Teaching Reflective Skills in an Engineering Course

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Abstract

One of the most effective tools for lifelong learning is the ability to reflect and learn from past experience. Reflection helps to clarify our understanding of the world and to create new distinctions and possibilities for the future. It is a way of creating intention. By putting our attention on the perception of what has happened and what we want to achieve, solutions to problems emerge more easily. We also believe reflective skills are among the main characteristics that distinguish excellent engineers from merely good ones. This makes these skills important to teach.

This paper describes a set of reflective practices that we implemented in a 9-week course in software engineering at the junior undergraduate level. These techniques, many of them borrowed from professional leadership training programs, include individual, team, and project practices such as retrospectives (e.g., "What went well and what didn't?"), informal chats with guest experts (e.g., "Do they really do it that way in industry?"), workshop simulations (e.g., "How do we decide when to ship a product?"), journaling, and some unusual activities (e.g., "Draw a picture of your team"). To gauge student progress we also used weekly reflective assignments as well as reflective questions on the take-home final exam. All of these techniques were well received by the students, as evidenced by anonymous, detailed end-of-course evaluations, and by voluntary feedback students provided four months after the end of the course. The experience applying reflective practices appears to have influenced a number of the students into viewing their project, careers, social interactions, and life choices in a different, more positive light. Many have continued using several of these techniques after the course.

We believe the practices worked particularly well because we set up the course with ample opportunities for students to make mistakes (a fodder for reflection) and learn from them in a non-threatening (academic) environment. While we recommend the approach to engineering educators interested in teaching "soft skills," we caution that to successfully apply it one needs to be comfortable identifying and handling conflict that may emerge.

1. Introduction

This paper describes a set of reflective practices that formed the backbone of a 9-week software engineering course at the junior undergraduate level. We report on our, and our students', assessments of the effectiveness of these practices, collected during the course, at the end of the course, and four months after the course.

One of the main goals we set for the course was to teach a set of team and project practices necessary for doing projects effectively. Our industrial experience[1] and assessments like ABET 2000 show that being skilled at doing these practices is highly valuable for enabling software engineers to be successful. We believe experiential learning [Weinberg 1985] is one effective way to teach these skills. It requires that students continually go through a learning cycle whereby they practice, reflect on their difficulties, discover new models or have them introduced by facilitators or other students, and then practice again.

In order to create an effective experiential learning situation within an academic context, we designed the course around several strategies:

[1] David has 11 years of industrial experience developing software and managing teams of software developers. Valentin has 3 years industrial experience developing software. Elizabeth has over 20 years experience as a family therapist, and thus has a good understanding of how people "function" and learn.

1. *Project–based, a single large team*. To force the students to deal with team and project coordination issues that could be missed in smaller teams, the course was designed to be project-based with *all* 22 students working in a single team for the duration of the quarter.
2. *Teaching with our mouths shut*. To maximize the chance for student learning, instructors focused on being facilitators within an experiential learning environment, and on teaching by example. Instructors provided some project requirements[2], choices, observations, facilitation, and minor guidance. After an outside marketing person presented the marketing requirements for the product, the students had the freedom and responsibility to run and manage the entire project, including deciding what to do when they do not know what to do.
3. *Reflective practices*. To maximize student learning, we embedded this project within a system of many individual and group reflective practices.
4. *Resembling real life*. To maximize the practicality of what students would learn, the project was done in an environment as close to that in industry as possible within the constraints of an academic 5-credit course. The main exception was that, in the spirit of academia, student learning was emphasized as more important than project success and there was no real customer[3].
5. *Expert practitioners*. To ground our assessments of what an engineering job demands and to help students appreciate the diversity of needs of different constituents, we had eight class sessions where outside expert practitioners led experiential simulations or told reflective stories of their work.
6. *Need-for over how-to*. To fit within the constraints of a 9-week course, we were more concerned with teaching need-for than how-to knowledge. The need-for is about appreciating that there is a need for some type of action, while the how-to is about how specifically to perform that action effectively.

The results were encouraging. We were initially surprised by how many students readily provided us with feedback four months after the course was over. University-wide statistics show that typically only one or two students respond to queries after the end of a course. We had a 45% response rate and nearly all students were very positive about their experience. To us this indicates that they were passionate about how the course was taught and how significant it was for them personally.

Of the wide range of reflective practices we experimented with, several seem to have made a lasting positive impression on students. Nearly all of our respondents said that they still continued to write in private journals regularly and found it rewarding, and more than half of them also practiced team conversations, team retrospectives, and the awareness of personality types in their interactions with colleagues.

Since the feedback we received was in response to questions about the techniques we applied in the course and the reflective practices we introduced but not the actual course material, and since nothing about these practices seems domain-specific, we believe they can be successfully applied in courses in all engineering disciplines.

Next, in Section 2 we provide some background and lay out our basic approach to designing this course. Section 3 describes the reflective practices around which the course skeleton was built, while the details of each appear in Sections 4 through 6. Finally, Section 7 reports the results from student feedback and concludes.

2. Our Approach

Many courses have taught reflective practices [Jolly 2000, Sobek 2002]. There are many different types of reflective practices. In this course we experimented with a few that stand out as being particularly valuable for a wide range of people and circumstances. These include journaling, targeted reflective essays [Turns 1997], portfolios, retrospectives, and story telling.

Journaling helps an individual to clarify what has happened and learn about herself. Targeted reflective essays help the writer to learn from the exploration of a specific question. Portfolios help to build a sense of

[2] We restricted the set of development tools so that (a) students would not spend too much time on that choice, and (b) we could provide them with an industrial level set of development tools.

[3] We would think carefully before having a *real* customer for such a course, because this would increase the cost of failure, which in turn may prevent students from taking risks and trying something new. Academia is *not* the real world, and it may be best to use that to our advantage by doing things that are not easily done in the real world, such as encouraging students to focus on learning *even if it may lead to project failure*.

accomplishment as items accumulate [Upchurch 2001]. Retrospectives help teams to clarify what has happened and learn how to operate better. And story telling helps people to learn from the reflections of others.

The teaching style and structure of the course reported on in this paper were strongly influenced by our industry experience. Software engineering is about people working in teams on projects to create value for customers. While tools and the "hard skills" are important for software engineering, projects almost never fail solely because of technical limitations. Yet, the "soft skills" are largely missing from the curricula most undergraduates go through, even though their absence does lead to a great many project failures. Our goal therefore was to plant the seeds that would allow the students in our course to start and stay on the path toward becoming effective in real-world situations.

In particular, we consider the following five skill domains to be invaluable for effective engineers:

- Reflective skills (for lifelong learning) [Schön 1983]
- Team skills (for working with people) [Dunham 2001]
- Project skills (for navigating projects to success)
- Value skills (for identifying and creating value) [Denning 2001]
- Design skills (for discovering and building good designs)

These "soft skills" are necessary to effectively apply the "hard skills" traditionally taught in engineering courses [ABET 2000]. While an individual does not need to be proficient in all of these – that is the value of working in a team – the most effective professionals we know are very good at all of them. At the least, for someone to be effective in a team environment, they need to appreciate and respect the need for soft skills in their team.

In some way, reflective skills are more "fundamental" than team, project, value, or design skills. Reflective skills help one improve in *all* skill domains, whereas the same is not true for the other types of skills. For this reason, we put much attention on reflective skills in our course. However, we caution that while they are necessary, they are not sufficient for lifelong learning in any skill domain.

Unfortunately, a quarter is a very short time to teach such skills in completeness. They require a lot of practice to master. Furthermore, the "right" way to implement them depends on the context, so even if we had taught a right way, that way might not have been suitable in the next situation a student faced. Thus, we were more concerned with teaching students by example to develop an appreciation for these skills than with teaching the specifics of each skill set. We aimed to create an environment in which students had ample opportunities to practice *and learn from* the mistakes they make while practicing. Reflection is an essential component of this learning process.

We included a variety of individual and group reflective practices and exercises. Individual reflective practices provide a set of tools that a student can apply in private in order to understand what has happened and create intention in her life, but that view is often limited by what is possible within that student's set of stories about reality. Group reflective practices leverage the diversity of the group stories of what happened and what is possible in order to create a much richer design experience and understanding; the cost of this comes in the form of higher overhead to the team.

Providing a range of techniques allowed each student to assess which practices worked best for that student's personality and background, as well as for different situations she might encounter. Different people may learn better through different types of reflective practices. Typical introverts [Keirsey 1998] may prefer the privacy of a journal to participating in team retrospectives, while extroverts may be more effective the opposite way. Writing uses a different part of our brain than talking does. Many people think better when they are physically active [Thompson 2002].

While we experimented with many reflective practices aiming to cover a wide variety of individual learning styles (our specific choice of techniques being based upon our experience and the limited time in the course), several of these techniques proved to be valuable to many students.

The next four sections discuss the set of choices we made and the practices we implemented in the course. They include the background for each of these, our assessments of how well they worked, and the results from the student feedback.

3. Designing the Course Around Reflection

For students to learn and for their learning to last, they must be engaged in the material. We expected some resistance to learning "soft skills" because most engineering students had gone through their academic lives largely by working on their own and so had become accustomed to this style. Thus, we employed several

principles to try to awaken the students to the importance of these skills, though in some cases that realization did not come until late in the quarter (or perhaps not at all). Many of these principles were motivated by trying to create as corporate an environment as possible within the constraints of a university class in order to maximize the learning.

The principles behind our course design were:

- Reflective practices require time and practicing.
- Large teams force students to deal with team and project coordination, and thus create material for reflection.
- Experiential learning provides material for reflection.
- Reflection supports the development of key skills in all domains.
- For students to benefit from reflective writing, it helps to put them into a situation where they have to struggle enough to collect material for reflection, but not too much [Socha 2003].

From these principles we derived the following major course elements that promote reflective learning:

1. Pre-course setup
    a. Increased length of class sessions
    b. Availability of both a lecture room and a computer lab
2. During the course
    a. Setting the tone in the first class session
    b. Journaling
    c. Starting and staying on the path to Mastery
    d. A single large project team
    e. Team conversations
    f. Weekly reflective essays
    g. Experiential simulations & Expert practitioners telling stories
    h. Retrospectives
3. End-of-course closure
    a. Personality types
    b. Portfolios
    c. Peer reviews
    d. Final Exam

The following sections describe these elements. Appendix 1 summarizes them and other reflective practices we experimented with in the course.

4. Pre-course Setup

A couple of elements helped structure the course so that it could better accommodate our mix of project and experiential simulations.

Increased length of class sessions. The first adjustment came before the course started. David changed the course from its normal weekly schedule of three one-hour lectures and one one-hour lab to three two-hour sessions so that we could fit in simulations. A simulation is an experiential learning situation carefully crafted for a specific learning outcome and controlled by a facilitator [Tener 2001]. We believe a simulation ideally has at least the following sequence of stages: an introduction, a period of acting in the simulation, a reflective debrief, another period of acting in the simulation, and a final debrief. One hour does not give sufficient time for this. Three hours seems to be the ideal length [Smith 2002b] but for practical reasons we settled on 2-hour periods. Now, given the benefit of hindsight, we suspect that having yet another hour would have further improved the learning process since the level of interaction and engagement tended to still be rising at end of each 2-hour simulation session. This observation was also supported by feedback from one of our students.

Availability of both a lecture room and a computer lab. We also arranged for the course to have both a standard lecture room and a computer lab available for all class sessions. This allowed us the flexibility to choose the most appropriate environment as needed. Simulations typically benefit from a flexible seating and

desk arrangement, while project work benefits from in-class time spent working on the project where instructors can observe and facilitate.

5. During the Course

This section lists the techniques emphasizing the importance of reflection as an essential component of the learning process. Most of these were introduced in the first week of the course.

Setting the tone in the first class session. The beginning of a course is an important time. Students are fresh from the recent break. How the class starts sets the tone that lasts for the duration of the course. The first session was devoted to the reasons behind the course structure. We began with a discussion using some reflective questions from *Teaching With Your Mouth Shut* [Finkel 2000] to uncover the learning cycle model [Weinberg 1985] of experiential learning upon which we based the course. This learning model, very similar to Kolb's [Tener 2001], explicitly includes reflection as a necessary component of learning. As we told the students, we would be doing this over and over again, both in sessions with outside experts facilitating simulations and in the project itself. The purpose was to put reflection foremost in the students' attention.

From the beginning and throughout the course we made it clear that the students were the ones expected to make most of the decisions in this class. The project was theirs to organize and run. We, instructors, largely taught with our mouths shut, primarily acting as facilitators and providing feedback on homework and on the state of the project. We would *not* tell them how to do the project. As expected of people not used to experiential learning (in an academic setting), this disconcerted many of the students, but they gradually got used to this freedom and responsibility.

We also outlined the five skill domains listed above and grounded the importance of these with stories from our own experience in industry as well as using quotes from other industry practitioners.

Of course, these were merely words, and some students did not believe us until the project was well underway and they had experienced the problems of not using the soft skills. In week six, one student apologized to David for not having believed him earlier in the quarter.

Journaling. The first session also introduced journaling – a lightweight and particularly effective mechanism for individual reflection. The act of choosing words to express our thoughts helps to clarify them. Writing in a private journal is a safe and often effective way to get an insight into a situation, since it tends to reduce the emotional load and thus makes it easier to understand the issues. It reduces the need to prove something or defend one's actions. Instead, it allows one to focus on creating an honest assessment of a situation. In particular, writing about uncomfortable experiences often reveals that they were not as bad as they felt or uncovers ways to deal with them. This is less likely to be the outcome of talking to someone else unless that person is both a close and wise friend.

We required each student to use a physical journal to record her[4] reflections during the class. We find many good reasons for using a physical journal. Writing by hand uses different muscles than typing and thus promotes different ways of thinking that in turn helps to construct new knowledge. Furthermore, even with the latest advances in technology, the physical page still remains a much richer[5] and more accessible medium. A physical journal promotes writing down over continual revision, so students work more on the concepts and less on reformatting the expression of a concept. Finally, physical journals form a more stable historical record.

We wanted the students to write often enough to start seeing the value of journaling, but we could not force them to write in a journal outside of class. Instead, we dedicated the first and last five minutes of each class session to this activity. David also emphasized the importance of journaling by purchasing an expensive leather-bound journal and writing in it while students wrote in theirs.

We instructed students to "write about whatever is important to write about at that moment." We do not claim that this is preferable to the more structured approaches other educators have taken but it did not restrict the students' own choices and so allowed them to develop their own styles. More importantly, it implied that a journal could be used for reflections on anything in their lives, not only on course-related issues. We believe this is essential because school is just one venue for lifelong learning, and a temporary one at that. To us, of higher importance was to instill the practices that would help these people become and stay lifelong learners.

[4] We use feminine pronouns for all students, to preserve their anonymity.
[5] For a thought-provoking description of the social aspects of paper see [Gladwell 2002].

One of the difficulties of using experiential learning in a classroom is judging when to leave students alone and when to intervene. We tended toward allowing them more freedom – something that many appreciated later, even if it caused them some discomfort at the time. By letting them run the entire project, we allowed each student to challenge herself as she felt appropriate.

With journals, for instance, we considered whether we should ask to read the students' journals in order to provide feedback, or have them be private so that the students could freely express themselves even if their writings contained criticisms of the instructors.

In the end, we decided in favor of the journals remaining private to the students. We felt this freedom to write anything without having to think about who would read it was more valuable than the feedback we could have provided on their journal entries, especially since we were providing feedback on their weekly reflective essays that they submitted to a public forum. We believed it would increase the chance that they write about what matters to them in as open a manner as possible, even if these issues had nothing to do with the class. For instance, one of the students became a "converted" fan of journaling about half way through the course when writing about her sibling's problems greatly helped both her and her sibling. She has kept it up ever since and now, four months later, claims it has changed her life[6].

We did not provide example structures to use in reflective writing, such as in the Reflective Learner [Turns 1997] or the Critical Incident Reports used by [Jolly 2000]. We felt that a completely unrestrained forum would be the best tool to complement other reflective techniques in maximizing student learning.

Starting and staying on the path to Mastery. The first assigned reading was *Mastery* [Leonard 1991]. We chose this book because of the value it had provided to us and others we knew, and the emphasis it placed on the practice necessary for lifelong learning. The book had an important impact on the tone of the course. (Simply seeing it on the required reading list changed Valentin's perspective of this course from being "just another software engineering course" into being something novel and interesting.) The book itself is a profoundly reflective work, so reading it implicitly reinforced the message about the importance of reflection. Writing reflective essays on parts of *Mastery* during the first two weeks forced students to practice reflection themselves, and our written commentary on each of their writings gave them feedback and served as individual guidance. *Mastery* also created a common vocabulary that survived for the duration of the course – something we had not anticipated but which was a welcome success. Students continually reflected upon concepts from the book, such as how different situations related to their own "path to mastery," their tendencies toward being a "dabbler," "obsessive," or "hacker," and seeing "homeostasis" in action. Many students remarked on the value they got from this book. As one student told us three months after the class, *Mastery* helped focus student attention on reflective techniques.

Not all students appreciated *Mastery*. Many were eager to get to the "meat" of the course – the project – which is precisely the reason why we delayed telling them about the project definition, domain, or tool set until half way through the second week. This gave us the time necessary to first lay the foundation for lifelong learning and development of team skills.

A single large project team. During the second session we told the students that they all would work together on a single instance of a project. The motivation was to force them to deal with the coordination and leadership issues of teams, which would support our goal of teaching them the soft skills that are so crucial for effective (software) engineers. Small teams, however, can perform well with a much smaller use of formal team and project skills. In some cases, even if the rest of the team is not performing, a single super-star developer can "rescue" a small team's project. With 22 people in a single team, however, that is hardly possible.

The larger team also provided ample material for reflection. It increased the chance for inter-personal problems as some students assessed that others were not doing their fair share or keeping their promises. Even if a sub-group of the students worked very well together, they would still have to deal with the rest of the class and there is a very high chance that someone will get upset at someone else. While this type of conflict is often viewed as negative, learning to deal with it effectively in a safe academic environment can provide invaluable lessons before the pressures of industry set in [Socha 2003].

The decision to use a large team disconcerted many of the students. We believe this was partly due to the common practice of limiting team sizes to at most 5 individuals in virtually all courses taught at our department

[6] This is grounded by her changes in career and life direction.

and at most other universities, and partly due to students lacking any prior team or project skills, much less exposure to complex environments with larger teams. The decision, however, was critical for creating a more authentic environment where the students could explore the coordination skills necessary for many of the team and project experiences they would encounter in industry. Most students came to realize the value of the large team. Of the ten people who gave us feedback (on our broad question what we should keep and what we should change in future versions of this course) four months after the course had ended, five of the six who mentioned the large project team said they found it valuable. One student said she "especially found working in a large group environment to be eye-opening and educational." Another "particularly liked working in a large group. I found this really taught me the most about group dynamics, and how many people can come together to produce a large product in a relatively small amount of time."

After the instructors led a class discussion on potential strategies for effectively organizing many people, students were given one minute to choose their teams. (An alternative would have been to let them take as long as they needed to, but we expected them to learn a lot regardless of which team they were in, and we felt that there were more valuable things to concentrate on especially in light of the very short quarter.) The students made a decision to organize into five teams of 4-6 students with each team having a lead. Additionally, all team leads formed a "Lead Team".

Team conversations. After forming teams, we introduced the ten conversations that Robert Dunham [Dunham 2001] believes constitute a team. He defines a team as a set of ongoing conversations taking place in a community of people. The claim is that teams must have these conversations in order to be effective, even if the conversations are done quite informally. This is a view of teams that provides clear guidance on how to establish teams and keep them healthy, even if it still requires a lot of practice.

One of these conversations is about safety. In order to maximize learning, it is important to provide an environment where students feel safe enough to take risks and learn from mistakes. The first conversation that we suggested to the sub-teams was aimed at answering the following two questions: "What must happen for you to feel safe?" and "What must not happen for you to feel safe?"

Each team spent 30 minutes writing their collective answers onto a large sheet of paper. The entire class then discussed what different teams had found in order to see the similar yet different needs of the different teams. Each team's answers became their established "rules" which the members of that team had agreed to abide by in order to foster an atmosphere of safety, and by extension creativity, within the team.

However, no inter-team rules were established, which led to misunderstandings as early as the second week of the project.

Another conversation was about leadership. After it was agreed that teams should have leaders, each team spent 30 minutes electing its representative. As it quickly became apparent in the weeks to follow, the elected team leads had little effective authority vested in them by members of their teams, which indicates a failure in at least one of the conversations. Still, even though their leadership was mostly ineffective – nearly all students felt that way at the end of the course – the reflective essays team leads wrote indicate that these students were able to nevertheless learn some important lessons from their experience.

Weekly reflective essays. Writing reflective essays to which instructors provide feedback enhances student reflective skills and learning [Turns 1997]. In our course, students had to submit two essays per week, each answering two reflective questions (see below). Instructors returned these with written comments within a week. These essays also provided feedback to the instructors and were a starting ground for conversations between instructors and students.

Students submitted their essays to a web site where they were publicly visible. Our hope was that in allowing public access to this site, students would learn from reading and reflecting on the writings of their peers. Although we know that some of the students read other students' writings, we do not know how prevalent or useful this was.

The questions on the reflective essays were:

1. Describe what you learned in this class during the past week and why it was significant to you.
2. Give an example of your best work from last week and explain why it was a good accomplishment.

We also assigned reading-specific writings. The ones for the Pragmatic Programmer [Hunt 1999] were:

3. What ONE thing will you do during the next week that you would not have done if you had not read this part of "The Pragmatic Programmer"? Why?

4. Reflect upon ONE specific thing that you did last week. How well did it work? Were you satisfied? Why? Did it achieve the result you had expected? If not, was the unexpected better than the expected? Why or why not? What would you do differently to make it more successful next time? Why?

Answers to question #1 provided the most indication of reflection. The examples of best work from the previous week were often things mentioned in the answer to question #1. Question #2 did not work so well, since the students almost never kept to what they said they would do in their answers to question #1. We did not address this problem during the course.

Experiential simulations & Expert practitioners telling stories. During the quarter, industry experts facilitated eight experiential simulations or interactive sessions where they told reflective stories from their careers. The simulations were group exercises crafted for a specific type of outcome and facilitated by the guests. This gave students a chance to practice doing, learning, and reflecting under expert tutelage, and provided them with some key lessons.

The first simulation, led by David Schmaltz and Amy Schwab [Schwab 2002], addressed the question of "What do you do when you don't know what to do?" The facilitators introduced the Satir Change Model [Weinberg 1997] and then had the students play the "Small Change Game" whose explicit goal was to maximize a certain metric. After a while, they paused the simulation and asked students if they knew what they were doing. Most students thought that they did, but as the conversation evolved it became clear that none of them did. What looked like a simple "success" criterion turned out to be extremely vague. The students could now look back and see what they were doing when they did not know what they were doing. Many of them reflected upon this in their later writings. As one student wrote four months later, this question is something that "I'll always keep with me."

In week five Steven Smith led a simulation about "When is a product ready to ship?" [Smith 2002a]. Again, this was a seemingly simple game that required students to make the tradeoffs as would be expected in industry. The difference was that it was done in a safe environment where they could learn from their "mistakes." On one of the final exam essays one student wrote that "Through my inability to effectively debug ... in Steve Smith's marble QA game, I realized and then began making sure I had a reason for doing something before investing time in doing it."

When James Bullock came in week seven to do an experiential session, he quickly changed gears when it became clear that the students were already overloaded with their project work and had more pressing questions they wished to ask him. He spent the full two hours answering student questions about how to handle certain problems they were having and whether such problems really happen in industry. This provided a valuable perspective to help students gauge whether the lessons they were learning were valuable. By that time, students were fully into reflecting about their project.

Later that week Bjorn Freeman-Benson talked about how engineers create value. Then he randomly chose students and asked them what their value was to the customer. This caused students some discomfort, because most of them were not prepared to answer this question. One student wrote about her discomfort when she "miserably failed to answer the question." It is precisely this sort of discomfort that prompted several students to reflect upon this event in that week's reflective writing.

Retrospectives. Retrospectives [Kerth 2001] are a mechanism to leverage the design capacity of groups to learn from what happened, strengthen teams, and create intention for what to do in the future. They also help students to realize how much was accomplished, which brings satisfaction and confidence, and how much was not accomplished, which brings realism and identifies areas for innovation. We scheduled one 30-minute retrospective every other week, with full 2-hour retrospectives half way through the course and at the end of it (see Appendix 2 for our complete course schedule). These retrospectives used a variety of exercises done by groups or by the entire class. One of the most successful exercises was the Emotions Seismograph [Kerth 2001, p. 127] where teams drew a chart showing how each team member's mood (or emotions) changed over a given period of time. This exercise introduced emotions and moods as legitimate aspects of work, recognizing their strong influence on individuals and others around them.

Using a variety of group reflective exercises exposed students to different ways of reflecting and creating intent for the future. Doing group exercises allowed them to see the difference between their individual reflections and those generated by the entire class. Many of these exercises derived from exercises in the

Weinberg & Weinberg leadership courses, Norm Kerth's book on Project Retrospectives [Kerth 2001], and the Amplifying Your Effectiveness conferences [AYE].

Students appreciated the variety of the retrospectives, though one student recommended (in the feedback we solicited four months after the class) that the retrospectives be more focused on how well the prior week's plan had been accomplished.

6. End-of-course Closure

We ended the course with several elements designed to bring closure and help students to recognize their individual and group achievements.

Personality types. Recognizing that other people *really* do think differently and have different perceptions of what is "best" makes it easier to respect people. We had not planned to cover personality types until a student recommended it and by that time it had become clear that many students were struggling with respecting some of their colleagues. We adjusted the original schedule to cover personality types in the second-last session.

In that session, the students first took an online version of the Myers-Briggs [Keirsey 1998] Personality Type Indicator test and then proceeded to the classroom to discuss the results. Because of the danger that people might put too much emphasis on being of a particular type, we were careful to state that the measures reflected current preferences, *not* definitions of who the test taker is and always will be. They measure a person's "strengths" for that day and in that setting, but can change over time as well as across different contexts (e.g., at home versus at work).

Portfolios. Portfolios [Olds 2000] are a mechanism for students to gain an appreciation of how much they have accomplished and can be valuable when students prepare for a job interview. On the last day of class, each student handed in a hard-copy portfolio of examples of their best work related to the class. Each example had to have a short description of it. Although we were surprised by the creativity of some of these, it was not clear how much value students got from this exercise. Perhaps one reason for this is that portfolios were never a central aspect of the course design.

Peer reviews. Peer reviews are a valuable industry technique for learning how your peers see you. In order to provide this benefit to the students, and to emulate yet another aspect of industry, we had each student fill out (on the last day of class) an anonymous peer review of all the students in the class on the last day. (To alleviate concerns about grading, we had stated that we would not use the results of the peer review for grading purposes even though we would have those results at that time.) The instructors compiled the results and sent each student her results after the end of the quarter. Only one student wrote back acknowledging the receipt of her results, so it is hard to gauge the effectiveness of the practice. We suspect that if the practice had been more tightly integrated into the course – perhaps performed several times during the quarter – it might have affected student behavior and caused learning.

Final Exam. The take-home Final Exam consisted of four questions intended to get the students to consolidate their learning and create intention for the future:

1. Of the things that you did in [this course] which would you do again and why?
2. Of the things that you did in [this course] which would you *not* do again and why?
3. Describe your current assessment of what a "software engineer" does and how.
4. From the customer's point of view what value did you add to this project?

In order to help them focus on building their reflective skills and on learning during the quarter, we had told them the first two questions in the first week of class and had repeated them a few weeks later.

The final exams demonstrated a variety of lessons. Most students claimed they would continue journaling. Many had thought through their answers to the "value"-question (question #4) on which they had stumbled upon earlier. Here are some example quotes:

- "These habits made me unproductive ... seeing them when writing the weekly reflections was demoralizing"
- "That period of prolonged chaos we went through was useful.... That's where we started asking ourselves some tough questions, and reevaluating our previous decisions."
- "The environment [of the class] itself made learning from my classmates easy."

- "There were a lot of things all of us in the class did that didn't work so well, but we learned from it, and I wouldn't want to change that."

7. Results and Conclusions

Our goal was to get the students to appreciate the need for "soft skills" so that they would spend the time and effort honing their people skills. While the reflective essays and final exams gave us some indication of what the students had learned, these could be biased by their desire for a good grade, especially since they knew that the practice of reflective techniques was a main factor in determining their grades. Similarly, how they rated various parts of the course does not necessarily indicate what they learned. To assess what students have actually learned we asked them the following questions four months after the course had ended:

1. "If we teach this course again, which aspects of it would you recommend that we keep and which ones may need to be changed? Some things did not go as well as we all wanted. Others went better than we had expected. What is your take on this?"
2. "Have you found yourself applying some of the lessons you learned in [the class] and if so, which ones (of the following): journaling, team conversations, team retrospectives, thinking of the path to mastery, portfolio, personality types, learning cycle, Pragmatic Programmer lessons, Peer Review feedback."

Eight of the 22 students replied to the second question, while we received 10 responses to the first. The key points from the feedback are:

- The number of those eight students who have continued using that lesson are: journaling (5), thinking of the path to mastery (4), team conversations (3), team retrospectives (3), personality types (3), learning cycle (2), Pragmatic Programmer lessons (2), portfolio (1), Peer Review feedback (1).
- Five of the six people who mentioned the large team believed it was valuable. One student wrote, "I especially found working in a large group environment to be eye-opening and educational." Another wrote "I particularly liked working in a large group."
- Several students mentioned the value of the experiential simulations. One remarked on how she liked the "variety of the exercises," though she would have liked more of them to be closely linked to the project material.
- Five students said they would have liked more direction from the instructors, though one of these also mentioned that they had not believed us when we spoke of the need for a detailed project plan and that "If we hadn't faltered as we did, I don't think we would have fully realized the importance and need for these tools." We believe it would have helped students to get more examples of good instances of tools for managing projects, such as different types of project plans. Even so, it is not clear whether they would have adopted any of those until they were forced to by having failed to achieve the desired results otherwise.
- As shown above, 5 of the 8 students have continued journaling. One student wrote, "I think that [journaling] is the most valuable thing I picked up from this class." Another one with many years of executive experience said, "I was not in the practice of journaling everyday. I use this now and find it useful."

  Even when we consider the full-class response on journaling in the end-of-course questionnaire, it appeared to be the practice that they saw as bringing them the most value: 75% of the students rated journaling as giving them 'value', while 32% qualified it as one of 'high value'. In the final exams, journaling was the most commonly mentioned practice students said they would continue.
- Half of the students continued thinking of the path to mastery. One said "I think of the following when I ran into some difficulties: thinking of the path to mastery, learning cycle."
- Three of the students continued to use team conversations.
- Several of the students noted the benefit of the challenges they faced. "I absolutely enjoyed the class better because of the difficulties we had. It made the project much more challenging, and it made it feel like a much bigger accomplishment when we were finished."

In addition, we have received unsolicited emails from students. In one of them a student had the following to say about the impact of this course on her career: "The team conversations and retrospective methods have been highly effective in building strong and creative communications within the team... Nevertheless, the tool I have

found to be the most effective has been journaling, it has helped me to manage and track my learning experiences, converting goals into reality and ideas into actions."

From their reflective essays and the post-course feedback it appears we were successful in teaching reflection and in raising the importance of team and project practices. As one student put it: "This simulated corporate scenario in a controlled environment was the best learning experience in all my 4 years at the UW. More important than learning out of a book, I learned about myself."

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Appendix 1. List of Reflective Practices

Table 1: List of reflective practices and techniques we used in the course

Technique	Brief Description	Reflective Purpose
TWYMS test[7]	• What were your most significant learning experiences in life? • Was an instructor directly involved?	• Gets students to reflect in first class session
Learning cycle	• Do; reflect; introduce new models; do again	• Identifies reflection as an integral part of learning • Discourages looking for quick solutions
Journaling	• Students wrote in journals for the first and last five minutes of each class session	• Builds the habit and discipline for practicing • Promotes individual reflection
Team conversations	• 10 types of conversations that effective teams regularly have	• Emphasizes the importance of teams • Provides tools for running teams
Safety exercise	• What must happen for you to feel safe? • What must not happen for you to feel safe?	• Gets students to do a group reflective exercise
Teaching with our mouths shut	• Instructors created an environment for experiential learning, used facilitation, and avoided lecturing	• Provokes students to not fear the difficulties and practice • Forces students to make their own choices and construct their knowledge
Emphasis on learning	• Instructors made it clear that they were most interested in student learning • Reflective exercises were a major grading component	• Fosters a culture of lifelong learning

Staying on the path to mastery	• Students read the Mastery book and wrote about it	• Gets students to reflect upon
		  o their learning style
		  o how mastery relates to the subject matter (software engineering)
		• Connects reflection to something bigger (the student's path to mastery)

Reflective writings	• Weekly 1-page essays directed by questions • A take-home Final Exam	• Forces practicing reflection • Helps instructors gauge learning and guide students individually
Simulations	• Experiential workshops each aimed at a specific learning outcome	• Forces practicing reflection under the guidance of an expert facilitator • Demonstrates how the learning cycle works • Creates material for reflection
Operating as one large team with sub-teams	• All 22 students worked together on a single project	• Provides reflective material by forcing students to deal with team and project coordination
Project retrospectives	• Group reflective exercises	• Gives students practice in a variety of group reflective exercises
Stories from expert practitioners	• Sessions where outside industry experts told work-related stories	• Exposes students to many reflective stories in an interactive setting

[7] A set of questions drawn from *Teaching With Your Mouth Shut* [Finkel 2000]

Technique	Brief Description	Reflective Purpose
Personality type test	• Took and discussed the Myers-Briggs personality type test	• Promotes reflection on how a personality type changes one's perceptions and actions
Individual student portfolios	• Each student prepared an end-of-term portfolio of her best work	• Forces a reflection on the value of the individual's contribution to the team and on the learning that the experience led to
Challenging students	• Instructors provided assessments of student and project performance, including challenging students' own assessments	• Provokes students to reflect
Individual feedback on student writings	• Instructors provided ample individual feedback on reflective essays	• Provides material for reflection • Helps teach techniques for reflective writing
Openness of student writings	• Weekly student essays were stored digitally in a public-domain site	• Enables learning from peer reflections
Public presentations	• Presentation #1: Each team presented the architecture of their respective component • Presentation #2: Final official customer presentation to instructors and an outside marketing person	• Forces students to objectively evaluate their product and put those assessments in the perspective of what brings value to the customer

Appendix 2. Our Class Calendar

Week	Monday	Wednesday	Friday
Week 1	Welcome Why are we here?	Join company Form teams	Action Meeting Team conversations Retrospective (last 30 min)
Week 2	Workshop: Managing Change	Action Meeting Meet a Marketing person Introduce project & development system	Workshop: Use cases Retrospective (last 30 min) *Due:* project plan v.1 at 5pm
Week 3	Workshop: Supporting Work in Distributed Organizations *Due:* project plan v.2 at 5pm	Action Meeting Work on project *Due:* project plan v.3 at 5pm	Finish architecture spec Retrospective (last 30 min) *Due:* project plan v.4 at 5pm (arch + schedule)
Week 4	Workshop: Testing *is* Science	Workshop: About Business	Action Meeting Work on project Retrospective (last 30 min)
Week 5	Workshop: When to ship	Action Meeting Work on project	Midterm Retrospective
Week 6	Work on project	Action Meeting Work on project	In-class Team Presentations Retrospective (last 30 min)
Week 7	Workshop: Development Systems	Action Meeting Work on project	Guest Retrospective (first 30 min) Work on projects
Week 8	Work on project	Action Meeting Work on project	Practice customer presentation Retrospective (last 30 min) *Due:* project CD-ROM at 5pm
Week 9	Customer presentation and project demo Customer feedback	Personality Types	Peer appreciation Fill in peer evaluations *Due:* Portfolios, take-home final exam, questionnaire