

Facilitating Habitual Reflection in Students - Application to an Engineering Capstone Project

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Abstract— This work-in-progress examines an attempt to develop reflective habits in engineering students, towards engendering life-long reflective practices. The intervention was designed to implement theoretical frameworks of reflection in engineering education and self-regulated learning. The theory of reflection used is based on five elements of reflective activities: the experience, its features, the lens through which reflection is taken, the meaning making, and influence on future action. Self-regulated learning focuses on instilling behaviors and character traits to help students understand themselves as learners, strengthening their abilities to engage in new topics.

This study was implemented with four senior civil engineering students throughout a year-long senior capstone project. Reflection was facilitated within the team by applying a consistent reflection framework (rate individual and team progress, identify goals for improvement, identify a plan to meet these goals, assess success in implementing plan from previous week) onto diverse aspects of the design project (individual performance, group meetings, and presentations) with multiple contexts (thoughtful review for individual performance, video review for group meeting and presentation performance). Reflection activities were carried out weekly with advisor notes returned to them prior to the next week's activity.

Through *repetitive reflection* using a *consistent framework* applied through *various contexts* the students are trained to *implicitly apply* reflection in their coursework and, ideally, in their daily lives. This paper documents the successes and challenges of applying this methodology to a year-long senior capstone project with four undergraduate students.

Keywords— *reflection, self-regulated learning, assessment*

I. INTRODUCTION

Reflective practices are key to many pedagogies that seek to empower students in their own learning and development. Reflection is a strategy that helps students to gain a deeper understanding of an educational experience, which can be broadly related to three areas: technical knowledge, understanding of themselves as learners, and development of their personal and professional identities [1]. Helping to develop engineering students and professionals towards these ends should be a central goal of engineering educators – a goal reflected in the ABET criterion 3 objectives of educating lifelong learners, ethically and professionally responsible engineers, and engineers who understand the broader impact

of their work in varied contexts [2]. Reflection could be a strong strategy toward achieving these educational goals.

A five-element framework developed as part of the Consortium to Promote Reflection in Engineering Education (CPREE) was used in the intervention design. This framework characterizes reflection as having five key elements – *experience, features, lens, meaning, and action* [1]. Explanations of each of these features and a description of how they guided the development of the reflection intervention are discussed in the methods section.

Self-regulated learning (SRL) and service-learning are two pedagogical approaches that incorporate reflection. SRL focuses on instilling behaviors and character traits that help students to understand themselves as learners, strengthening their abilities to engage in new topics [3,4]. The three key elements of self-regulated learning focus on preparatory work before an event, skills to improve performance during that event, and self-reflection that helps participants assess their performance during the event with the goal of improving for future activities. Reflection plays a key role in SRL as it allows the participant to review their performance, tie it to their preparation, and ideally adjust their preparation behavior on similar future activities to improve performance. SRL has been shown to improve student learning in courses, engage students in deeper thinking, increase awareness among students of their learning styles and adjust behavior to foster better learning, and to develop reflective and responsible professionalism [3, 5-6].

Reflection also plays a central role in the effectiveness of service-learning. Research has shown that service-learning helps students improve academic performance, increase their ability to apply technical learning to “the real world”, and improved interpersonal development including leadership and communication skills [7,8]. Reflection is key to realizing these benefits. In service learning, reflection allows students to connect their out-of-class service with the course content [9], and helps students to better understand the societal impact of engineering work [10].

The overarching goal of this work was to engender a reflective habit in students, such that they reflexively apply it to coursework and outside of class. *Specific goals* included: 1) have students engage with a structured reflection framework across diverse contexts, 2) understand the key components of productive reflection, 3) use reflection in various forms (survey, video, open answer, feedback) to improve project,

presentation, and group meeting performance, 4) have students begin using reflective practices beyond the scope of this project, perhaps in other coursework or “out-of-school” situations (i.e., evidencing habitual reflective practices).

II. METHODS

A. Intervention Development

This project was created as part of the CPREE program. This framework identifies five key elements to structure reflective activities; 1) The *experience* that the students considered was individual and team progress in a senior design capstone engineering project (including weekly work, presentations, and group meetings), 2) The *features* are individual and team progress towards meeting weekly and overall project goals, ability to carry out a plan towards satisfying weekly personal goals, reviewing success of previous plans and whether they should be continued, and reviewing how often their reflection plan/goals affected their weekly performance, 3) The *lenses* through which students reflect include ‘accountable disciplinary knowledge’ through meeting design project milestones, and ‘preparing for future learning’ through engendering reflective attitudes and instilling the elements needed for productive reflection; instructor feedback is also used to ‘support student awareness’ and encourage buy-in, 4) The *meanings* include increasing student understanding of productive reflection practices, increasing perceived value of reflection in their professional life, and increasing frequency of habitual reflection, and 5) The *action* fomented includes independently and reflexively using reflection.

B. Subject Group

Participants in this project include four senior undergraduate civil and environmental engineering students. These students are members of a senior design team working on a year-long design project, administered through the Seattle University project center with a sponsor, in this case a water and wastewater district. Each team has a faculty advisor and professional liaisons from the sponsor. A mixed-methods single case study approach was employed. Quantitative data are used primarily as descriptive while qualitative data are used to explore trends in the students’ reaction and thoughts for improvement. Team data are also compared against the class average to gauge trends.

C. Intervention Structure

This intervention uses four different reflection exercises; weekly project/team reflections, group meeting reflections, presentation reflections, and end-of-quarter reflection review. All exercises share a common structure of 1) reviewing your performance, 2) identifying what could be improved, 3) identifying a plan to improve it, and 4) reviewing your previous plan for improvement and assessing your success in realizing it.

Weekly project reflections are completed after thoughtful review of the week, whereas group meeting reflections are completed after watching a video of that students’ progress update in the group meeting, and presentation reflections are

completed after watching video of their in-class presentation. All reflections include open-ended and Likert items. Each assignment has room for advisor feedback.

At the beginning of the year and end of each term the students are given a reflection activity intended to assess how their attitudes towards reflection and uses of reflection are changing. Additionally, this assignment was given to the entire senior design class at the beginning of the academic year, and at the end of the academic year, to compare changes in the student team to those of the class at-large.

In order to better understand the four students’ perspectives on reflection in general and the intervention specifically, semi-structured interviews were conducted six months into the intervention. These interviews were conducted by a faculty member who was not the team advisor, and lasted between 20 and 40 minutes. *A priori* coding was used, focused on the four intervention objectives, and provides evidence of successes and challenges that supported the descriptive quantitative results seen through the assignments.

III. RESULTS AND DISCUSSION

Results will be discussed within the context of meeting the overarching goal of engendering a reflective habit in students, and towards meeting each of the four specific goals identified in the introduction. Results are based on the reflection assignments turned in by students, providing quantitative data, and interviews reviewing the overall intervention, providing contextual data.

1. Have students engage with a structured reflection framework across diverse contexts.

The team of four undergraduate students carried out nineteen individual and team weekly progress reflections, four group meeting video reflections, four presentation video reflections, and four ‘attitudes towards reflection’ assessments, per student. As outlined in the methods section, these reflection activities all used a consistent framework, and were applied onto diverse contexts, meeting the first goal of the exercise.

2. Understand the key components of productive reflection.

The authors identified four key components to productive reflection: 1) reviewing your performance, 2) identifying what could be improved, 3) identifying a plan to improve it, and 4) reviewing your previous plan for improvement and assessing your success in realizing it (closing the loop). Students were asked in quarterly reflections and the interview to identify the steps required in productive reflection, and their responses were scored 1-4 depending on how they compared to the definitions above. Figure 1a compares changes in team responses relative to the entire class. Class and student team responses were similar at the beginning of the study (1.6 and 2 respectively, Sep. 15), and class responses remained similar at the end of the study (June 6), again scoring near 1.6. In contrast, by the end of winter quarter (Dec. 15), and sustained throughout the year, the team demonstrated a more thorough understanding of the steps required for productive reflection, scoring near 3, though it did not develop to level 4 – review

and assess your plan for improvement (closing the loop). The data indicate that repetitive reflection with a consistent framework can deepen the understanding of the steps required for productive reflection.

At the beginning of the student interviews, each participant was asked to define reflection. In their responses, all four students' definitions included first an element of breaking from the normal routine (e.g., "taking the time" or "slow down") to "look back" at a previous experience. This view of pausing to look back is also key in the CPREE working definition of reflection [1]. They all spoke about "evaluating...how it went", generally about past performances or approaches, to then see "how things could possibly be improved for the future." These definitions seemed, generally, to embody the key features of reflection from the CPREE framework, namely, pausing to examine a previous experience toward improving future similar experiences.

3. Use reflection in various forms (survey, video, open answer, feedback) to improve project, presentation, and group meeting performance

Students applied the reflection framework to multiple aspects of their senior design course, including individual and team weekly progress, group meetings, and presentations. Though the goal of this intervention was to develop reflective habits, because the reflections were focused on these parts of the design project it's logical they would also be affected by the reflection process.

The team's perception of their presentation ability, Figure 1b, was initially lower than the class average (5.7 vs. 4.8 out of 10), but consistently increased from the end of fall quarter (5.8/10) to the end of winter quarter (6.3/10), to the end of the academic year (8.1), whereas the class, who gave a similar number of presentations as the team, only rated an improvement to 7.1 at the end of the academic year. One team member stated in her year-end reflection assessment "I feel like I really improved with giving presentations largely because I watched the video and made goals for improvement." Additionally student interviews indicated that for two of the four team members, the analysis of their presentations was very helpful, allowing them to see presentation habits that they had not previously recognized. For those two, watching the videos helped them to set future goals focused on their presentation skills. In this context it seems the students recognized the connection between reflection and targeted improvement.

To gauge the relationship between student perceptions of individual and team progress, and how frequently they applied areas of emphasis from reflection exercises ('frequency data'), the students scored their progress from 1-10 on a Likert type scale, and scored the frequency data on a 0-4 scale. Data for each student over the duration of fall and winter quarters is presented in Figure 2.

Overall the student perceptions of team and individual progress track each other, with Spearman Correlation Coefficients of 0.82, 0.62, and 0.79 for three of the four students, but -0.01 for the fourth student. These data could indicate that students do a poor job of differentiating team

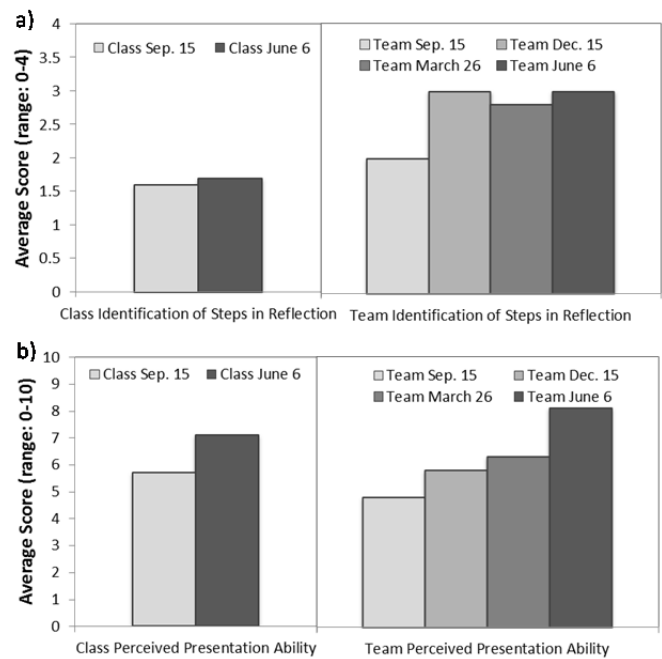


Fig. 1: Class vs. Team changes in understanding steps necessary for productive reflection (a) and in perception of presentation ability (b).

from individual progress, that team progress is a strong function of individual progress, or that students did not spend time during the reflection to precisely gauge differences in team and individual progress.

During the interviews, all four students talked about the weekly reflections, focusing mainly on the assessment of individual and team performance. Several students talked about how they felt discomfort with the Likert-item approach as it was "subjective" and that their scores tended to be more reactionary to their feelings about the week's progress. All four students commented on how they usually could not remember the goals that they had set for themselves the previous week, indicating that these goals were neither driving their work for the week, nor informing their evaluation of performance for themselves or the team. They did, however, all indicate that the goal setting and assessment of performance was useful and that this was one element of the intervention that they would suggest applying to all of the senior design teams in future years.

Several students also commented on how the advisor feedback was important both as a motivational factor for them to do the reflections and as guidance for them toward improving their future performance on the project. One student said, "The feedback is helpful. That makes it feel more important, that it's not just like I'm writing something, I'm giving it to you and it's just going in a pile somewhere. It's like [the faculty advisor is] actually reading it and giving thought back..."

4. Have students begin using reflective practices beyond the scope of this project, perhaps in other coursework or "out-of-school" situations (i.e., evidencing habitual reflective practices).

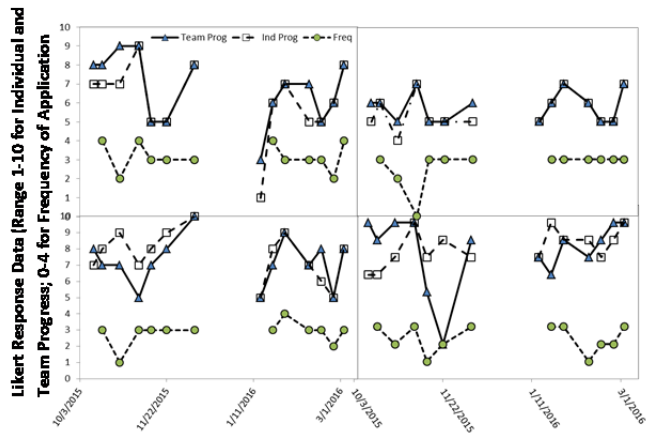


Fig. 2: Perceptions of team and individual progress, and how frequently the previous week's reflection exercise impacted student behavior for the current week, for each student and each week during fall and winter quarter.

The overall goal of this project was to create a reflective habit. Measures of meeting this goal include more frequently applying reflection outside of classroom activities, valuing reflection more highly, and if students are more likely to use reflection in the future. Table 1 shows team relative to the class data for frequency of using reflection outside of the course, for valuation of reflection, and for likelihood of using reflection in the future. Data do not indicate increased rates of using reflection outside of class, increased valuation of reflection, or increased likelihood to use reflection in the future.

The interviews supported these quantitative findings where the structured approach to reflection did not seem to have spread to other contexts. Several students talked about how they already considered themselves reflective people - usually in terms of reflecting on social contexts - and so they already knew how to reflect. This perspective seemed to significantly affect student 'buy-in', discussed further in the conclusion section. One student spoke candidly about applying reflection to other courses, saying "...I do reflect. I should have better study habits or I should start earlier. And then you get your grade back and you get like a B+ and then, like, 'oh well, [it] worked out', so you don't change."

IV. CONCLUSIONS AND LESSONS LEARNED

The goal of this work was to foment a reflective attitude in students. It was hypothesized that by having students frequently apply a consistent reflection framework to multiple aspects of a single course, and via different review processes (thoughtful review vs. video review), that students would 1) better understand the steps necessary for productive reflection, 2) improve project performance, and 3) upon seeing the benefits of reflection begin to naturally reflect more frequently both in class and outside of class. Preliminary conclusions include: i) Students in the team developed a better understanding of the steps required for productive reflection than the class at-large, ii) students consistently perceived their presentation skills as improving and stated that watching video of their performance and reflection on it helped spur improvement, iii) students valued goal-setting and

Table 1: Student team perceptions of the value of reflection and the likelihood of using reflection in the future for the student team relative to the entire design class.

	Class Sep. 15	Class June 6	Team Sep. 15	Team Dec. 15	Team March	Team June 6
Frequency of Using Reflection Outside of Class (out of 4)	1.8	1.7	1.8	1.5	1.5	1.8
Value of Reflection (out of 10)	8.1	7.7	7.3	7.5	7.3	7.8
Likelihood to Use Reflection in Future (out of 10)	7.6	7.4	7.8	6.8	7.3	7.5

recommended it for future teams, and iv) students in the team did not indicate that they valued reflection more highly, that they were more likely to use it outside of class, or that they were more likely to use it in the future.

The overall goal of engendering a naturally reflective attitude in students was not supported by the data. In general, students seemed most focused on using reflections to improve efficiency and productivity, but did not advance the techniques beyond this project or see them as a method for achieving deeper personal awareness or clarity.

The possible reasons for this are manifold. Paramount among them is a seeming low level of 'buy-in' by the students, uncertainty regarding how to score 'progress' each week, and a lack of clarity regarding goals of the intervention from the student perspective. The lack of buy-in seemed to be the largest barrier for this project as it was heavily discussed by all four students in the interviews. Student feedback attributed this lack of buy-in to feelings that this was "another thing that we're doing on top of everything else", that they were already reflective people, and that group dissent ("common complaining") made it easier to collectively not like the activities. When asked how to get better buy-in the students had few suggestions other than giving time in class for these activities and making the activities shorter. Though the actual time spent each week was little (5-10 minutes on average), the perception of time and another task is difficult to combat. The authors plan to better incorporate these types of reflections into future projects so that students see it as "part of", instead of "in addition to". Options include shortening the weekly group meeting by the equivalent time needed to complete the weekly reflection, carrying out the weekly reflection in the group meeting, or scoring participation in completing the reflections.

The lack of clarity regarding project goals was created intentionally because the authors did not want to bias the students and so introduced and administered the project in a very open-ended manner. This can be resolved by presenting more scaffolding at the beginning of the project; introducing the process and goals in steps that build on each other. This can be augmented by having periodic meetings at the beginning of the year where the team discusses with the advisor how they are scoring their progress and why, so that the team members can normalize their assessment scoring to each other and feel more confident in it. Reflection outside of class will only be reinforced if the students feel the benefits offset the costs. In this way, the authors believe that by providing more scaffolding the reflection exercises will also be more productive and beneficial, encouraging buy-in.

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