Self-Reflection Assignments for Evaluating Non-Technical Skills and Setting Goals for Professional Development

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Introduction

Development of professional skills—both technical and non-technical—is an integral part of engineering undergraduate programs. The ABET 2000 student outcomes criterion involves several non-technical skills including teamwork and communication[1]. Several examples of instructional efforts to foster development of non-technical skills have been published[2-5]. Assessing non-technical skills is a more of a challenge than implementing strategies focused on building these skills[3]. Here, we discuss the adoption of a rubric for non-technical skills assessment called the *self-evaluation rubric*[6] in an undergraduate junior-level chemical reaction engineering course at a large, public state university through a series of essays called the *self-reflection assignments*. The assignments are designed to promote self-awareness of students through evaluation of their current non-technical skill levels and goal setting for future development followed by instructor feedback and periodic updates on progress for accountability.

Reflection through writing has been used as a learning and assessment tool for setting goals, defining strategies to reach the goals, and detailing progress toward goals[7]. Some have used reflection as a way to have students learn from prior coursework or project-based experiences in both individual and team settings[7-12]. Recently, Sepp et. al[12] reviewed the role of reflection in engineering education as detailed in ASEE conference proceedings. The most prevalent types of reflection activities used in engineering education are essays and portfolios[12]. The reflection exercises described here involve essay assignments that ask students to reflect on their prior experiences regarding a variety of non-technical skills. The prior experiences are not restricted to any specific course or project context and may be from students' personal or academic backgrounds.

The aims of the self-reflection assignments are to promote student awareness of non-technical skills, motivate students to set personal goals to progress in their skill development, and to enhance student confidence in their self-efficacy related to non-technical skills. These aims align with the philosophy described in Ponton et al.[13] that engineering educators must train students in course content while preparing them to become practicing professionals.

Self-reflection assignments have been used in three offerings of an undergraduate chemical reaction engineering course. Data from the second offering were collected with Institutional Review Board approval and are presented here. The self-reflection assignments involve brief essays and goal setting related to professional, non-technical skills. The assignments utilize the self-evaluation rubric[6] originally designed for guided reflection assignments. The outcomes of the assignments have not been previously measured and reported in an engineering course. The self-evaluation rubric contains a list of non-technical skills important for scientists and engineers, such as persistence, organization, self-compassion, and reflection. A classroom research study was conducted to assess the impact of the assignments using pre- and post-assignment surveys of student perceptions of their non-technical skill levels and their opinions on the impact of the assignments on any changes in their skill levels.

Methods

Self-Evaluation Rubric

The self-evaluation rubric was originally developed for use in the University of California Berkley Compass Project for improving physics undergraduate education[6, 14, 15]. The introduction of the self-evaluation rubric has been modified for use in a chemical engineering course and is included as Appendix A (red boxes for blinded review). The self-evaluation rubric involves 10 skills classified as basic or advanced. Each skill has three proficiency levels: beginning, developing, and succeeding.

Basic Skills
- Persistence
- Organization
- Connections
- Self-compassion

Advanced Skills
- Courage
- Mental Resourcefulness
- Communication
- Diligent Skepticism
- Collaboration
- Reflection

Self-Reflection Assignments

The self-evaluation rubric has been incorporated into a junior-level chemical engineering undergraduate course through self-reflection assignments. Five times during the semester, students were given an essay prompt to identify one or more skills to work on in the following two-week period (first essay) or one-month period (subsequent essays except the last). Students were asked to assess their current proficiency level in that skill according to the self-evaluation rubric, describe their goals related to the skill and their plan for improvement, and share progress in the skill(s) if any had been made since the previous essay. This process required the students to identify the change they wanted to make, come up with a plan to implement that change, and frequently assess how their changes worked. The essays were submitted electronically as small percentage homework assignments graded solely on completion. The instructor provided feedback through the classroom management system, typically ranging from 1 sentence to 2 paragraphs, depending on the number of skills assessed in a given essay. Besides the intended goal of professional skill development, the assignments also gave the students practice with written communication and forged connections between the students and the faculty instructor for the course.

The essay prompt for self-reflection assignment 1 was
- Write a brief essay
- Identify one (or more) primary skill(s) to evaluate
- Identify changes you want to make
- Identify how to implement your plan
- Be consistent in implementing plan
- Frequently assess how change is working (subsequent assignments)
- Graded pass/fail for credit: 3/1000 points.
- Instructor will give detailed feedback on assignment

The essay prompt for self-reflection assignments 2 – 5 was
- Reflect on instructor feedback
- Asses how change is working
- Repeat assignment 1.
- If succeeding in chosen skill, pick a new basic or advanced skill
- Graded pass/fail for credit: 3/1000 points
- Instructor will give detailed feedback on assignment

The instructor adopted the practice of self-reflection assignments in a required class with 63 chemical engineering juniors in spring 2015, her first time to teach the course. Anecdotal evidence showed students gaining in confidence in skills and relating on personal level to instructor. A classroom research study (detailed in the next section) was designed and approved in winter 2015-2016 to measure and report the outcomes of the assignments in a chemical engineering context. The study was conducted in spring 2016 in a class of 82 students. The instructor is continuing to use self-reflection assignments in further course offerings including spring 2017. The assignments have been used in all course offerings taught by the instructor, and no control group has been used for comparison.

Research Study

The use of reflection assignments guided by the self-evaluation rubric has been studied in a University of Colorado Boulder physics class[16]. The qualitative study with twelve participants focused on analyzing the student essay responses for common themes and variations over time. Here, a classroom research study was conducted to assess student perceptions of their skills development. The study used pre- and post-assignment surveys of student perceptions of their non-technical skill levels and their opinions on the impact of the assignments on any changes in their skill levels.

The study had a three-part hypothesis:
- self-reflection assignments positively impact student progression toward higher levels of non-technical skills
- skills that students focus on actively will improve during the semester with some level of attribution to the self-reflection assignments
- skills that students are simply made aware of through the exercises and do not actively reflect on in course assignments will also improve during the semester with some level of attribution to the self-reflection assignments

The pre- and post-assignment surveys were anonymous and optional. The surveys had two parts. In part 1, students were asked to rank their proficiency levels (beginning, developing, or succeeding) for each of the 10 skills in the self-evaluation rubric. In part 2, students were asked which skills that they believe that they most need to improve upon, which skills they purposely plan/planned to work on and document through the self-reflection assignments, and several Likert-scale (1 – 5) questions. The post-assignment survey prompted students to elaborate on all of their Likert-scale responses. These open-ended questions were included to elicit student opinions about potential causes for skill level changes (if any), about skills they focused on throughout the term for the self-reflection assignments, and about the self-reflection assignments

in general. Additionally, the surveys included space for open-ended additional comments responses. The pre-assignment survey called Survey 1 is included as Appendix B. The post-assignment survey called Survey 2 is included as Appendix C. The Likert-scale questions in Survey 2 are summarized and labeled as Q1 – Q7 in Table 1.

Table 1: Likert-scale questions in Part 2 of the post-assignment survey.

Question Number	Question
Q1	I believe that the self-reflection assignments resulted in positive changes in my proficiency level(s) for at least one of the skills that I actively worked on during the semester.
Q2	I believe that the self-reflection assignments resulted in positive changes in my proficiency level(s) for at least one of the skills that I DID NOT actively work on during the semester.
Q3	I believe that the completing the self-reflection assignments was the most significant factor influencing changes in my proficiency level(s) for at least one of the skills listed in the self-evaluation rubric by the end of the semester.
Q4	I believe that WITHOUT the self-reflection assignments I would have made the same changes in my proficiency level(s) for at least one of the skills that I actively worked on during the semester.
Q5	I believe that developing professional, nontechnical skills is a valuable experience in an engineering course.
Q6	I believe that the completing the self-reflection assignments was a positive experience in the chemical reaction engineering course.
Q7	I recommend using the self-reflection assignments in this course or other engineering courses for developing professional, nontechnical skills.

Both surveys were administered online using Google forms without requiring login to maintain anonymity. Survey 1 was open from the beginning of the semester until self-reflection assignment 1 was due. Survey 2 was open after the final self-reflection assignment was due until the end of the semester. Actual student submissions for the graded self-reflection assignments were not used as part of this research student to allow students to have privacy in their reflections throughout the semester.

Results

Part 1: Ranking of Proficiency Levels

We quantified the number of students that ranked themselves as beginning, developing, or succeeding for each skill on the rubric before and after the use of self-reflection assignments in the course. 46 of 82 students took the pre-assignment survey. 31 of 82 students took the post-assignment survey. Pre- and post-assignment surveys (Surveys 1 and 2, respectively) have been matched using unique, non-identifiable keys generated by users. 22 matches were identified. The fact that 22 is only a subset of the 31 Survey 2 responses suggests that 9 students took Survey 2 that did not take Survey 1 or provided incorrect keys on either survey. The data were analyzed in aggregate form. Figs. 1 and 2 show the proficiency levels of beginning, developing, or succeeding for the matched cohort of students who took both Surveys 1 and 2. Fig. 1 shows the results for the basic non-technical skills of persistence, organization, connections, and self-compassion. Fig. 2 shows the results for the advanced non-technical skills of courage, mental resourcefulness, communication, diligent skepticism, collaboration, and reflection. Fig. 3 shows

the proficiency levels for all the students who responded to either survey. The responses are shown as percentages of the 46 responses for Survey 1 and of the 31 responses for Survey 2.

For the basic non-technical skills, the trends were toward fewer student at the beginning levels and higher percentages of students at the succeeding level after the self-reflection assignments (Fig. 1 and 3 a – d). The largest percentage of the respondents rated themselves at the succeeding level for the skill of organization (Fig. 3b). Even though they did not necessarily need to improve much in organization (Fig. 4), many students reflected on their progress in organization in at least one self-reflection assignment (Fig. 5). Notably, self-compassion was the only basic skill for which the number and percentage of students at the developing level increased. This is a testament to the large number of students who identified this skill as a major area for improvement (Fig. 4) and as the prevalent skill to be addressed intentionally through the self-reflection assignments (Fig. 5).

Of the advanced non-technical skills, courage and collaboration were evaluated as having higher numbers of students at the beginning level at the end of the semester compared to at the start of the semester (Fig. 2). However, for courage the beginning level percentage of the total respondents to Survey 2 decreased (Fig. 3e). An explanation for the apparent regression in these skills is that some students may have gained experiences that tested their skills throughout the semester in new ways, revealing that they had deficiencies in these skills that they were not originally aware of. An example of such an experience is the team projects in the concurrent course Unit Operations Laboratory where students were randomly assigned to work in several different teams throughout the semester rather than forming teams with their friends.
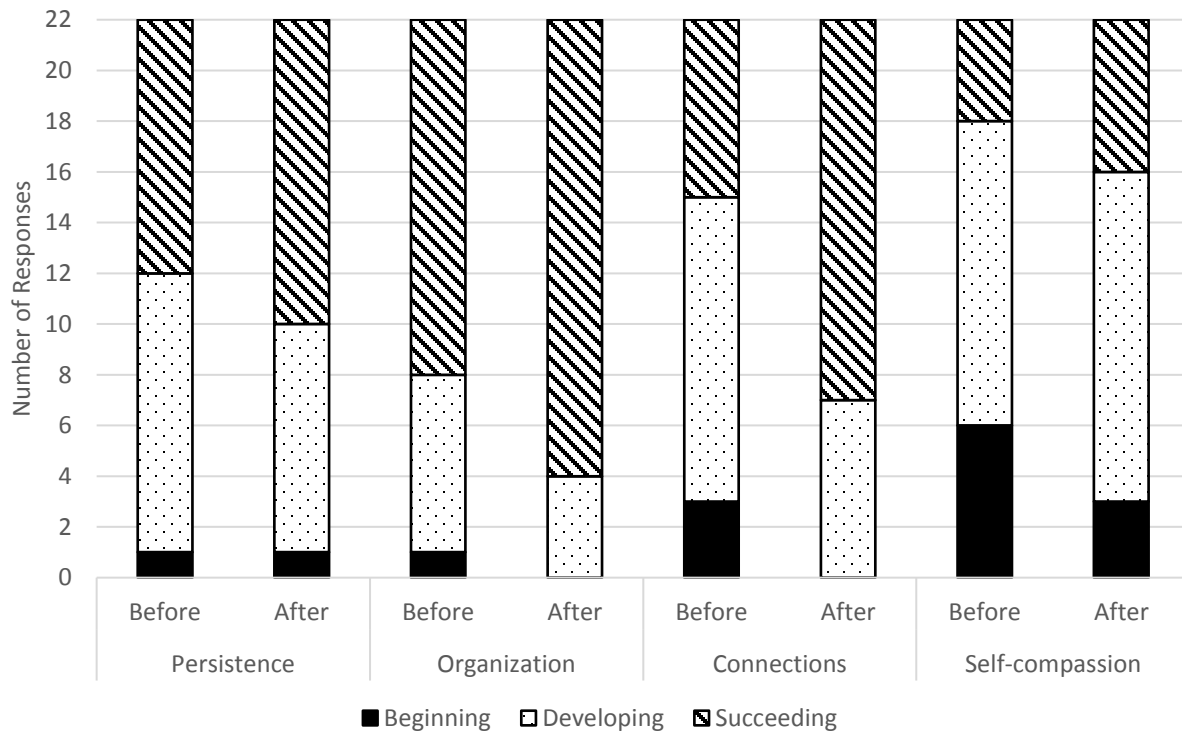

Figure 1: Proficiency levels for the basic non-technical skills with aggregated responses from students who took both surveys. "Before" denotes the pre-assignment survey, while "after" denotes the post-assignment survey.
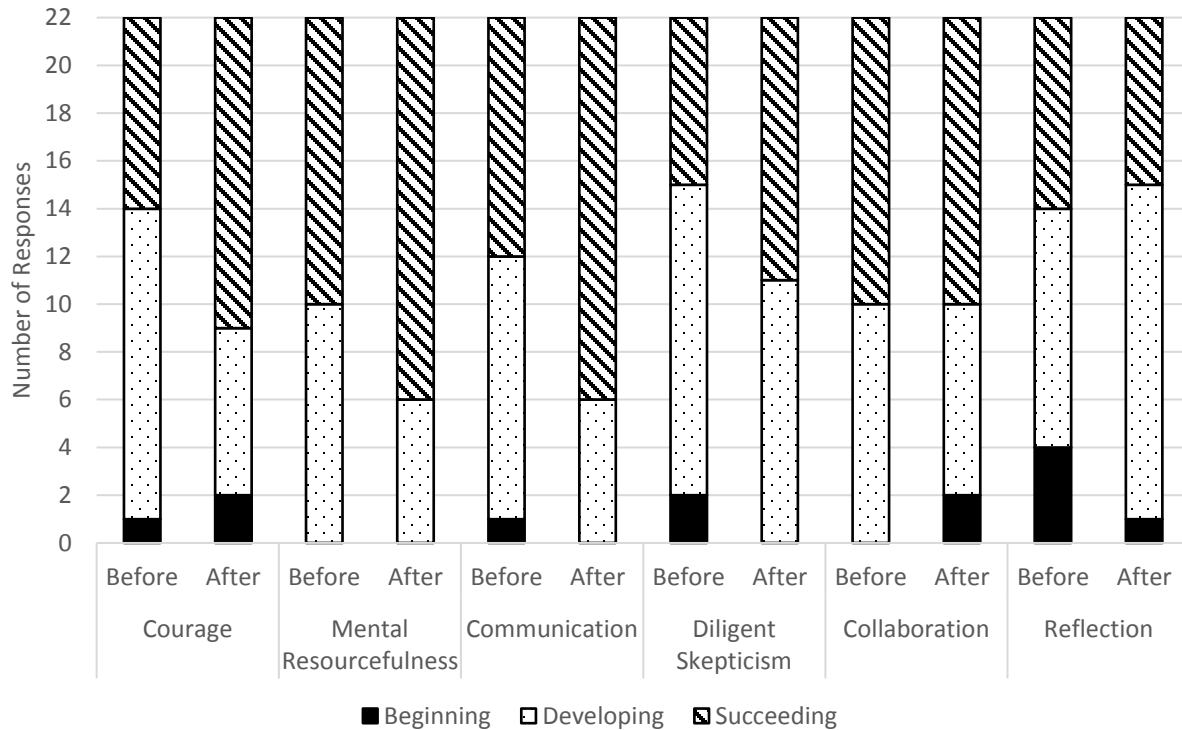
Figure 2: Proficiency levels for the advanced non-technical skills with aggregated responses from students who took both surveys. "Before" denotes the pre-assignment survey, while "after" denotes the post-assignment survey.

The remaining four advanced non-technical skills followed the same trends as the basic non-technical skills. The largest percentage of the respondents rated themselves at the succeeding level for the advanced skill of mental resourcefulness (Fig. 3f). This skill is related to lifelong learning and finding the resources both from prior experience and external sources to scaffold new ideas and tackle new challenges. Communication came in at second place in terms of percentage of respondents who rated themselves at the succeeding level (Fig. 3g). Of the matched cohort who took both surveys, equal numbers of students rated communication and mental resourcefulness at the succeeding level. The concurrent Unit Operations Laboratory course involves the students' first major written engineering project reports and their first open-ended laboratory experiences. Both of these aspects of Unit Operations Laboratory build strength in mental resourcefulness and communication. Thus, we do not claim that the self-reflection assignments are independently responsible for skill development in these areas.

Through the self-reflection assignments, students reflected on a variety of the skills—predominately self-compassion, organization, connections, and communication (Fig. 5). These are the same areas that the most students identified as being skills that they improved upon (Fig. 6) even though the gains in the percentages (Fig. 3) at each level do not necessarily indicate the same magnitude of improvements in these categories specifically. Very few students wrote about trying to develop their skills in courage, diligent skepticism, or reflection.
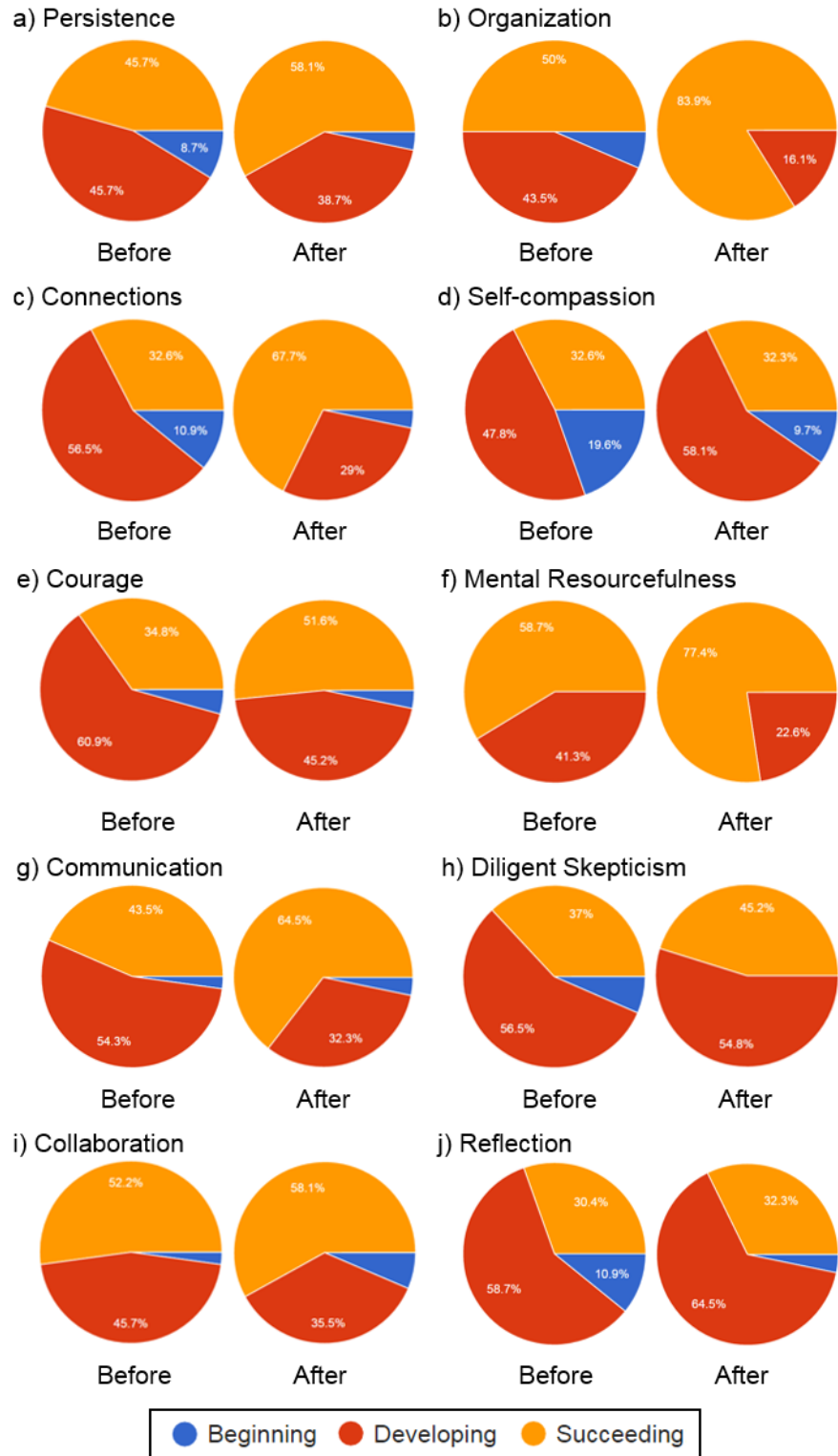
Figure 3: Percentage of total survey respondents who evaluated themselves at proficiency levels of beginning (blue, located at 3 o' clock), developing (red, located clockwise from the beginning segment), and succeeding (yellow, located clockwise from the developing segment) for the non-technical skills. "Before" denotes the pre-assignment survey, while "After" denotes the post-assignment survey. Note that b) After, f) Before and After, and h) After do not have beginning segments, and the corresponding developing segments are located at 3 o' clock.

a) The skill(s) that I believe that I most need to improve upon is(are) (46 responses)

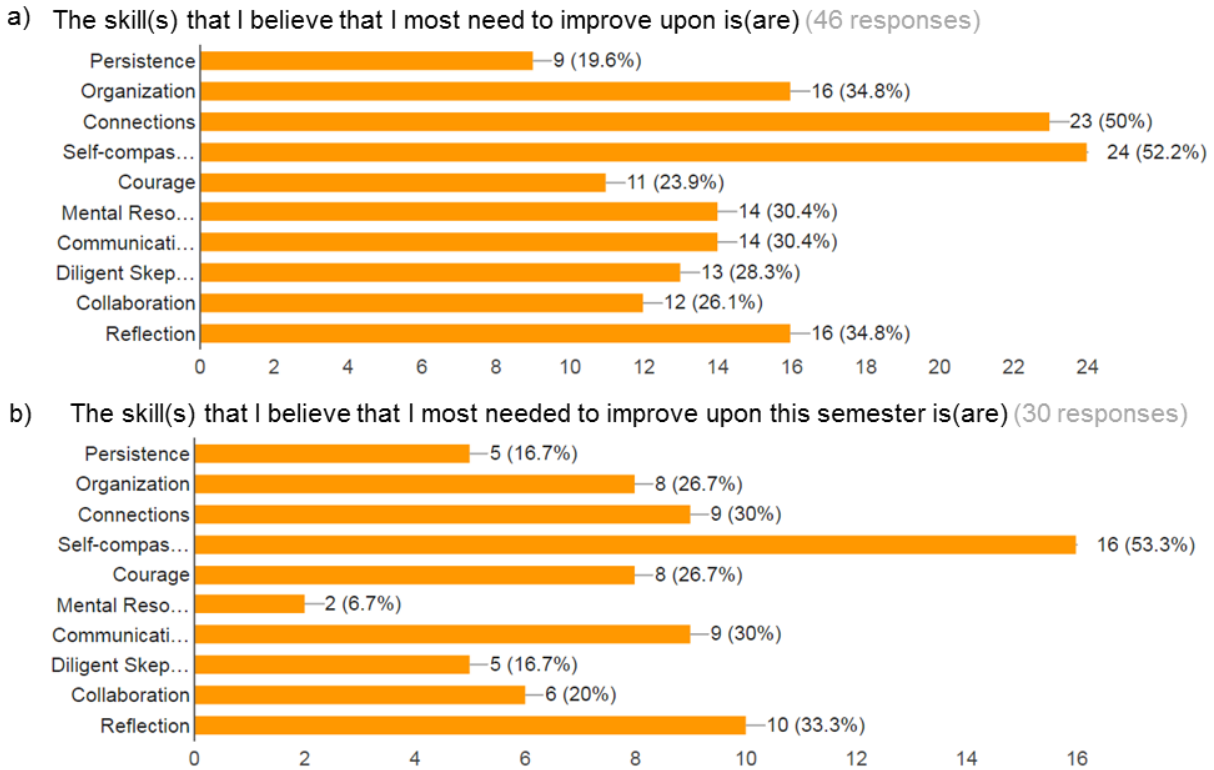| Skill	Count
Persistence	9 (19.6%)
Organization	16 (34.8%)
Connections	23 (50%)
Self-compas...	24 (52.2%)
Courage	11 (23.9%)
Mental Reso...	14 (30.4%)
Communicati...	14 (30.4%)
Diligent Skep...	13 (28.3%)
Collaboration	12 (26.1%)
Reflection	16 (34.8%)

b) The skill(s) that I believe that I most needed to improve upon this semester is(are) (30 responses)

Skill	Count
Persistence	5 (16.7%)
Organization	8 (26.7%)
Connections	9 (30%)
Self-compas...	16 (53.3%)
Courage	8 (26.7%)
Mental Reso...	2 (6.7%)
Communicati...	9 (30%)
Diligent Skep...	5 (16.7%)
Collaboration	6 (20%)
Reflection	10 (33.3%)

Figure 4: Skills that students identified as needing improvement as reported in a) the pre-assignment survey and b) the post-assignment survey.

a) The skill(s) that I purposely plan to work on and document through the self-reflection assignments during the semester is(are) (46 responses)

Skill	Count
Persistence	6 (13%)
Organization	16 (34.8%)
Connections	16 (34.8%)
Self-compas...	19 (41.3%)
Courage	5 (10.9%)
Mental Reso...	11 (23.9%)
Communicati...	8 (17.4%)
Diligent Skep...	8 (17.4%)
Collaboration	6 (13%)
Reflection	11 (23.9%)

b) The skill(s) that I actively worked on and documented through the self-reflection assignments this semester is(are) (30 responses)

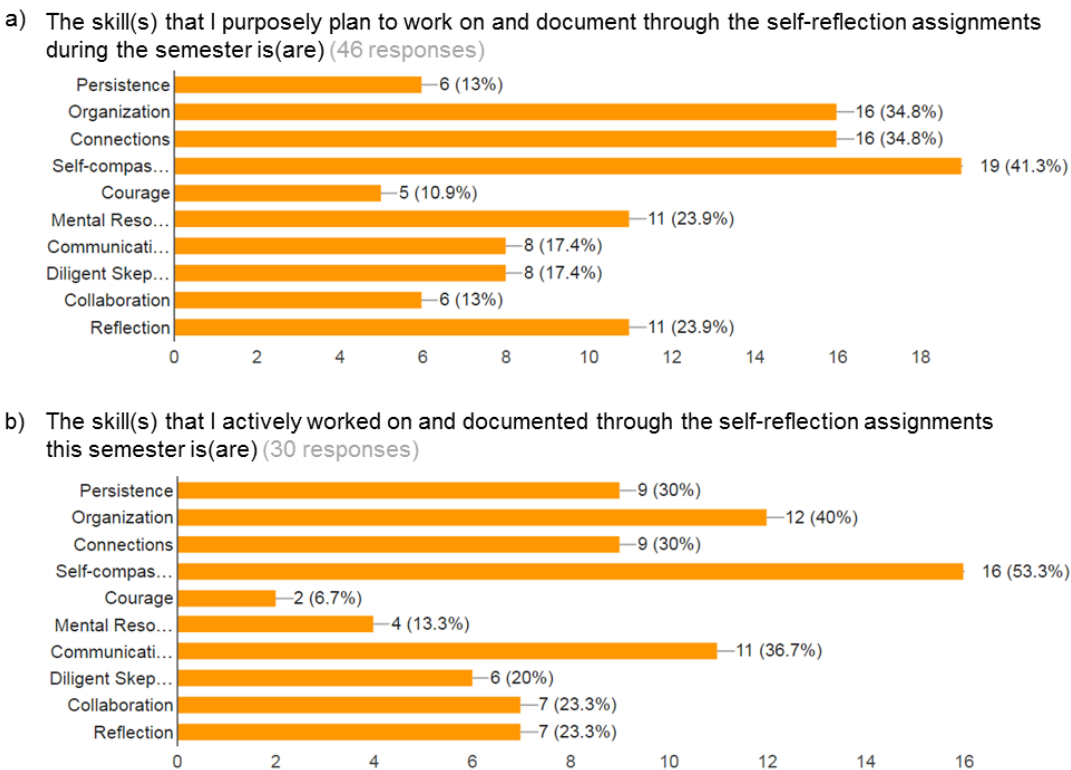| Skill	Count
Persistence	9 (30%)
Organization	12 (40%)
Connections	9 (30%)
Self-compas...	16 (53.3%)
Courage	2 (6.7%)
Mental Reso...	4 (13.3%)
Communicati...	11 (36.7%)
Diligent Skep...	6 (20%)
Collaboration	7 (23.3%)
Reflection	7 (23.3%)

Figure 5: Skills that students disclosed as those they worked on throughout the semester as part of the self-reflection assignments as reported in a) the pre-assignment survey and b) the post-assignment survey.

The skill(s) that I improved upon this semester (with or without the use of the self-reflection assignments) is(are) (30 responses)
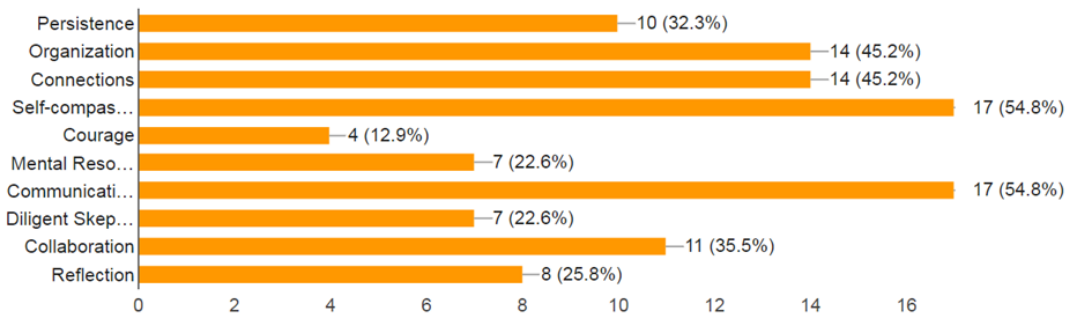
Figure 6: Skills that students disclosed as those they improved upon throughout the semester as reported in the post-assignment survey.

Part 2: Likert-Scale and Open-Ended Questions

We used the collective responses from the 31 total respondents to Survey 2 for the Likert-scale and open-ended questions. Note that only 30 students responded to all of the questions in part 2 of the survey. One additional student responded to some of the questions. The summary of responses to the Likert-scale questions is presented in Fig. 7.
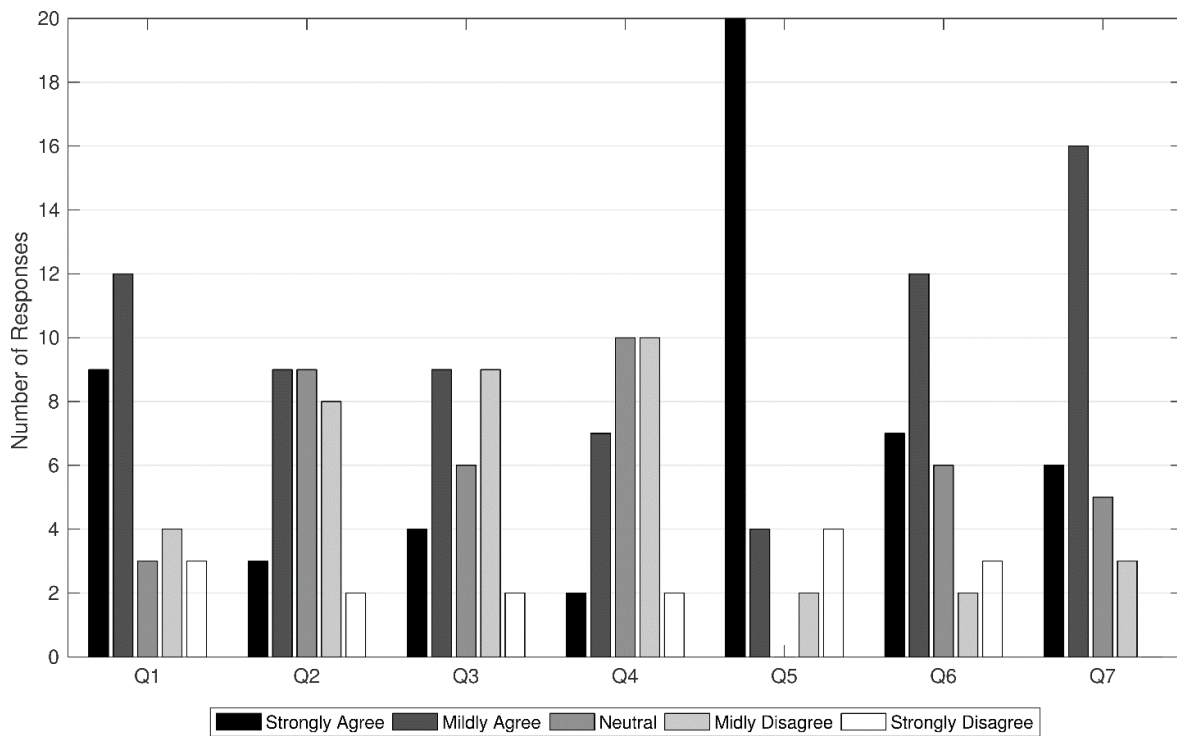

Figure 7: Likert-scale question responses on the post-assignment survey.

Q1 focused on the impact of self-reflection assignments on the skills the students actively worked on. The majority of respondents (21/31) agreed that the self-reflection assignments postitively impacted the skills they actively worked on (Fig. 7). The following comments are a subset of the open-ended responses to the prompt to elaborate on their responses to Q1:

- "In reviewing how I was improving, I could see if I were actively trying to change. Too often, I know what I must do, but I will forget because I don't have reminders. These self-reflection assignments helped me to keep my mind on task."
- "Self-reflection assignments encouraged the measurement of skills, so they could be improved"
- "Focusing on each specific category and just writing about each allowed me to think more on each and develop skills in each category."
- "Keeping me focused on being organized was a very large positive in my way of becoming better organized. The Self-reflection assignments helped me do that."
- "I think that they helped a lot. I was actively and mindfully working on my skills."
- "Assignments forced me to focus on the progress I was making, however, did not have a strong impact on my daily actions."

Q2 aimed to assess the impact of self-reflection assignments on the skills the students did not actively work on. The students had very mixed opinions with a near-uniform distribution between midly agree, neutral, and midly disagree and similar numbers for strongly agree and disagree (Fig. 7). Through the open-ended responses, it seems that the mixed feelings regarded the self-reflection assignments, not necessarily the self-evaluation rubric. For future surveys, we recommend decomposing this question into two to ask separately about the assignments and the rubric. The new question related to the rubric specifically should be "I believe the use of the self-evaluation rubric resulted in positive changes in my proficiency level(s) for at least one of the skills that I DID NOT actively work on through the self-reflection assignments during the semester." The following comments are a subset of the open-ended responses to the prompt to elaborate on their responses to Q2:
- "The assignments helped me to see all facets I could improve. I may not have chosen them, but I was made aware of these issues I could augment."
- "They somewhat helped me improve due to me having to write about what I need to change."
- "Neutral, simply acknowledging the skills helps."
- "Just thinking about and not necessarily concentrating on that skill still gets you thinking about it and how you can improve it."
- "With or without the help of the self-reflection assignments, I did begin to focus on other areas of improvement."
- "Sometimes, I didn't even think of self-compassion before. Now, I am more aware."
- "No, the natural difficulty of course work and more collaborative nature of this semester lead to growth in certain skills."
- "I only focused on the skills that I addressed in the assignments."

Q3 was similar to Q2 in garnering opinions on the role of the self-reflection assignments on the skill development. Like for Q2, the students had mixed opinions (Fig. 7). The following comments are a subset of the open-ended responses to the prompt to elaborate on their responses to Q3:
- "They helped, but I don't believe they were a key factor."
- "Again, it allowed for reflection on my actions but did not inspire real change. I took steps outside of the self-reflection to work on issues I saw."

- "It brought the issue to mind."
- "Self-reflection assignments were quite helpful but with the combination of the classes that I was enrolled in along with actively trying to change my outlook had a more significant effect on my skills."
- "I don't believe I would have cared about the trait I selected if I wasn't doing the reflections."
- "Unit ops lab helped the most."

Q4 was designed to solicit students' opinions of their development had they not had the self-reflection assignments. The question is a bit awkward and could be interpreted in a few different ways. As for Q2 and Q3, the responses were mixed (Fig. 7). The following comments are a subset of the open-ended responses to the prompt to elaborate on their responses to Q4:
- "I think the reflection assignments provide a good opportunity to really think about the positive changes that I have made this semester. I don't think I would be aware of how far I have come if I wasn't forced to really reflect on it."
- "I feel like every semester has me improving, but I do not believe it would have been so pronounced."
- "I took steps outside of the self-reflection assignment that improved my proficiency in certain skills."
- "Having UOL that forced students to work together helped me and even without the self-reflection assignments some of my skills would have improved anyway."
- "I used these quite a bit and wouldn't have been in the same spot without doing the assignments."
- "The reflection assignments bring attention to these skills so I couldn't just work on them for a day and forget about it afterwards."
- "I believe the self-reflection assignments helped me to understand what I needed to work on and what I needed to focus on. Projects I believe helped me the most with my proficiency levels."

Q5 assessed students' opinions on the value of developing non-technical professional skills. The overwhelming majority of respondents (24/30 with 20 strongly agreeing with Q5) valued non-technical skill development. (Fig. 7). The same question asked in Survey 1 had 33/46 respondents with strongly agree and 6/46 with midly agree for 84.7% responding favorably. This question had the strongest positive opinions of the 7 questions. The following comments are a subset of the open-ended responses to the prompt to elaborate on their responses to Q5:
- "I know that when I entered these courses, I was a stereotypical engineering student. I needed the assistance of these courses to push me to be more interactive with those around me."
- "These skills are just as important as technical skills."
- "Soft skills are significant for success."
- "I think it's important to be a well-rounded individual. Technical knowledge is clearly invaluable to being an engineering but it will not serve you or your employer as well as it can if you aren't proficient in non-technical skills as well"

- "Once we graduate we will be expected to perform well with others, and have these basic skills. Being exposed to the fact that they will need to be developed before entering industry is EXTREMELY helpful."
- "Necessary to obtain these skills for the future workplace."
- "You can be as smart as they come but if you don't have professional skills you won't thrive in the job environment you go into."
- "If it matters in a job, it matters in classes"
- "Being an engineer is more than just understanding technical aspects but also being able to work with others efficiently."

Q6 focused on the experience of self-reflection assignments in the particular course offering. The majority of respondents (19/30) responded positively and 6 more responded neutrally (Fig. 7). The same question asked in Survey 1 (in the future tense) had 21/46 respondents with strongly agree and 12/46 with midly agree for 71.8% responding favorably. The following comments are a subset of the open-ended responses to the prompt to elaborate on their responses to Q6:
- "It gave me the opportunity to see how I have grown. It made me feel good about my progress."
- "Although it sometimes felt like a distracting aside, I think it was overall positive because I could see how I changed throughout the semester."
- "It wasn't the most beneficial thing ever, but, at the same time it wasn't completely useless."
- "It allowed students to reflect more than they may have in the past and highlighted soft skills that one may not think of as important. It also provided clear examples of what being 'successful' in that skill was qualified as."
- "Yes, it gets us thinking about these skills and in what ways we can improve them."
- "I'm luke-warm on it. I didn't hate the experience but having additional things to do for a grade was just more things for me to have to worry about."
- "Reflection is always useful"
- "It helped me to focus in on what I needed to work on but it wasn't necessarily the thing that helped me change my habits."

Finally, Q7 solicited student opinions regarding the use of the self-reflection assignments either at our home institution in this or other engineering courses or at other institutions in general. The majority of respondents (22/30) responded positively (Fig. 7). Notably, none of the respondents strongly disagreed with the statement. This question had the second strongest positive opinions of the 7 questions. The following comments are a subset of the open-ended responses to the prompt to elaborate on their responses to Q7:
- "It is extremely helpful to mark progress in a skill set. It gives one a sense that the goals are tangible. Group projects help, but until you're aware of what needs improvement, it's difficult to change."
- "I would try to get a self-reflection used in a seminar course, because self-reflections don't actually cover any material."
- "I wouldn't say to continue with as many self-reflections. I think a more pointed lecture over the soft skills outlined in the self-reflection assignments would be more beneficial.

Utilizing this in a seminar would be helpful. An additional in-class activity when going over these skills would also be more helpful."

- "Having self reflection assignments are good, but completing the same type of assignment throughout multiple assignments would not be helpful. However if this was something exposed to younger students it may be more helpful."
- "This should be done every year. It allows students to get their brain focused on set skills."
- "They are a good idea, but I would not recommend doing them in more than a couple courses as it could get repetitive."

As a follow-up to the third student's response to Q7, the 2017 offering requires one fewer self-reflection assignment and will incorporate in-class discussions of specific skills rather than simply electronic feedback one-on-one between the instructor and each student.

Conclusions

The research detailed here provides insight into the efficacy of self-reflection assignments in conjunction with the self-evaluation rubric for improving non-technical skills in the context of an upper division chemical engineering course by using student perceptions of their skill levels and their opinions on the effects of the assignments and causes for their changes.

Collectively, the responses to Q1 – Q4 indicated that students felt the intervention of the self-reflection assignments positively impacted their skill development, even if the assignments were not the primary contributor to that development. Several students mentioned the awareness of the skills and the rubric as being positive for bringing their attention to certain areas that could be improved. Student opinions on the value of development of non-technical skills were higher than expected and show that student interest in this area is strong. The strong positive response to the final question "I recommend using the self-reflection assignments in this course or other engineering courses for developing professional, nontechnical skills" strongly suggests to us that the self-reflection assignments guided by the self-evaluation rubric should indeed be adopted in other engineering contexts, thus motivating the submission of this manuscript for the ASEE Annual Conference Proceedings.

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Self-Evaluation Rubric
CHE 3123 Chemical Reaction Engineering

The self-evaluation rubric is designed to help you in your process of self-reflection on the primary and advanced non-technical skills listed below. Each skill in the rubric has questions to help you understand what the skill means and descriptions of what it means to be beginning, developing, and succeeding in each skill. The skills are divided into a primary set, which you should focus on first, and an advanced set, which you should move on to once you feel like you are succeeding in the primary set.

Use the rubric to identify skills that you want to work on and write about your progress in those skills in your self-reflection assignments. Honest, thoughtful reflection is key here: there is no way to improve if you are not truthful with yourself about how you are doing. However, you should not disclose any deeply personal, private, or sensitive information in the assignments submitted for the course.

The self-reflection assignments will each have specific prompts and due dates. In general, the assignments should contain the following pieces of information:

- The skill(s) you are evaluating
- Whether you think you are beginning, developing, or succeeding in each skill. This should be accompanied by evidence to support your decision (for example, an anecdote).
- In what way you want to improve in each skill, and how you will do that. This will require you to **identify** the change you want to make, come up with a plan to **implement** that change, be **consistent** in your implementation, and **frequently reassess** how your change is working.

Primary Skills

Skill	Questions to ask yourself	Beginning	Developing	Succeeding
Persistence	• What do you do when you're frustrated? • Do you independently pursue understanding?	I tend to try one or two things. I give up more easily than I should.	I try to stick with things, but I sometimes feel unsuccessful. Sometimes I seek new approaches to help.	I look for new ways to think about the problem. I find a way to persist when appropriate.
Organization	• Do you keep accurate, thorough, and consistent records of work? • Do you submit materials in a timely manner? • Do you refer to your records to support conclusions?	There are significant gaps in my records, and/or I consistently forget to complete assignments on time.	I don't complete all assignments on time or I have no record of some of my work/activities. When I neglect to do something, I forget about it because it's too late.	I am timely and thorough with work and record-keeping. When I've neglected something, I correct my oversight quickly. My records are a valuable resource.
Connections	• Do you try to make connections with new people who might be able to help you in the future? • Do you make use of your connections when you need help?	I tend to go it alone.	I sometimes get help from other people, but only when I really need it. My network of supporters could be better developed.	I have a strong network of people who I go to regularly for help and support.
Self-compassion	• When you're having difficulty with something, how do you feel about yourself? • Do you make productive use of failure?	I have trouble with feeling like a failure, and these feelings often make me feel like giving up. I'm my own worst critic.	I am sometimes overly critical of myself. I tend to ignore feelings of failure rather than using them to improve.	I acknowledge my difficulty, but I don't let it define how I feel about myself. I act kindly towards myself and view failure as an opportunity for self-improvement.

Advanced Skills

Skill	Questions to ask yourself	Beginning	Developing	Succeeding
Courage	• How do you react to uncertainty? • What do you do when you feel overwhelmed? • Do you take intellectual risks?	I don't like to try things unless I'm reasonably certain what the outcome will be.	I take some risks, but I sometimes miss out on some good opportunities.	I make a decision to trust that I'll learn something from each experience, even if I'm unsure at times.
Mental Resourcefulness	• Where do you turn for new ideas? • Do you look for connections between ideas? • Do you apply past experiences to new situations?	When something feels unfamiliar, I often assume it's not useful.	There have been times when I disregarded new ideas before considering them fully. I don't often see connections between what I'm doing and what I've done.	I always try to consider things, even if they seem odd or surprising at first. I often relate new ideas to old ones.
Communication	• Can you clearly convey an idea to someone else using pictures, speech, or demonstrations? • Do you give examples that support your ideas? • Do you seek consistency in ideas?	It seems like others don't understand what I'm trying to say/convey most of the time. Once I try to communicate something, I move on to the next thing.	I can usually convey my ideas, but often others don't seem to understand what I'm trying to communicate. When the message doesn't get across, I might try one other way of communicating.	Communication is strength of mine. When I'm feeling misunderstood, I search for new ways to convey my point. I look back through my conclusions to make sure they're clear and consistent.
Diligent Skepticism	• How do you evaluate the quality of procedures? • Do you scrutinize sources of information and search for ways to test ideas? • Can you identify problems with procedure that lead to erroneous or incomplete conclusions?	Much of what I believe came from someone else directly. When someone sounds convincing, I trust that they are right.	I should ask more questions about information that I receive, and steps that I'm taking. Sometimes I discover that I've been lead down a path that I could have avoided with more thought, testing, and questioning.	I ask plenty of questions (to myself and others) and head off problems before they start.
Collaboration	• Are you respectful, supportive, and critical of peers? • Do you share your ideas with others? • Do you consider strategies employed by your peers for study, organization, and investigation?	Sometimes I either: don't participate; dominate the work, so that others might not feel like they have a role; or, distract others.	I'm great as either a leader or participant, but not both. I could be more mindful of the needs of others with whom I work. I try to learn from what others are doing.	I am an asset to any team. I know how to lead when appropriate, and how to support others when they take the lead. I think pretty much everyone has something to offer me.
Reflection	• Do you consider past experiences when making choices? • Do you reference prior work? • Are your reflections thoughtful and substantive?	Once I complete something, I usually just move on to the next thing, without thinking about how it went.	I don't always reflect after each science experience. I don't review my notes during and after a topic of study. I'm not great about considering how things went.	I squeeze every bit of learning from everything that I do by evaluating what happened. My notes are excellent, and I use them often to check on my ideas.

Dr. Ashlee N. Ford Versypt adapted the introductory material for CHE 3123. The rubric is unchanged.

Appendix B

Survey 1

First of two surveys for the research study titled "Assessing changes in student self-evaluations of non-technical, professional skills in a chemical engineering undergraduate course"

Self-Evaluation Rubric

In the following questions, evaluate your proficiency level (beginning, developing, or succeeding) for each of the skills listed using the Self-Evaluation Rubric. The text of the rubric is reproduced in the questions below for your convenience.

1. **Skill: Persistence. Questions to ask yourself: What do you do when you're frustrated? Do you independently pursue understanding? ***

   Mark only one oval.

   ◯ Beginning: I tend to try one or two things. I give up more easily than I should.

   ◯ Developing: I try to stick with things, but I sometimes feel unsuccessful. Sometimes I seek new approaches to help.

   ◯ Succeeding: I look for new ways to think about the problem. I find a way to persist when appropriate.

2. **Skill: Organization. Questions to ask yourself: Do you keep accurate, thorough, and consistent records of work? Do you submit materials in a timely manner? Do you refer to your records to support conclusions? ***

   Mark only one oval.

   ◯ Beginning: There are significant gaps in my records, and/or I consistently forget to complete assignments on time.

   ◯ Developing: I don't complete all assignments on time or I have no record of some of my work/activities. When I neglect to do something, I forget about it because it's too late.

   ◯ Succeeding: I am timely and thorough with work and record-keeping. When I've neglected something, I correct my oversight quickly. My records are a valuable resource.

3. **Skill: Connections. Questions to ask yourself: Do you try to make connections with new people who might be able to help you in the future? Do you make use of your connections when you need help? ***

   Mark only one oval.

   ◯ Beginning: I tend to go it alone.

   ◯ Developing: I sometimes get help from other people, but only when I really need it. My network of supporters could be better developed.

   ◯ Succeeding: I have a strong network of people who I go to regularly for help and support.

4. **Skill: Self-compassion. Questions to ask yourself: When you're having difficulty with something, how do you feel about yourself? Do you make productive use of failure?** *

Mark only one oval.

◯ Beginning: I have trouble with feeling like a failure, and these feelings often make me feel like giving up. I'm my own worst critic.

◯ Developing: I am sometimes overly critical of myself. I tend to ignore feelings of failure rather than using them to improve.

◯ Succeeding: I acknowledge my difficulty, but I don't let it define how I feel about myself. I act kindly towards myself and view failure as an opportunity for self-improvement.

5. **Skill: Courage. Questions to ask yourself: How do you react to uncertainty? What do you do when you feel overwhelmed? Do you take intellectual risks?** *

Mark only one oval.

◯ Beginning: I don't like to try things unless I'm reasonably certain what the outcome will be.

◯ Developing: I take some risks, but I sometimes miss out on some good opportunities.

◯ Succeeding: I make a decision to trust that I'll learn something from each experience, even if I'm unsure at times.

6. **Skill: Mental Resourcefulness. Questions to ask yourself: Where do you turn for new ideas? Do you look for connections between ideas? Do you apply past experiences to new situations?** *

Mark only one oval.

◯ Beginning: When something feels unfamiliar, I often assume it's not useful.

◯ Developing: There have been times when I disregarded new ideas before considering them fully. I don't often see connections between what I'm doing and what I've done.

◯ Succeeding: I always try to consider things, even if they seem odd or surprising at first. I often relate new ideas to old ones.

7. **Skill: Communication. Questions to ask yourself: Can you clearly convey an idea to someone else using pictures, speech, or demonstrations? Do you give examples that support your ideas? Do you seek consistency in ideas?** *

Mark only one oval.

◯ Beginning: It seems like others don't understand what I'm trying to say/convey most of the time. Once I try to communicate something, I move on to the next thing.

◯ Developing: I can usually convey my ideas, but often others don't seem to understand what I'm trying to communicate. When the message doesn't get across, I might try one other way of communicating.

◯ Succeeding: Communication is a strength of mine. When I'm feeling misunderstood, I search for new ways to convey my point. I look back through my conclusions to make sure they're clear and consistent.

8. **Skill: Diligent Skepticism. Questions to ask yourself: How do you evaluate the quality of procedures? Do you scrutinize sources of information and search for ways to test ideas? Can you identify problems with procedure that lead to erroneous or incomplete conclusions? ***

Mark only one oval.

- ( ) Beginning: Much of what I believe came from someone else directly. When someone sounds convincing, I trust that they are right.

- ( ) Developing: I should ask more questions about information that I receive and steps that I'm taking. Sometimes I discover that I've been lead down a path that I could have avoided with more thought, testing, and questioning.

- ( ) Succeeding: I ask plenty of questions (to myself and others) and head off problems before they start.

9. **Skill: Collaboration. Questions to ask yourself: Are you respectful, supportive, and critical of peers? Do you share your ideas with others? Do you consider strategies employed by your peers for study, organization, and investigation? ***

Mark only one oval.

- ( ) Beginning: Sometimes I either: don't participate; dominate the work, so that others might not feel like they have a role; or distract others.

- ( ) Developing: I'm great as either a leader or participant, but not both. I could be more mindful of the needs of others with whom I work. I try to learn from what others are doing.

- ( ) Succeeding: I am an asset to any team. I know how to lead when appropriate, and how to support others when they take the lead. I think pretty much everyone has something to offer me.

10. **Skill: Reflection. Questions to ask yourself: Do you consider past experiences when making choices? Do you reference prior work? Are your reflections thoughtful and substantive? ***

Mark only one oval.

- ( ) Beginning: Once I complete something, I usually just move on to the next thing, without thinking about how it went.

- ( ) Developing: I don't always reflect after each science experience. I don't review my notes during and after a topic of study. I'm not great about considering how things went.

- ( ) Succeeding: I squeeze every bit of learning from everything that I do by evaluating what happened. My notes are excellent, and I use them often to check on my ideas.

General Questions

Please answer the following questions regarding the skills listed in the Self-Evaluation Rubric and the Self-Reflection Assignments.

11. **The skill(s) that I believe that I most need to improve upon is(are)**
Check all that apply.

- [ ] Persistence
- [ ] Organization
- [ ] Connections
- [ ] Self-compassion
- [ ] Courage
- [ ] Mental Resourcefulness
- [ ] Communication
- [ ] Diligent Skepticism
- [ ] Collaboration
- [ ] Reflection

12. **The skill(s) that I purposely plan to work on and document through the Self-Reflection Assignments during the semester is(are)**
Check all that apply.

- [ ] Persistence
- [ ] Organization
- [ ] Connections
- [ ] Self-compassion
- [ ] Courage
- [ ] Mental Resourcefulness
- [ ] Communication
- [ ] Diligent Skepticism
- [ ] Collaboration
- [ ] Reflection

13. **Please rate your level of agreement/disagreement with the following statement: I believe that the Self-Reflection Assignments will result in positive changes in my proficiency level(s) for at least one of the skills that I actively plan to work on during the semester.**
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

14. **Please rate your level of agreement/disagreement with the following statement: I believe that the Self-Reflection Assignments will result in positive changes in my proficiency level(s) for at least one of the skills that I DO NOT actively plan to work on during the semester.**
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

15. **Please rate your level of agreement/disagreement with the following statement: I believe that the completing Self-Reflection Assignments will be the most significant factor influencing changes in my proficiency level(s) for at least one of the skills listed in the Self-Evaluation Rubric by the end of the semester.**

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

16. **Please rate your level of agreement/disagreement with the following statement: I believe that WITHOUT the Self-Reflection Assignments I would make the same changes in my proficiency level(s) for as least one of the skill(s) that I actively plan to work on during the semester.**

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

17. **Please rate your level of agreement/disagreement with the following statement: I believe that developing professional, non-technical skills is a valuable experience in an engineering course.**

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

18. **Please rate your level of agreement/disagreement with the following statement: I believe that completing the Self-Reflection Assignments will be a positive experience in the chemical reaction engineering course.**

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

19. **Please include any additional comments that you have related to the skills listed in the Self-Evaluation Rubric or related to the Self-Reflection Assignments.**

_____

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Personal Key

This survey is anonymous. In order to match responses from Survey 1 and Survey 2 to unidentified individuals, you must generate a unique key known only to yourself.

20. **Follow this formula to generate your unique key and enter it in the space provided: last letter of your middle name (last name if you have no middle name) plus day of birth plus height in inches (two digits) plus last two digits of your cell phone number (home phone if no cell). For example, Dr. Ford Versypt's key is E96531 for middle name Nicole, birthdate of Aug. 9, 5 ft 5 inches tall, and cell phone ***-***-**31. ***

Appendix C

Survey 2

Second of two surveys for the research study titled "Assessing changes in student self-evaluations of non-technical, professional skills in a chemical engineering undergraduate course"

Self-Evaluation Rubric

In the following questions, evaluate your proficiency level (beginning, developing, or succeeding) for each of the skills listed using the Self-Evaluation Rubric. The text of the rubric is reproduced in the questions below for your convenience.

1. **Skill: Persistence. Questions to ask yourself: What do you do when you're frustrated? Do you independently pursue understanding? ***
   Mark only one oval.

   ◯ Beginning: I tend to try one or two things. I give up more easily than I should.

   ◯ Developing: I try to stick with things, but I sometimes feel unsuccessful. Sometimes I seek new approaches to help.

   ◯ Succeeding: I look for new ways to think about the problem. I find a way to persist when appropriate.

2. **Skill: Organization. Questions to ask yourself: Do you keep accurate, thorough, and consistent records of work? Do you submit materials in a timely manner? Do you refer to your records to support conclusions? ***
   Mark only one oval.

   ◯ Beginning: There are significant gaps in my records, and/or I consistently forget to complete assignments on time.

   ◯ Developing: I don't complete all assignments on time or I have no record of some of my work/activities. When I neglect to do something, I forget about it because it's too late.

   ◯ Succeeding: I am timely and thorough with work and record-keeping. When I've neglected something, I correct my oversight quickly. My records are a valuable resource.

3. **Skill: Connections. Questions to ask yourself: Do you try to make connections with new people who might be able to help you in the future? Do you make use of your connections when you need help? ***
   Mark only one oval.

   ◯ Beginning: I tend to go it alone.

   ◯ Developing: I sometimes get help from other people, but only when I really need it. My network of supporters could be better developed.

   ◯ Succeeding: I have a strong network of people who I go to regularly for help and support.

4. **Skill: Self-compassion. Questions to ask yourself: When you're having difficulty with something, how do you feel about yourself? Do you make productive use of failure?** *

Mark only one oval.

◯ Beginning: I have trouble with feeling like a failure, and these feelings often make me feel like giving up. I'm my own worst critic.

◯ Developing: I am sometimes overly critical of myself. I tend to ignore feelings of failure rather than using them to improve.

◯ Succeeding: I acknowledge my difficulty, but I don't let it define how I feel about myself. I act kindly towards myself and view failure as an opportunity for self-improvement.

5. **Skill: Courage. Questions to ask yourself: How do you react to uncertainty? What do you do when you feel overwhelmed? Do you take intellectual risks?** *

Mark only one oval.

◯ Beginning: I don't like to try things unless I'm reasonably certain what the outcome will be.

◯ Developing: I take some risks, but I sometimes miss out on some good opportunities.

◯ Succeeding: I make a decision to trust that I'll learn something from each experience, even if I'm unsure at times.

6. **Skill: Mental Resourcefulness. Questions to ask yourself: Where do you turn for new ideas? Do you look for connections between ideas? Do you apply past experiences to new situations?** *

Mark only one oval.

◯ Beginning: When something feels unfamiliar, I often assume it's not useful.

◯ Developing: There have been times when I disregarded new ideas before considering them fully. I don't often see connections between what I'm doing and what I've done.

◯ Succeeding: I always try to consider things, even if they seem odd or surprising at first. I often relate new ideas to old ones.

7. **Skill: Communication. Questions to ask yourself: Can you clearly convey an idea to someone else using pictures, speech, or demonstrations? Do you give examples that support your ideas? Do you seek consistency in ideas?** *

Mark only one oval.

◯ Beginning: It seems like others don't understand what I'm trying to say/convey most of the time. Once I try to communicate something, I move on to the next thing.

◯ Developing: I can usually convey my ideas, but often others don't seem to understand what I'm trying to communicate. When the message doesn't get across, I might try one other way of communicating.

◯ Succeeding: Communication is a strength of mine. When I'm feeling misunderstood, I search for new ways to convey my point. I look back through my conclusions to make sure they're clear and consistent.

8. **Skill: Diligent Skepticism. Questions to ask yourself: How do you evaluate the quality of procedures? Do you scrutinize sources of information and search for ways to test ideas? Can you identify problems with procedure that lead to erroneous or incomplete conclusions? ***

Mark only one oval.

○ Beginning: Much of what I believe came from someone else directly. When someone sounds convincing, I trust that they are right.

○ Developing: I should ask more questions about information that I receive and steps that I'm taking. Sometimes I discover that I've been lead down a path that I could have avoided with more thought, testing, and questioning.

○ Succeeding: I ask plenty of questions (to myself and others) and head off problems before they start.

9. **Skill: Collaboration. Questions to ask yourself: Are you respectful, supportive, and critical of peers? Do you share your ideas with others? Do you consider strategies employed by your peers for study, organization, and investigation? ***

Mark only one oval.

○ Beginning: Sometimes I either: don't participate; dominate the work, so that others might not feel like they have a role; or distract others.

○ Developing: I'm great as either a leader or participant, but not both. I could be more mindful of the needs of others with whom I work. I try to learn from what others are doing.

○ Succeeding: I am an asset to any team. I know how to lead when appropriate, and how to support others when they take the lead. I think pretty much everyone has something to offer me.

10. **Skill: Reflection. Questions to ask yourself: Do you consider past experiences when making choices? Do you reference prior work? Are your reflections thoughtful and substantive? ***

Mark only one oval.

○ Beginning: Once I complete something, I usually just move on to the next thing, without thinking about how it went.

○ Developing: I don't always reflect after each science experience. I don't review my notes during and after a topic of study. I'm not great about considering how things went.

○ Succeeding: I squeeze every bit of learning from everything that I do by evaluating what happened. My notes are excellent, and I use them often to check on my ideas.

General Questions

Please answer the following questions regarding the skills listed in the Self-Evaluation Rubric and the Self-Reflection Assignments.

11. **The skill(s) that I believe that I most needed to improve upon this semester is(are)**

Check all that apply.

- [ ] Persistence
- [ ] Organization
- [ ] Connections
- [ ] Self-compassion
- [ ] Courage
- [ ] Mental Resourcefulness
- [ ] Communication
- [ ] Diligent Skepticism
- [ ] Collaboration
- [ ] Reflection

12. **The skill(s) that I actively worked on and documented through the Self-Reflection Assignments this semester is(are)**

Check all that apply.

- [ ] Persistence
- [ ] Organization
- [ ] Connections
- [ ] Self-compassion
- [ ] Courage
- [ ] Mental Resourcefulness
- [ ] Communication
- [ ] Diligent Skepticism
- [ ] Collaboration
- [ ] Reflection

13. **The skill(s) that I improved upon this semester (with or without the use of the Self-Reflection Assignments) is(are)**

Check all that apply.

- [ ] Persistence
- [ ] Organization
- [ ] Connections
- [ ] Self-compassion
- [ ] Courage
- [ ] Mental Resourcefulness
- [ ] Communication
- [ ] Diligent Skepticism
- [ ] Collaboration
- [ ] Reflection

14. **Please rate your level of agreement/disagreement with the following statement: I believe that the Self-Reflection Assignments resulted in positive changes in my proficiency level(s) for at least one of the skills that I actively worked on during the semester.**

Mark only one oval.

1	2	3	4	5
◯	◯	◯	◯	◯

15. **Please elaborate on your response to the previous question.**

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16. **Please rate your level of agreement/disagreement with the following statement: I believe that the Self-Reflection Assignments resulted in positive changes in my proficiency level(s) for at least one of the skills that I DID NOT actively work on during the semester.**

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

17. **Please elaborate on your response to the previous question.**

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18. **Please rate your level of agreement/disagreement with the following statement: I believe that the completing the Self-Reflection Assignments was the most significant factor influencing changes in my proficiency level(s) for at least one of the skills listed in the Self-Evaluation Rubric by the end of the semester.**

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

19. **Please elaborate on your response to the previous question.**

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20. **Please rate your level of agreement/disagreement with the following statement: I believe that WITHOUT the Self-Reflection Assignments I would have made the same changes in my proficiency level(s) for at least one of the skills that I actively worked on during the semester.**
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

21. **Please elaborate on your response to the previous question.**

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22. **Please rate your level of agreement/disagreement with the following statement: I believe that developing professional, non-technical skills is a valuable experience in an engineering course.**
Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

23. **Please elaborate on your response to the previous question.**

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24. **Please rate your level of agreement/disagreement with the following statement: I believe that the completing the Self-Reflection Assignments was a positive experience in the chemical reaction engineering course.**

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

25. **Please elaborate on your response to the previous question.**

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26. **Please rate your level of agreement/disagreement with the following statement: I recommend using the Self-Reflection Assignments in this course or other engineering courses for developing professional, non-technical skills.**

Mark only one oval.

	1	2	3	4	5	
Strongly agree	◯	◯	◯	◯	◯	Strongly disagree

27. **Please elaborate on your response to the previous question.**

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28. **Please describe any reasons for proficiency level changes for any of the skills in the Self-Evaluation Rubric over the course of the semester. You may describe changes to more than one skill.**

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29. **Please include any additional comments that you have related to the skills listed in the Self-Evaluation Rubric or related to the Self-Reflection Assignments.**

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Personal Key

This survey is anonymous. In order to match responses from Survey 1 and Survey 2 to unidentified individuals, you must generate a unique key known only to yourself.

30. **Follow this formula to generate your unique key and enter it in the space provided: last letter of your middle name (last name if you have no middle name) plus day of birth plus height in inches (two digits) plus last two digits of your cell phone number (home phone if no cell). For example, Dr. Ford Versypt's key is E96531 for middle name Nicole, birthdate of Aug. 9, 5 ft 5 inches tall, and cell phone ***-***-**31.** *

_____