An Analysis of the Reflection Component in the EPICS Model of Service Learning

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Abstract – Service learning is a pedagogy providing a structured environment for students to link service with course learning objectives. Key to the service learning experience is critical reflection. This gives students the opportunity to examine their coursework in the context of the service they provide to their community and, in a broader sense, the impact they can have on the world. Research has shown that students participating in service learning have a higher comprehension of the course material and also develop an awareness of their local community and the issues it faces. In engineering, there are many examples of service-learning programs ranging from freshman introductory courses to senior capstone courses. Despite their successes, an area that the engineering education community has yet to fully develop is the reflection component of service learning. This paper addresses the development of reflection activities and materials in the Engineering Projects in Community Service (EPICS) program at Purdue University. EPICS engages students in long-term design projects that provide technical solutions to problems faced by local community service organizations. It is a multidisciplinary (composed of students from 20 majors), vertically integrated (freshman-senior), engineering-based design course. Students design, build, test, and deploy projects meeting the specific needs of their community partners. Reflection has been integrated in the EPICS program through curricular activities and key milestones of the course. These activities guide students through the reflection process on a variety of topics. Critical reflection on the design process and teaming complement those on more traditional areas of ethics and social context to enhance a student's service-learning experience. This paper presents an overview of the reflection activities that have been developed, interpretations of student reflections from these activities, and plans to evolve the reflection component in EPICS.

INTRODUCTION

Service-learning is a pedagogy in which students engage in activities that address societal needs while simultaneously addressing student learning objectives. Necessary, and to distinguish itself from community service, is a reflection component [1], [2]. Students gain an appreciation for the role they can as an engineer can play in society by reflecting on various socioeconomic and ethical factors.

Traditional modes of reflection include journal writing and group discussions [3]. Journal writing provides a safe environment for students to express their thoughts and feelings. Group discussions present an opportunity to express one's views and to learn from other points of view. Students can also reflect on the impact they have by answering reflection worksheets. When designing service-learning

projects, they can be set up analogously to traditional design projects. The main changes between the two include the community sponsor, interaction, and synthesis [4].

Reflective judgment (i.e., critical thinking) and the associated skills are an important educational outcome for engineering students [4]. The development of these critical thinking skills enables the engineering undergraduate to develop a broader appreciation of concerns facing the engineering profession. Traditionally, reflective judgment within engineering service learning has focused primarily on the social, political, and cultural impact of engineering and technology on society. This emphasis notwithstanding, the EPICS program recognizes the value of reflective judgment and has attempted to expand the use of critical thinking skills to include reflections on the community partner (called the project partner), team dynamics, the design process, and ethics.

This expansion demonstrates ABET program outcomes "an understanding of professional and ethical responsibility" and "the broad education necessary to understand the impact of engineering solutions in a global and societal context" as well as such outcome as "an ability to function on multi-disciplinary teams" and "an ability to identify, formulate, and solve engineering problems" [5]. Direct contact on projects with groups such as not-for-profit organizations and K-12 schools and the reflection on the impact a student is making on these groups, rudimentary in service-learning, are aligned with these program outcomes.

One of the traditional barriers to integrating reflection into engineering courses has been the perception or stereotype that reflection is an activity that would fit into a humanities course but not an engineering course. By designing the reflection activities as analysis of the learning outcomes, such as the design process and team dynamics, the reflection process has been put into a form that is more familiar and comfortable for the students and faculty [6]. It has provided a process to include issues related to the community partner (partly under "customer awareness"), and issues related to the social problems being addressed by the community agency (societal context and contemporary issues as listed under ABET) [7].

This paper provides an overview of the Engineering Projects in Community Service (EPICS) Program, describes the reflection components and presents an analysis of these components using the Reflection Rubric of Barbara Olds presented in [4]. The two-dimensions of the rubric are based on the Blosser Taxonomy (evaluative, divergent, convergent, and cognitive thinking) and the Reflective Judgment Model (RJ 3 and less, RJ 4, RJ 5, and RJ 6 and higher). These scales range from Pre-Reflective/Pre-Evaluative thinking to Quasi-Reflective/Quasi-Evaluative thinking to Reflective/Evaluative thinking.

THE EPICS PROGRAM

The EPICS Program [8] enables long-term projects in which teams of engineering undergraduates are matched with community service agencies that request technical assistance. Under the guidance of faculty and industry advisors, these EPICS project teams work closely over many years with their partner community organizations to define, design, build, test, deploy, and support the systems the agencies need. The results are systems that have a significant, lasting impact on the community organizations and the people they serve.

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. They also learn many valuable lessons in citizenship such as the role of community service in society, the significant impact that their engineering skills can have on their community; and the personal growth that comes from assisting others.

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

Each team is vertically integrated, consisting of a mix of freshmen, sophomores, juniors, and seniors. Each team is constituted for several years, from initial project definition through final deployment. Each student may earn academic credit for several semesters, registering for the course for one or two 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 tackled 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.

Important to the infrastructure of the EPICS program are the project milestones shown in Table 1. Project milestones calibrate the progress of the project teams and aid the students in understanding the project itself and the contributions they can make. Some of these milestones include, meeting with their project partner or participating in a team dynamics exercise in the second and third week of the semester, demonstrating their knowledge of and assessing the current status of the project in the fourth week, reporting on the progress of the project in the eighth week, and receiving technical and project partner feedback in the eleventh week. These milestones require a combination of team discussions, written reports, and informal or formal presentations.

Table 1: EPICS Milestones

Week	Milestone
1	Develop semester plan
2 or 3	Meet with project partner one week; Do team dynamics exercise the other
2	Turn in semester plan
3	Submit personal semester goals
	In lab demo
4	Progress report due
9	Design Review
12	Deadline to deliver projects
14	Final report due; End of the semester reflection
15	include in final report

REFLECTION IN EPICS

The underlying philosophy of the reflection activities has been to integrate them into the activities and milestones workings of the course. We have broadened the focus of the reflection component in EPICS from the traditional service learning reflection (ethics and social context) to that which addresses multiple learning objectives including teaming and the design process. The reflective activities are integrated throughout the semester and take many forms. We have intentionally broadened the reflection activities since metacognition is a sound educational model for the many learning outcomes of the EPICS courses.

An ongoing practice by all EPICS students is to keep a notebook which they are encouraged to include reflections and reactions to their meetings and the work that is being done over the semester and when meeting with their community partners. The design notebooks have become the primary means to document and collect written reflections. Students also compose individual reflection statements to be included in the end-of-the-semester final report.

Reflections activities have been integrated with the evaluation process as well with students setting personal goals for their experience in the third week of the semester. At the middle and end of the semester, students are required to complete a self-assessment where they reflect on their experience and accomplishments relative to their team and personal goals.

While some reflection occurs with individual teams and is led by the faculty advisor for the teams, programmatic reflection activities have been integrated into the milestones for the program as shown in Table 2. These reflection modules focus on critical issues and dimensions of engineering education highlighted by the ABET's Engineering Criteria 2000. The reflections are embedded within the context of important project team milestones. The modules focus on their community partner ("customer"), the design process, team values, and ethics.

Table 2: Revised EPICS Milestones

Week	Milestone
1	Develop semester plan
2 or 3	Meet with project partner one week; Do team dynamics exercise the other
2	Turn in semester plan
3	Submit personal semester goals; **Reflection on project partner** meeting
4	In lab demo; **Reflection on the design process**
8	Progress report due
9	**Reflection on team values**
11	Design Review
12	**Reflection on ethics**
14	Deadline to deliver projects
15	Final report due; End of the semester reflection include in final report

Reflection Exercise: The Community Partner

In the second and third week of the semester, EPICS teams are asked to visit their community partner, called the project partner, at their place of work. The project partner meeting reinforces the dedication of the team by placing them in the work environment of the project partner. New team members are introduced to the mission of the project partner, while returning members ask for valuable feedback on the process and substance of the project. After the meeting, students are given time to answer questions about their community partner on a reflection worksheet:

1. Summarize your project partner's mission in the community (e.g., What community issue is your project partner attempting to address?).
2. Summarize the task (s) your project partner is asking you to perform.
3. How do these tasks relate to or advance the mission of your project partner?
4. How would you describe the response of your team to the project partner's concerns at this meeting?
5. Describe your participation at this meeting.

Reflection Exercise: Teaming

On the week they are not visiting their partner, the teams participate in a team dynamics exercise. At the end of the exercise, a team is expected to produce a list of, at least, five team values that the team believes are important to their functioning as a team. Each value is defined along with a list of behavioral attributes intended to measure the achievement of that value within the team. Halfway through the semester in week eight or nine, the students revisit this exercise to assess their "living up" to the team values. Students answer reflection questions on a worksheet dealing with teaming issues:

1. List the Team Values that you generated during the Team Dynamics Exercise.
2. Rate your performance on these values. (Based on a Likert Scale from 1=Poor to 5=Outstanding)
3. What have you done to promote these values on your team? Be specific, list behaviors, and give examples.
4. What have you done to inhibit these values on your team? Be specific, list behaviors, and give examples.
5. Rate your team's performance on these values. (See Question 2 above for scale.)
6. What has the team done to promote these values? Be specific.
7. What specific suggestions do you have to improve your team's performance for the rest of the semester?

After completing the reflection during the two-hour project team lab, there is a general discussion of how the team is doing based on reflection questions 5, 6, and 7.

Reflection Exercise: The Design Process

In the fourth week of the semester, students make an internal, informal presentation known as the "Fourth Week Demo". As the title indicates all team members should demonstrate a familiarity with all aspects of the project. New members should know the substance of the project and returning members should be making steady progress toward achieving project goals. At this juncture, the importance of the design process becomes evident. Students are expected to reflect on where the team is in that process. Student reflect on the design process by answering three questions:

1. Where in the design process is the project at the time of the Demo?

2. What stages of the design process have been completed and documented for the project?
3. What stages of the design process are anticipated to be completed this semester.

Reflection Exercise: Ethics

Students in the eleventh week of the semester are required to do a formal presentation to their project partners and technical reviewers. The design review focuses on the technical aspects of the project. A week before the presentation, reviewers are supplied with a technical appendix and all relevant material pertaining to the project. They are asked to make comments and suggestions to the team at the end of the presentation. Most reviewers will also submit more extensive written comments following the session.

During this session, ethical issues of various types often arise. Whether it is product safety or honesty with the project partner on deployment deadlines, EPICS students face the practical challenges all engineers face in dealing with real life consumers of engineering products and services. The design review offers a perfect opportunity to reflect on questions of ethics and ethical practice in engineering. Toward this end, after the design review, students are asked to reflect upon and discuss issues that were brought up for discussion during the design review:

1. Using the design review as a basis for reflection, outline the two most important ethical issues that face your team? (Examples of ethical issues would be product safety, honesty with project partner, plagiarism, deliberate undermining of team effectiveness by dysfunctional behavior(s), confidentiality, etc.)
2. The engineering design process is like the ethical decision making process in that there is no "perfect" solution to a particular problem but optimum course(s) of action that balance all the constraints and resources involved. From your knowledge and experience, please suggest a course of action that your team could take to attain an "optimum" resolution to the ethical issues you outlined above.
3. Suggest the types of resources* you believe your team would need to resolve these issues and how these resources would be used. (*Resources are any people, information, or equipment that would assist you in resolving the issue.)

The EPICS program staff in cooperation with the advisors and TA's of the project teams will evaluate the quality of the responses and discussions based on these questions over time. This will permit the staff to refine the reflection instruments.

Supplemental Reflection Activities

The EPICS program also presents specific modules for guided reflection in areas that are related to specific ABET criteria. These include design, ethics and community awareness. These activities were created to help students document their mastery of ABET outcomes for students taking EPICS as their capstone requirement. These modules, however, have become a valuable component in the reflection activities. The presentations are made during a lecture time that parallels the lab. Students are not required to attend every lecture so all students do not participate in these supplemental activities each semester.

Design Module

This module leads students through overview models for the design process. Methods are provided and

one specific model is used for illustration and reflection purposes. Students are asked to evaluate the current state of their project relative to the design process presented as a model. They respond to written questions to identify where they anticipate their design reaching over the coming semester based on their project planning.

Tools for design are also presented including decision matrices, brain storming models, functional decomposition and a model for Quality Functional Design. Since most students take EPICS for multiple semesters, the design tools are staggered between semesters.

Ethics Module

This module explores issues of ethics and professional responsibility in engineering. Students are introduced to moral and ethical terminology and challenged to wrestle with these concepts through the use of "ethical dilemmas" and by the reflection on the work of their project team. Objectives of this module are: to introduce the student to distinctions and concepts commonly used in ethical discourse (e.g., values vs. preferences), to challenge the student to use ethical concepts and reasoning in resolving ethical dilemmas, to relate ethics and moral guidelines to the work of the project team, and to introduce the student to the professional ethical codes of the various engineering disciplines and to the general ethical code of engineering.

These objectives are accomplished in three phases. First, students are assigned the National Society of Professional Engineers (NSPE) Code of Ethics for Engineers [9] to read before lecture. Lecture addresses this code in relation to the issues a project team can face in dealing with its project partner. At the completion of the lecture, students complete a reflection sheet on ethics:

1. Outline what moral values and concepts you consider essential in your conduct and relationship with each of the groups or persons below. Explain why you think those particular values are important.
    - Your project partner
    - The other members of your team
    - Your advisor(s)

2. After reading the NSPE Code of Ethics for Engineers: detail what kind of ethical issues you believe your particular project team faces? Examples: Being honest with your project partner, treating the project partner with mutual respect, issues of intellectual property (i.e., plagiarism). How do you believe your EPICS project team could make "moral" or "ethical" considerations more a part of the design process?

Social Context Module

This module explores the general idea of "social context". Students are challenged to look at their projects as more than just a "technical problem" but as existing within a larger constellation of economic, political, and cultural interactions. They are introduced to some of the ideas and tools needed to understand the exact nature of the "problem" their community partner is addressing and the challenges that community agencies face in meeting these challenges.

In this module students define a particular issue or problem being addressed by their community partner. They then reflect on how issues of race, ethnicity, gender, socioeconomic class, and other "social facts" might affect that issue or problem. Students also learn three general approaches to understanding society and how it operates.

A handout on social theory [10] outlines how sociologists understand society and "map-out" the idea of social context. The excerpt presents three "sociological maps" or ways of explaining what makes society possible and how people behave in society: Functionalism (associated with Emile Durkheim), Conflict Theory (associated with Karl Marx), Symbolic Interactionism (associated with George Mead). This reading is assigned before lecture. After lecture, students complete a reflection sheet dealing with social context:

1. How would you define the "problem" or challenge that your community partner deals with on a daily basis? (Hint: Some of your project partners have a "Mission Statement". Also some projects groups, for example Constructed Wetlands or Eliot Ditch, have "large issues" of social impact to consider such as the "the environment" or "public health and safety")?
2. What kind of information or facts would you think are important to understand the challenge faced by your community partner (for example, disabled people often face discrimination in education or jobs)?
3. How would any of the following affect your community partner and how they respond to their particular challenge? If you don't think it has an effect explain why not? Respond on race, gender, class (socio-economic status), and power.
4. Choose one sociological theory that you think would best "explain" or shed light on the challenge or problem faced by your community partner. An example of a couple questions you might ask yourself: What dynamics have created this problem? Does the way society is organized or structured contribute to this problem and, if so, in what way (for example, how the economy is organized might exacerbate issues of poverty and thus contribute to homelessness or lack of affordable housing)? There are many more questions you can ask so be creative on this one and try to relate the concepts in the handout to your particular project partner.

Analysis of Reflection Exercises

The Reflection Rubric [4] can be used to evaluate the reflection exercises in EPICS on two levels. First, the exercises themselves can be evaluated to determine the types of questions asked of the students. Second, the responses to these questions by students can be categorized by the rubric. The dimensions of the reflection rubric are the Blosser Taxonomy and the Reflective Judgment (RJ) Model. Each type of thinking in the Blosser Taxonomy is divided into four levels based on RJ level. For Evaluative Thinking the RJ level ranges from 3 and less, indicating a response in which a student is not able to evaluate the presented information, to 6 or higher, demonstrating the use of and identifying strategies that address limitations.

The reflection exercises were first introduced during the Spring 2003 semester. Responses to exercises from that first semester have been analyzed on random samples selected from that data. It was expected that responses to questions eliciting critical thinking by the student would fall predominantly in the Pre-Reflective/Pre-Evaluative Thinking stage of the rubric; responses in these categories demonstrate minimal analysis and interpretation of how well goals were met. Responses on the opposite ends of the scales, Reflective/Evaluative Thinking, show organized analysis or prioritized evidence supporting goal achievement as well as assessment of one's limitations. This expectation was based on the assumption that, for many students, the reflection exercises represented initial opportunities for critical reflection.

For the reflection on the Community Partner, students are asked to summarize their partner's mission

and the tasks to be performed as well as the relation of these tasks to the mission. Responses ranged from the Pre-Reflective/Pre-Evaluative Thinking stage of the rubric (e.g., a listing of goals and tasks with limited to no interpretation of how these tasks further the partner's mission for a team working with the local art museum) to (Quasi) Reflective/Evaluative think (e.g., an assessment of how the tasks further the partner's mission of art preservation, and an argument tying together the mission of the museum with what it means to be a museum and how art factors into that and with the community).

The Teaming reflection exercise asks students to rate their performance and their team's performance based on a list of team values generated by the team at the beginning of the semester, to list specific behaviors that promote and inhibit these values, as well as to provide suggestions to improve the team's performance. Most teams' values include communication, cooperation, organization, accountability, trust, and respect. All students rated themselves and their teams in the mid to outstanding range. Behaviors promoting these values include keeping in touch with teammates, dividing tasks and organization, and documenting work in their design notebooks. Many students cite inhibitory examples such as lack of planning, taking on too much work, not communicating, and not making others accountable. Responses to the last question, suggestions for improving team performance, cluster around the Pre-Reflective/Pre-Evaluative thinking range on the rubric and are simple, straightforward suggestions for improving team performance with little interpretation of how limitations present in the team (e.g., due to conflicting personality types, varying degrees of technical knowledge and interpersonal skills, etc.) can be addressed.

The reflection on ethics following the design review asks the students to identify the two most important ethical issues facing their team and to suggest a plan of action to attain an optimum resolution to these issues. Students easily listed the two most important ethical issues. Many responses cited safety (as on teams working with children and people with disabilities), plagiarism (commonly mentioned by students on teams with large software projects or in reference to a lack of citing sources), honesty and open communication with the team's partner, and confidentiality (particularly on teams working with partners in the human services area). When describing a plan of action to attain an optimal solution given these issues, student's responses were generally Pre- to Quasi-Reflective/Evaluative. Some students merely repeated the ethical issues and stated that they need to be met but did not provide any course of action. Many include straight forward solutions (such as obtaining permission to use and citing the work of others) without a discussion of a course of action when two ethical issues compete with each other.

Conclusions

The reflection exercises developed guide students in their evaluative and reflective thinking during their service learning experience. Responses were distributed throughout the reflection rubric. These which will be used to modify future reflection exercises. In the future, as students complete these reflection exercises for each additional semester they are enrolled in the program, it will be interesting to evaluate how their responses change over time.

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