Began in Fall 1997, in Fall 1998, Burtsfield School closed and transitioned to Happy Hollow Elementary School.
Mission: Develop technology-based interfaces to improve the usability of school science, computing, and media facilities, including a weather station and a TV studio.
Delivered: Web page software, electrical design for TV studio. Instrumentation that feeds weather station data to a web page.
Technologies: Software, electronics, computer interfaces.
Disciplines: Electrical and Comp E, ME, Edu.
Impact: Improved educational resources and educational experience for 4^{th}-6^{th} graders.

Social Services

Homelessness Prevention Network
Project Partner: Eight Agencies of the Tippecanoe County Homelessness Prevention Network.
Facts: Began in Fall 1995. **Mission:** Design and implement a centralized database that allows agencies to coordinate their services, track their clients, and assemble accurate reports without violating clients' confidentiality.
Delivered: Six client machines deployed with agencies; server deployed and running. Version 2 of the software has increased security and encryption features, full report generation capability, duplicate client-file merge algorithm on server, and custom, private email system to enhance interagency communications. Over 1500 client files are now resident on server.
Technologies: Databases, cryptography, communications, software.
Disciplines: CompE, CS, EE, IE, Soc.
Impact: Improved coordination of agencies serving the homeless; more accurate

understanding of homelessness in Tippecanoe County, Indiana.

Setting Student Expectations – New students enrolling in EPICS attend a one hour orientation lecture during the first week of classes. An important component of this orientation is an introduction to the grading process in the course. Students are familiar with a formula, so many points for an A, which is not used in the customer-driven design environment of EPICS. Students are given the expectations of work that they will do inside and outside of class. While hours are given, the emphasis is on results. This introduction tries to tie in the analogy of their future positions as professionals, where they will need to accomplish tasks for recognition and promotion.

Students can assume different leadership roles on the teams. These roles and their implication on their assessment are addressed during the grading process. For example, students who become the leader of a project team are evaluated more heavily based on the accomplishments of the team and may not have as many individual accomplishments because they are spending time helping others make progress and looking out for the whole project. Some positions require administrative time, compiling reports and preparing presentations. The intention is to be clear once the semester gets underway for students to understand the expectations for them individually. Some of the advisors meet individually with each student at the beginning of the semester to clarify these expectations.

Students help to set the expectation for the semester through their own planning as well. In the second week of the semester, the team establishes a semester plan that is submitted to the advisor and the community partner. This becomes the standard by which they are evaluated from a team perspective for the semester. After these are established, each student identifies personal goals for the semester and enters them in their weekly report in week 3 of the semester. Students are expected to meet these personal goals as the semester progresses.

Data Collected on Students– An intentional design aspect of the EPICS courses is the production of artifacts by the students that can be used in assessment. These artifacts provide a collection of the work and accomplishments of each student which allows an individual grade to be determined for each student.

Design Notebooks – Each student is required to maintain a design notebook. Guidelines are given to the students for completing the notebooks. To quote one of our team leaders "basically, we put everything we do into the notebook". The notebooks are evaluated three times during the semester, in weeks 4, 8 and 15, by the teaching assistants. The first evaluation is often a time to point out formatting issues and the level of detail that is expected. The content of the notebook is an excellent record of the students work. A sample design notebook evaluation form is given in Figure 1.

Weekly Reports – Each student is required to fill out a weekly report. These reports (see Figure 2) ask the student to summarize their accomplishments for that week, to provide page numbers in the design notebook that document these accomplishments, and to outline the work they have planned for the following week. The reports are entered into a web-based tool that compiles the reports by teams and allows the advisors to view a given team's report each week and to comment on the reports. The software allows students to enter their reports any time but marks reports as late if entered after the weekly deadline. Another feature of the software is that an individual's reports can be viewed by the advisor over the whole semester.

Presentations – Each team is required to make four presentations over the semester:

1. Demonstration – less formal presentation that demonstrates the state of the project from the previous semester
2. Progress presentation – formal presentation made to the team, advisors and a small number of invited guests on the progress at the middle of the semester.
3. Design Review – formal technical presentation to a panel of invited reviewers with technical expertise in the areas of the projects
4. Final Presentation – formal presentation to three other teams, directors and community guests.

There are evaluation forms for each presentation that those in attendance complete and return to the teams. For the design reviews, these include a list of action items recommended before the projects are deployed in the community. The presentations are videotaped and can be viewed by the teams later. Final presentations are digitized so that the next semester's teams can view the presentation using the EPICS video server.

Reports – Each team completes a midsemester report and an end of semester report. The midsemester report is critiqued by an English consultant as well as the advisor. This allows the advisor to concentrate on the technical aspects of the report and the English consultant can work with the team to revise the report in terms of style and grammar.

Peer Evaluations – Each student completes an evaluation for each team member using a web-based evaluation form at the middle and end of the semester. The tool asks students to evaluate each team member over a number of aspects, providing a numerical score for each attribute. A category of "confidence in your score" is included since the EPICS teams are large (up to 20) not all students know all the team members well and may not be able to effectively evaluate all team members. A column of a 10K bonus is included. The intention is that if the team were awarded $10,000, how would they distribute the bonus. They are discouraged from giving everyone on the team the same. This forces the students to make delineations between team members. There is a space for students to enter comments that are helpful. Students evaluate themselves which allows them to compare to the summary scores given to them by their team members.

In the peer evaluation form, the students are asked to evaluate several roles the other students do or could play. These roles are listed in the online form (Figure 3) but were deleted for illustration purposes. These roles are explained on the EPICS website using the following explanations

> ***Technical Contributions:*** Technical work that pertains to the project. Technical contributions may take many different forms, depending on the project and the team

members' disciplines. Contributions to the content of the project.

EPICS: DESIGN NOTEBOOK EVALUATION FORM

Name: Login: Team:
Credits____________

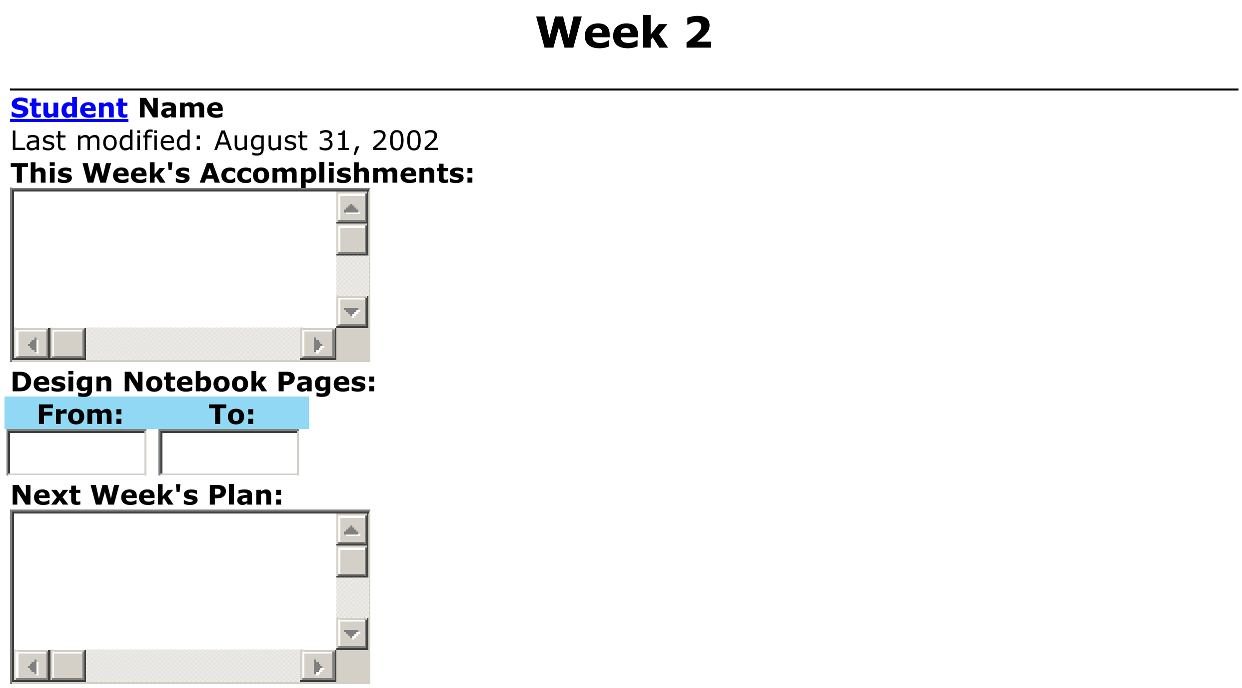
Class: ___ENGR 170 ___CE296/EE290/ME283 ___CE396/EE390/ME383 ___CE496/EE490/ME483
___CDFS 390E ___EDCI 490T ___SOC 493 ___Other

Requirements for Cover: Student's Name _____ E-mail Address ______ Team Name _____ Phone Number _____

	Points Possible	1st Evaluation	2nd Evaluation	3rd Evaluation
Entries Showing Individual Work and Accomplishments	**25**			
Level of Detail	**25**			
Readability and Clarity	**10**			
Entries for Lab & Group Meetings	**10**			
Entries for Contacts/Resources	**10**			
Dated Entries, Pages Numbered	**10**			
Loose Pages Attached to Notebook, Entries in Ink	**10**			
Evidence of Technical Work (outcome i)	Check fulfilled requirements			
Evidence of Attention to Design Process (outcome ii)				
Evidence of Customer Awareness (outcome iii)				
Notebook Entries Intelligible to Other Readers (outcome v)				
Evidence of Awareness of Project's Significance (outcome vi)				
TOTAL POINTS	**100**			

Comments

Figure 1: Notebook evaluation form.



Week 2

Student Name
Last modified: August 31, 2002
This Week's Accomplishments:

Design Notebook Pages:

From:	To:

Next Week's Plan:

Figure 2: Sample weekly report form.

Task Definition: Activity in the early phase of the design process leading to the problem definition and identification of tasks that the team will work on to address the project partner's needs.

Reporting/Demos/Presentations: Work on team reports, demonstrations, design reviews, talks, and/or poster presentations, either for EPICS milestones or for the project partner.

Leadership/Contributions to keeping the team on track: Team or project leadership; group task roles such as Coordinating, Summarizing, Harmonizing, Gatekeeping.

Teamwork: Contributions to the overall smooth functioning of the project group or team. Absence of Self-Oriented (Selfish) Behaviors.

Interactions with Agency: Interaction with the project partner.

Effectiveness in Personal Task(s): In whatever job(s) the team member is involved, how conscientiously and well has he or she done their job?

Confidence in Your Scores: Rate how familiar you are with each team member's activities and contributions. You are to evaluate all of the team members. This column allows you to indicate that you are not very familiar with the contributions of some of the team members with whom you have not work directly.

EPICS
Peer Evaluation Form

Name	Course	Credits	Role 1	Role 2	Confidence in your Scores	Distribution of 10k bonus
	EE490	2				
	ME383	1				
	ENGR170	1				
	CE396	2				
	Soc493	2				

Name	Course	Credits	Area of Greatest Contribution	Comments
same names appear here	EE490	2		
	ME383	1		
	ENGR170	1		
	CE396	2		
	Soc493	2		

Submit Reset

Figure 3: Sample peer evaluation form.

Distribution of (hypothetical) $10K Bonus: Enter amounts as integers (e.g., 2000 rather than $2,000 or 2K). The entries must sum to $10,000.

Area of Greatest Contribution: Could be in any project or contribution to the team in general.

To provide some consistency for the numerical scores in the peer evaluations, we provide a guideline for the students. These comments have helped provide a level of consistency to the peer evaluations.

1 – Poor –
- Does NOT recognize his/her role on the team in this area.
- Functioning below what is expected in this area.
- Minimal initiative shown in this area.
- Often misses meetings or commitments in this area

3 – Below average
- Can define and/or identify his/her role in this area.
- Needs help identifying future tasks.
- Occasionally takes initiative in this area.
- This person is not as effective as other team members.

5 – Average
- Schedules tasks to meet established goals.
- Apply basic knowledge/experiences to accomplish his/her tasks.
- Takes initiative sometimes in this area.
- Does basically what is asked to do.

8 – Good
- Analyzes and tests options, questions actions when appropriate.
- Provides constructive feedback to the team when appropriate.
- Regularly takes initiative in this area and is very dependable.
- Does at least his/her share for the team in this area.

10 – Outstanding
- A key member of the team.
- Consistently shows initiative.
- Takes responsibility of a significant share of the team's work.
- Assesses options, advocates for the most effective solutions.

Self Assessment – Students complete a short self assessment form to identify their main accomplishments over the semester. These are completed at the middle and end of each semester. The advisor reads the assessments and can comment if he or she agrees with the assessment.

Lecture Attendance – All EPICS students are required to attend lectures (10 for two credit students and five for one credit students) over the semester. Their attendance is recorded and posted on a web tool which allows them to verify its accuracy. These summaries are also viewable by the advisors.

Delivered Projects – Since the EPICS teams deliver real projects to the community, one of the artifacts is the delivered projects to the community. The expectation is not that all teams will deliver projects each semester. Projects often span several semesters and these are encouraged if the larger scope projects are needed by the community partners.

Community Partner Feedback – The formal evaluations by the community partners are used in the assessment of the program's impact on the community partner. A formal evaluation of each student is not made by the community partner, but the advisors consult the community partner each semester for input to the assessment of the team and individuals.

Resources for advisors – tools have been developed to assist the advisors in processing and summarizing the artifacts of the class to assess individual students. These resources include the web tools to view and summarize the weekly reports and peer evaluations. Summaries of the peer evaluations can be made and the individual scores given to students can be viewed. A sample of the resources can be found at the EPICS website at http://epics.ecn.purdue.edu/staff_documents/Grading_ABET.htm.

Grading matrix
As a resource for advisors, an evaluation matrix was developed to help identify the competencies that are consistent with the course objectives. The matrix was designed using Bloom's Taxonomy and a scale for initiative and leadership. Each competency is categorized using four levels, Beginning, Developing, Accomplished and Exemplary as shown in Table 1. An example of the rubric for technical skills is illustrated in Table 2. Rubrics are also available for the design process, teamwork, communication, resourcefulness, community awareness and ethics at http://epicsdev.ecn.purdue.edu/staff_documents/evaluation_matrix.htm. This tool has had mixed success in translating to grades. Issues that the EPICS advisors struggle with are translating the evaluation to account for multiple academic levels (freshman – seniors), different disciplines and the fact that the students register for one or two credits each semester. This is one of the tools that is under discussion for revision and will be the subject of future work.

Table 1: Bloom's Taxonomy was Used as a Basis for the Grading Matrix

	Beginning	Developing	Accomplished	Exemplary
Bloom's Level	Knowledge & Comprehension	Comprehension & Application	Application & Analysis	Synthesis & Evaluation
Other characteristics	Follower			Leadership, sophistication and initiative

EPICS Self-Assessment Form

Name___________________________________ Team ____________ Date _____________

Major ____________ Year: Sr Jr So Fr Credits: 1 2

Please list your major accomplishments for the semester in the following areas. Please note that you do not need to have accomplishments in each category. Return this form to your adviser or the EPICS office. The advisers are to make comments and return the completed forms with the course grades at the end of the semester.

Category: Technical (as it applies to the project and/or your major)

Advisor: ❒ I agree with the student's assessment
Comments:

Category: Communication

Advisor: ❒ I agree with the student's assessment
Comments:

Category: Teamwork and leadership

Advisor: ❒ I agree with the student's assessment
Comments:

Category: Any other areas of significant accomplishment

Advisor: ❒ I agree with the student's assessment
Comments:

Figure 4: Self-assessment evaluation form.

Table 2: Example rubric for Technical Skills.

Competencies	**Beginning**	**Developing**	**Accomplished**	**Exemplary**
Technical Skills - ability to apply technical skills (from the student's major) to their work	• Able to recognize basic technical needs of the project. • Able to define basic technical skills and tasks needed for the project(s).	• Able to identify technical issues related to one's field. • Able to apply concept from major's core courses to project. • Applies basic understanding of technical knowledge to project.	• Able to apply concepts from advanced and/or multiple courses in one's major to the project. • Able to distinguish technical issues of the project. • Able to describe concepts to teammates needed for the project.	• Able to apply knowledge from multiple courses to the project. • Able to organize technical issues of the project into parts that can be done by teammates. • Able to teach teammates from other disciplines relevant concepts needed for the project.

Dry Run Grades

One of the successful models for assessment of student performance has been the mid-semester Dry Run Grading process. In the middle of the semester, we simulate the same grading process that will occur at the end of the semester. The data is collected as identified above and the advisors and TA's meet to discuss and determine the grades under the premise that the semester is ending then. The students are evaluated as if the semester were to end at that point. This gives the advisors an opportunity to assess the level of detail and content from the students through the artifacts and documentation they are producing.

Grades are sent out individually over email and a master copy is sent to the central EPICS office. Each student receives a grade and comments for their team and for themselves. These comments include what, if anything, is lacking at that point in the semester and how to overcome those deficiencies by the end of the semester. Helpful suggestions are included by the advisors when appropriate. Sometimes, the grades are given as a range if there are items that are unclear. These grades are not recorded and averaged with the final grades, but rather serve the purpose of running through the system once to insure that there is a consistency of expectations between the students and advisors. The grades take into account the year in school, number of credits the course is worth that semester, major and the role on the team for each student.

Senior design
In assessing student performance, grades are an important aspect. For the senior Electrical and Computer Engineering Students, they can take EPICS for their senior design requirement. Since this is a core requirement, it has specific outcomes that must be met as part of the course. For other students in EPICS, the outcomes are a much larger list and in any given semester they will master a subset of these outcomes. For the senior design students in ECE, we need to verify that these specific outcomes have been met, along with a grade being determined. Two additional tools have been developed to allow us to monitor these students to insure they meet the senior design outcomes. First is a project description that is used to approve the projects as appropriate for senior design. The second form is an outcomes matrix which allows the specific outcomes to be tracked and recorded. These forms can be found at http://epics.ecn.purdue.edu/staff_documents/Grading_ABET.htm#abet and are described more fully in by Jamieson, Oakes and Coyle[14].

Final Grading At the end of the semester, the same procedure is repeated that was used in the Dry Run Grading. While team grades are given for each team, only the individual grades are recorded for the students. The team grades are determined so that they can be factored into the individual grades. The relative weighting of the various inputs and artifacts produced during the semester are weighted differently between teams and advisors. This allows the flexibility to evaluate students who take on different roles on the team and for teams that are in different phases of the design process. For example, a senior who takes on the role of overall team leader will have the team grade weighted more heavily. A team that is beginning that is beginning a large project will have more weight on understanding the community partner and specification development than a team that is getting ready to deploy a project.

Results - The student assessment process has proven effective over the seven years of the EPICS programs. As new advisors have come into the program, they have been mentored and shown how to use the various tools and documentation that the students produce during the course of the semester. The process has been in place during the most recent ABET review of the schools of engineering when EPICS received positive comments from the reviewers.

While the EPICS program has strived to develop common tools, they have been implemented slightly differently by different advisors. Some advisors have tried to tie the expected deliverables to a formula to eliminate as much subjectivity as possible. One problem with that is that these teams have begun to think about the formulas rather than meeting the customer's needs. A visible sign of this bias is in the projects the students design. In teams with formulas, there is a tendency to produce one or at most two semester projects because a deliverable to the customer factors in each semester. One of the important aspects of EPICS is that the curricular structure allows for projects that are large scale and significance. Such projects often take multiple years for teams to complete.

The advisors have found the weekly reports and the design notebooks to have the highest value in assessing student work. There has been mixed reaction to the peer evaluations with some finding it very helpful and other finding it less helpful. One confounding factor for peer evaluations is that in the large teams (up to 20 students) all team members do not know all the other team members. They may know their own sub-team well, but not the other team members which makes the peer evaluation more difficult to factor in.

One of the tools that is under development and would add value to the current system is a rubric to characterize the contributions from students from other disciplines more effectively. EPICS students come from many disciplines across campus and many of the tools are written with engineering students in mind. Such tools can help for advisors and students set better expectations and assist in the assessment of those students.

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