Enhancing Student Leadership Competencies Through Reflection

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Introduction
This paper describes the use of pedagogical approaches using reflection to enhance leadership competencies in two bioengineering courses at the University of Washington, building on our previous work [1]. Our aim is to 1) provide a set of curricular materials that any engineering educator can use to add reflection to any course to enhance student learning around leadership and 2) to analyze self-reported data regarding student development of leadership competencies.

Although leadership is an essential professional skill for bioengineering students, many programs do not teach it explicitly, for a variety of reasons, including the challenge of defining leadership in concrete terms and the lack of instructor and student buy-in. Our aim is to make teaching leadership to undergraduates more manageable by documenting our experience using leadership-focused activities in bioengineering courses. These activities leverage a teaching approach whose importance is becoming increasingly recognized in engineering education: reflection [2, 3].

Reflection is often used to promote cognitive development and can help students learn more from projects, internships, and other educational experiences [4]. For example, a common in-class reflective activity is the "exam wrapper": shortly after an exam, students articulate what they did that helped them do well on the exam and what they could do differently to improve their performance on a future exam. In this work, our teaching innovation is using reflection to promote understanding and development of leadership as a professional skill. By reflecting on course-related activities through a leadership lens, students appreciate that these experiences are helping them develop leadership skills.

To facilitate reflection on leadership, students in the two featured courses are introduced to the "leadership competencies" identified by Seemiller [5], including ethics, conflict negotiation, communication, problem solving, decision making, personal contributions to effectiveness of a group, and providing/receiving feedback. (See Appendix A for complete list of leadership competencies.) The competencies provide a common vocabulary that helps students articulate their leadership abilities and goals for further development of leadership skills.

Here, we provide several examples and student assessments of reflection activities to enhance student leadership competencies. Although these activities are described in a bioengineering context, they can easily be adapted to have value in other disciplinary contexts. Overall, students reported that reflective exercises helped them develop leadership competencies and increased their understanding of what leadership means, in general and in the field of bioengineering.

Methods
Courses. The featured reflection activities have been implemented in multiple offerings of two bioengineering seminar courses with different learning objectives and student populations. The Bioengineering Honors Seminar is a leadership-focused, discussion-based seminar with each offering comprised of approximately 25–30 senior bioengineering students in the departmental honors program. The collegium seminar, Bioengineering: Advancing Human Health, is a small seminar course with enrollment of approximately 15 first-year students (bioengineering majors and non-majors) and provides exposure to different research areas in bioengineering through

guest speakers and a team project in which students research and lead a class discussion on a biomedical innovation.

Table 1. Reflection activities to enhance leadership competencies (*=detailed description in text).	
Leadership Competency	**Description of Reflection Activity**
Receiving and providing feedback	*Reflecting on project feedback:* Students critique other teams' preliminary project proposal presentations. Teams are required to prioritize received feedback and document how they modified their proposals in response to feedback.
Conflict negotiation	*Reflecting on team conflict:* During team check-in meetings with instructor, students are asked to reflect on instances of team conflict and identify approaches that may be helpful in future conflict situations.
Self-understanding, Self-development	*Reflecting on challenge and development:* In the first class meeting, students write a private letter to their future self, responding to prompts about prior and anticipated challenges. The instructor keeps the sealed letters until the last class meeting, when students revisit the prompts before reading their letters and consider the impact of reading these letters.*
Collaboration, Productive relationships	*Reflecting on team membership:* After a team project, each student writes about their contribution to their team and the value of the team experience.
Personal contributions to effectiveness of group	*Reflecting on complementary strengths:* At the beginning of the team service project, each student writes about how their leadership abilities interact with their teammates' abilities to help ensure project success.
Competencies self-selected by students	*Reflecting on expert accounts of leadership:* After guest presentations about leadership in bioengineering careers, students write about the leadership competencies that they deem most important and personally relevant in response to the following prompt: "Pick a competency mentioned today, and describe what lesson you many have learned about it from the guest speaker. How does this lesson apply to your own life?"
Self-understanding, Self-development, Productive Relationships, Collaboration, Responsibility for personal behavior	*Reflecting on self-value and personal goals for development of leadership skills:* In the first class meeting, students write a private letter to their future self, responding to prompts about goals for personal development during the team-based project. The instructor keeps the sealed letters for later use. *Reflecting on teamwork and project progress (midpoint check-in with instructor):* Students read their letters and review the areas they wanted to develop, their team contributions, and how they are taking steps to develop desired competencies. *Reflecting on development:* At the last class meeting, students revisit the prompts before re-reading their letters and considering how their perspective has changed. Students reflect on development of leadership competencies and how this will inform future actions as a leader.*
Verbal and nonverbal communication	*Reflecting after team-based presentations:* Students reflect on their experience of the visual and oral communication decisions made during their own presentations, as well as those of their peers.*
Note: Table 1 is modified from authors' previous work [1].	

Assessment. Assessment includes student self-reported data obtained by surveys examining 1) how reflection contributed to identification and development of students' individual leadership competencies, 2) the perceived impact of reflection on students' ability to utilize and refine their individual leadership strengths, and 3) student feedback about the effectiveness of reflection activities. We provide additional supporting data from end-of-course student evaluations, instructor observations, and excerpts of student work.

Example Activities
Here we present brief descriptions of reflection activities, including specific prompts used for each activity, to allow instructors to try these activities in their own courses. A summary of all reflective exercises implemented in each course with the corresponding leadership competencies is shown in Table 1. Below we provide detailed descriptions of two activities: 1) Letter to Future Self, which was used to enhance different learning competencies in each course and can be modified to be suitable for any bioengineering course, and 2) Reflecting after team-based presentations, which is applicable to any course involving development of visual or oral communication skills.

Letter to Future Self
Targeting self-understanding and self-development in the senior honors seminar. Students write a letter about current issues and problems they are facing, which is a general but appropriate topic for advanced students who are beginning to make post-graduation plans. In the first class meeting, students are given 15 minutes to write a private letter to their future self in which they address the following prompts, which are displayed on the classroom screen:
1. What are the pressing issues in your life at this moment?
2. What are a few specific questions/problems that you hope your future self will figure out by the end of the quarter?
3. What is some advice that you hope you will follow this quarter?

After students place their letter in a sealed envelope, the instructor keeps all sealed envelopes until the last class meeting. The instructor never reads the letter, so the letter's content is not graded. On the last class day, students are shown the prompts again and asked to think about how they would answer those questions in the present-day if they were to write another letter.

Finally, the students are given 15 minutes to read and reflect on their letter, and to complete a brief written reflection addressing the following prompts:
1. Overall, did you experience positive, negative, or neutral emotions as you read this letter?
   a. What was it about the letter that you think led to this emotional response?
2. Did the letter say what you remembered writing? Did anything surprise you?
3. What were the differences in how you answered the prompts today vs. first day of class?
   a. What might account for these differences?
4. How much of the advice you wrote in your letter still applies to your current situation?
5. What can you take away from this exercise for future use?

Targeting Self-understanding, Self-development, Productive Relationships, Collaboration, and Responsibility for personal behavior in the first year seminar. Students write a letter about personal development in the context of their end-of-quarter team project, which is an achievable

and appropriate task for first year students. On the first day of class, after a class discussion on defining leadership, students identify goals for personal development during the team-based project. The instructor keeps the sealed letters for later use.

At a check-in meeting with the instructor midway through the team-based project, students read their letters and review the areas they wanted to develop. Students consider how the project is progressing, their team contributions, and how they are taking steps to develop desired competencies.

In the last class meeting, students revisit the prompts before re-reading their letters and considering how their perspective has changed. Students reflect on the development of leadership competencies and describe any self-assessed changes in preparation to act in a leadership capacity after the course by answering the following:
1. Overall, did you experience positive, negative, or neutral emotions as you read this letter? What was it about the letter that you think led to this emotional response?
2. How have your skills improved?
3. What can you take away from this exercise for future use?

Reflection After Team-based Presentations
In this activity, students reflect on their experience of the visual and oral communication decisions made during their own presentations, as well as those of their peers. The assignment prompt is as follows:
Think about the bioengineering innovation presentation that you delivered in class. This presentation should have allowed you to work on communication, one of the key competencies of leadership! There are many types of communication, including verbal and nonverbal, which I'd like you to think about.

Assignment Description:

1) Describe how you experienced your presentation decisions (i.e. slide design, use of visuals) as you delivered your talk. How did you experience your design of the visual aids or your oral delivery style choices?

2) What worked well for you, and what did not?

3) How might your experience with this assignment affect your slide design or other presentation decisions for future presentations?

Results and Discussion
In both the Bioengineering Honors Seminar for senior Bioengineering students and the Bioengineering: Advancing Human Health seminar for first-year major and non-major students, we found that reflection promotes development of leadership competencies and understanding of leadership. Both qualitative and quantitative data were collected through end-of-course student self-assessments.

Table 2. Student comments regarding development of leadership competencies and understanding of leadership by first-year students enrolled in the Bioengineering: Advancing Human Health seminar. Data from student end-of-course self-assessments in 2016 and 2017.	
Development of specific leadership competencies in this class	*"I think that throughout this class I've learned to speak up, ask questions, and self-analyze myself."* *"Working with a team for presentations gave me an idea of leadership in academics."*
Reflective exercises helped develop leadership competencies	*"Reflection is something I often neglect, but it is so important to be able to take some time for my own thoughts to make me a more organized person and increase my leadership skills."* *"Reflective exercises force you to think about what you're doing."*
Course increased understanding of what leadership means	*"Through the presentations and reflections, I realized that leadership comes in many different forms…"* *"This class helped broaden how I define leadership."*
Course increased understanding of what leadership means in the field of bioengineering	*"Being a leader in this field can mean many things, from taking initiative to doing research. Additionally, just being motivated and persistent yields a great leader."* *"Listening to guest speakers reflect on how leadership was applicable to their careers in education in BIOE gave me an idea of how they applied their leadership skills."*
Other comments	*"One thing I learned about leadership is that sometimes things fail, but the key is to deal with failure well and learn from it. This applies to my life, because I tend to give up when I fail."*

Reflection promotes development of leadership competencies and understanding of what leadership means in both first year and senior students.
Students responded to three questions (#2–4 below) on a Likert scale (1=not at all, 3=neutral, 5=very much) and provided brief comments on their Likert scores. Representative comments are shown in Tables 2 and 3.

1. What ***course-related activities*** have helped you develop specific leadership competencies through this class?
2. To what extent have the ***reflective activities helped you*** develop any leadership competencies?
3. To what extent has your understanding of ***what leadership means*** increased as a result of this class?
4. To what extent has your understanding of what leadership means ***in the field of bioengineering*** increased as a result of this class?

In the first-year seminar, in response to the question "To what extent have the reflective activities helped you develop any leadership competencies?" the average student ratings were 3.8 (SD=0.9) and 3.9 (SD=0.6) in 2016 and 2017, respectively (Figure 1). In response to the question "To what extent has your understanding of what leadership means increased as a result of this class?" the average student ratings were 3.9 (SD= 0.9) and 4.2 (SD= 0.7) in 2016 and

2017, respectively. In response to "And what about your understanding of what leadership means in the bioengineering field?" the average student ratings were 4.5 (SD=0.8) and 4.4 (SD=0.8) in 2016 and 2017, respectively.

Table 3. Student comments regarding development of leadership competencies and understanding of leadership by Bioengineering seniors enrolled in the Bioengineering Honors Seminar.	
Development of specific leadership competencies in this class	*"Made me think about my skills, not knowledge. Made me consider how to use my strengths and reflect on soft skills I have."*
Reflective exercises helped develop leadership competencies	*"So many opportunities for learning! I think the reflection in this class was so helpful for personal development."* *"The internal reflections of the course [were] stimulating in that it's not something I would do regularly."* *"The reflections sometimes emphasized the most important ideas but sometimes just felt like busywork."* *"I'm not much of a reflective person and reflection doesn't help when it's mandatory in a class, but I can see why it could be helpful to other students!"*
Course increased understanding of what leadership means	*"I had to think about what it meant to be a leader and how I would meet those expectations."* *"Showed the multifaceted aspects of leaders"*
Course increased understanding of what leadership means in the field of bioengineering	*"Guest speakers brought up a lot of new/important descriptions of leaders [in bioengineering]"* *"I was able to relate service and bioengineering"* *"Through my honors project, I have seen that bioengineering can have a large leadership component to it. It is not just about doing individual research in a lab, but actually much more."*
Other comments	*"I have seen this [content] before."* *"I kind of knew what leadership was before, but having it reinforced in this class was nice."* *"Having been through a leadership program before, I felt I had a good understanding coming into this class."*

In the senior honors seminar, in response to the question "To what extent have the reflective activities helped you develop any leadership competencies?" the average student ratings were 3.7 (SD=0.6) and 3.6 (SD=0.9) in 2016 and 2017, respectively (Figure 1). In response to the question "To what extent has your understanding of what leadership means increased as a result of this class?" the average student ratings were 4.2 (SD=0.7) and 4.0 (SD= 0.9) in 2016 and 2017, respectively. In response to "And what about your understanding of what leadership means in the bioengineering field?" the average student ratings were 4.2 (SD=0.6) and 3.6 (SD=0.9) in 2016 and 2017, respectively.

Similar outcomes were observed when comparing students in each offering of the same course and when comparing students from the two different courses. We show data from 2016 and 2017 separately to demonstrate consistency in student outcomes in the two offerings of each course.
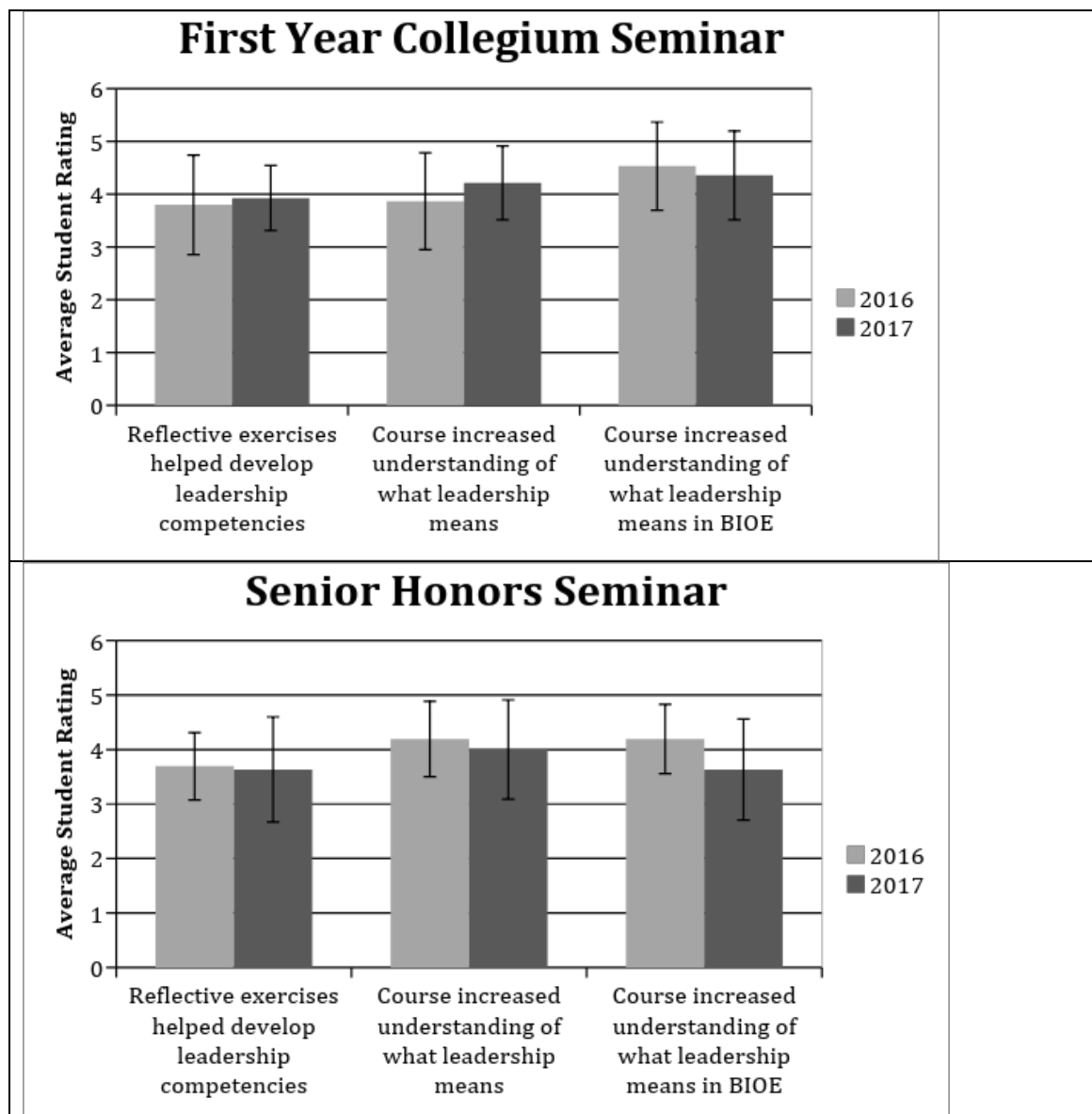
Figure 1. Reflection promotes development of leadership competencies and understanding of leadership. Data shown from two offerings of each course (top: first year seminar, bottom: senior honors seminar). Similar outcomes were observed when comparing students in each offering of the same course and when comparing students from the two different courses. Ratings on Likert scale: 1=not at all, 3=neutral, 5=very much.
Top: First year students enrolled in the Bioengineering: Advancing Human Health seminar (n=15 in 2016 and n=14 in 2017). **Bottom:** Bioengineering seniors enrolled in the Bioengineering Honors Seminar (n=27 in 2016 and n=31 in 2017).

In addition, students responded to questions about continuous improvement such as:
1. "How have you developed specific leadership competencies through this class?"
2. "Which exercises were critical to your development?"
3. "Which exercises should be refined?"

Students reported that the Letter to Future Self, reflection exercises following guest speakers and in-class team presentations for the final project, and reflection exercises in general were critical to their development of leadership competencies. Although students also indicated that the reflection exercises following guest speakers and in-class team presentations could be refined, they did not include any concrete suggestions for improvement.

The frequent identification by students of the Letter to Future Self activity as critical to development of leadership competencies in the Bioengineering: Advancing Human Health seminar is in agreement with data collected about this activity from the seniors enrolled in the Bioengineering Honors Seminar. These results support our assertion that the Letter to Future Self activity can be used in any engineering course.

Conclusion
In this paper, we describe reflection activities implemented in two bioengineering courses and assess their impact on enhancing student leadership competencies. Instructor observations of student engagement and positive emotional response suggest that the students enjoyed the activities. Most importantly, student data suggest that the reflection activities helped students develop leadership competencies and increased their understanding of what leadership means, in general and in the field of bioengineering.

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Appendix A. Leadership competencies identified by Seemiller [5].

Research	Mentoring	Facilitation
Other perspectives	Motivation	Conflict negotiation
Reflection and Application	Others' Contributions	Advocating for a point of view
Systems Thinking	Empowerment	Mission
Analysis	Providing feedback	Vision
Synthesis	Supervision	Goals
Evaluation	Collaboration	Plan
Idea generation	Organizational behavior	Organization
Problem solving	Power dynamics	Initiative
Decision making	Group development	Functioning independently
Self-understanding	Creating change	Follow-through
Personal values	Diversity	Responsibility for personal
Personal contributions	Others' circumstances	behavior
Scope of competence	Inclusion	Ethic
Receiving feedback	Social justice	Responding to ambiguity
Self-development	Social responsibility	Responding to change
Productive relationships	Service	Resiliency
Appropriate Interaction	Verbal communication	Positive attitude
Helping others	Nonverbal communication	Confidence
Empathy	Listening	Excellence
	Writing	