SELF-ASSESSMENT AS A VALUABLE TOOL FOR STUDENT ACHIEVEMENT, SELF-EFFICACY, AND PROMOTING A GROWTH MINDSET

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ABSTRACT

Self-reflection and self-assessment are an important part of the learning process and have been an area of interest for educators aiming to improve student learning gains. Prior research has focused on how student performance is affected due to the implementation of self-reflection credit compared with more traditional performative and graded assignments, as well as the correlation between self-reflection and student achievement. This study further investigated the effectiveness of self-assessment in the classroom by measuring the correctness and accuracy of student self-assessment performance and its effect on summative assessments and learning mindset. This was measured by analyzing student work via low-stakes self-assessment assignments in an organic chemistry lecture course. These assignments were intended to offer students the opportunity to self-assess without the need for instructor involvement. In addition to analyzing student work, surveys on students' impressions of the assessment process and how it might affect their learning mindset were administered. Our hypothesis was that students who consistently and accurately complete their self-assessments would be more strongly associated with higher summative assessment and overall course grades, as well as be associated with a growth-oriented mindset. Key findings of the study include assignment complexity influencing self-assessment accuracy, with A-students excelling in high-complexity assignments. Furthermore, the majority of students maintain a fixed mindset with some inclination towards growth-oriented ideas, as well as high levels of self-efficacy overall. This area of research is relevant for instructors who wish to develop a curriculum that facilitates a growth mindset for students while simultaneously promoting subject-specific learning goals. This study furthers this research by allowing the effect of self-assessment methods to be better understood and to allow for more effective future implementations.

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TABLE OF CONTENTS

INTRODUCTION

In the field of education, a significant dichotomy is evident between individuals who embody a growth mindset and those mired in a fixed mindset (Dweck, 2006). A growth mindset excels at assimilating new information, embracing ambiguity, and acknowledging mistakes as intrinsic to the learning process. It is closely associated with the belief that setbacks, challenges, and failures are seen as opportunities for improvement. Conversely, a person operating from a fixed mindset resists new learning, often misconstrues ambiguity as a threat, fears making mistakes, and grapples with self-doubt. A fixed mindset is a phenomenon commonly observed in many students, especially when they contend with the stresses of high academic achievement, GPA maintenance, and self-imposed expectations (Dweck, 2006). Fostering a growth mindset can promote resilience and academic achievement among students (Dweck, 2006). Dweck's work emphasizes the importance of mindset in shaping individuals' responses to challenges and setbacks, highlighting how a growth-oriented perspective can lead to greater perseverance and success in academic endeavors (Dweck, 2006). For example, Dweck suggests that individuals with a growth mindset are more likely to view effort as a path to mastery, leading to increased engagement and higher grades over time.

In one study, students with a growth mindset showed increased engagement in challenging tasks, leading to higher grades over time (Yeager & Dweck, 2012). The article highlights research indicating that students who believed that their intelligence could be developed were more likely to persevere through academic setbacks and challenges, ultimately achieving better outcomes (Yeager & Dweck, 2012). These findings suggest a strong association between a growth mindset and superior academic performance, providing support for the notion that fostering a growth mindset can lead to resilience and academic success. It is our hope that

supporting students with the tools and resources to enjoy the learning process will improve their academic performance and cultivate a growth-oriented mindset. The current project will investigate how a specific tool, namely self-assessment, influences the promotion of a growth mindset, as opposed to a performance-driven perspective fixated on outcomes.

Self-reflection and self-assessment are pivotal components of the learning process and have garnered attention from educators seeking to enhance students' learning success by honing their feedback literacy. Feedback literacy, defined as an individual's capacity to comprehend and effectively utilize feedback, empowers students to become independent, proactive learners who actively engage with the material (Yan & Carless, 2018). This boosts their emotional and intellectual confidence and, ultimately, their ability to engage in meaningful dialogues about their subjects and recognize the skills they acquire through their studies. This, in turn, contributes to improved student success and achievement.

Previous research has primarily focused on the impact of self-reflection feedback compared to more conventional performative and graded assignments, as well as the optimal strategies for implementing self-assessment and its influence on student learning and achievement (Andrade, 2010). As Heidi L. Andrade discovered in her study, consistency in self-assessment, student perceptions of self-assessment, and self-regulated learning are factors influencing student achievement. For instance, when students consistently evaluate their own performance accurately, it indicates a deeper understanding of their strengths and weaknesses, facilitating targeted learning and improvement. Moreover, student perceptions of self-assessment play a crucial role in shaping their attitudes and behaviors toward the practice. Positive perceptions, such as viewing self-assessment as a valuable tool for personal growth and development, are associated with more active engagement and effective utilization of feedback.

Lastly, the integration of self-regulated learning (SRL) practices with self-assessment enhances its effectiveness in promoting student achievement. SRL involves setting goals, monitoring progress, employing effective learning strategies, and adapting behaviors based on feedback. When students are equipped with the skills and strategies to regulate their own learning process, they are better able to leverage self-assessment feedback for continuous improvement. Her research indicates that the most significant impact on student achievement stems from the consistency and perception of self-assessment, laying a solid foundation for further investigation.

Additionally, research shows that students often favor self-assessment credit (Pereira et al., 2013). This preference correlates with higher perception scores in assessment effectiveness, fairness, and levels of participation and engagement (Pereira et al., 2013). This complements the notion that student perceptions of self-assessment are pivotal in improving student achievement. The study found that students who prefer alternative methods, such as self-reflection credit, exhibit higher levels of perceived effectiveness, fairness, participation, and engagement with summative exams, while those who lean toward traditional performative methods show contrasting trends (Pereira et al., 2013). This highlights the significance of student-centered assessment approaches in fostering a positive learning environment and promoting active student involvement.

Additionally, another study found that students who opt for completion and self-reflection credit, rather than performance grades, achieve higher scores on summative exams (Shryock, 2003). This is due in part to the role of self-assessment as a foundational step in enhancing students' self-efficacy (Buzzetto-Hollywood et al., 2010). Self-efficacy, defined as an individual's confidence in their innate ability to achieve goals, has a direct bearing on goal achievement

(Bandura, 1997). Higher self-efficacy encourages the development of robust study habits and self-motivation skills; as well as aligning students with a growth-oriented mindset.

Moreover, self-assessment fosters heightened self-awareness of learning and thinking processes, enabling students to fine-tune their study methods and bolster their self-efficacy (Mok et al., 2014). This, in turn, promotes a sense of fulfillment in the learning process, cultivating a more pronounced growth mindset. Evidence from Mok et al. (2014) supports this idea, showing that students make significant progress in their learning when they engage in self-assessment activities. For example, analysis of students' responses revealed that many progressed from having a basic understanding to a deeper one, with some showing substantial advancement (Mok et al., 2014). Additionally, students showed improvements in organizing their learning, setting clear goals, and reflecting on their learning experiences (Mok et al., 2014). These findings highlight the positive impact of self-assessment on student learning and the importance of fostering self-awareness and reflection in education.

Furthermore, while much of the literature focuses on self-assessment as a formative tool for learning, recent studies have suggested its potential utility in summative contexts as well (Nieminen et al., 2021). Nieminen et al. empirically compared formative and summative models of self-assessment, investigating their impact on students' approaches to learning and self-efficacy within the educational context. The study aimed to examine how students' studying, indicated by approaches to learning, self-efficacy, and academic achievement, differed between formative and summative models of self-assessment. Using a person-oriented approach, the research explored student subgroups based on deep and surface approaches to learning, seeking answers to specific research questions regarding the differences between the two self-assessment

models and the identification of student subgroups in terms of learning approaches (Nieminen et al., 2021).

The findings revealed variations in student profiles between the formative and summative self-assessment models. Students participating in the summative self-assessment group were overrepresented among those exhibiting a high level of deep approach to learning, indicating a potential link between summative self-assessment and enhanced engagement with course material (Nieminen et al., 2021). Additionally, summative self-assessment was associated with increased levels of self-efficacy among students, suggesting its potential to foster students' studying within appropriate educational contexts (Nieminen et al., 2021). These insights contribute to the ongoing discourse on self-assessment in education, highlighting the importance of considering both formative and summative approaches within pedagogical practices. Furthermore, the study suggests the need for aligning self-assessment practices with future-driven pedagogical purposes to maximize their effectiveness in promoting student learning and self-efficacy (Nieminen et al., 2021).

The cumulative evidence from previous research underscores the pivotal roles of feedback literacy and self-efficacy in enhancing academic achievement and success. Consequently, self-assessment emerges as a valuable tool to facilitate the improvement of students' learning strategies and study habits through the application of the right methods.

In this study, we aim to delve deeper into the effectiveness of self-assessment in the classroom by evaluating the consistency and accuracy of student formative self-assessments and their impact on summative assessment performance, growth versus fixed mindset, and self-efficacy. This investigation will center on the analysis of student work through low-stakes formative self-assessment assignments within an organic chemistry lecture course. These

formative assessments have been authored by the instructor and will be conducted regularly, serving as ongoing evaluations of student performance throughout the learning period, allowing students to self-assess their understanding of topics covered in the lectures. These self-assessment assignments allow students to make their best efforts on new material as they are learning it and then, in a second part of the assignment, grade their work based on a well-constructed rubric.

The primary objective of these assignments is to offer students the opportunity for self-assessment without the need for direct instructor involvement. They are specifically designed to stimulate critical thinking and reflection on the course material. We will analyze student work for both overall correctness as well as accuracy in grading themselves by applying the rubric to their work. Our hypothesis is that students who consistently and accurately complete these self-assessment assignments will develop a deeper understanding of their abilities, enabling them to focus their study efforts effectively. This, in turn, will enhance their self-efficacy and self-study habits, fostering a growth-oriented mindset where they engage with the material with the intent to understand their misconceptions and address those misconceptions as part of the learning process.

Recognizing the importance of student impressions in the learning process, we will also administer surveys to gauge their perceptions of the self-assessment process and its potential impact on their learning mindset. These surveys will assess the perceived impact of the self-assessment assignments on student achievement and mindset. To gain insight into the broader effects on students' mindsets, we will incorporate questions from the General Self-Efficacy Scale (Schwarzer et al., 1995) and the Dweck Mindset Quiz (Dweck, 2006). This

approach will enable us to not only capture students' opinions and perceptions of the assessments but also investigate how these assessments may influence their mindsets over time.

The overall performance of students will be assessed through course grades and exam grades, measured via summative assessments and final course grades at the end of the academic term. Our hypothesis suggests that students who consistently and accurately complete self-assessments will exhibit stronger associations with higher summative assessment and overall course grades, as well as a more pronounced growth-oriented mindset.

This research holds significance for educators who seek to design curricula that foster a growth mindset among students while simultaneously achieving subject-specific learning goals. Our study contributes to this endeavor by enhancing our understanding of the effects of self-assessment methods, enabling more effective implementations in the future. Our goal is to contribute to the design of curricula that promote student comprehension and learning through robust self-efficacy practices.

METHODS

Participants

Participants (N = 160) were University of California, Riverside (UCR) students recruited from and enrolled in Dr. Casselman's organic chemistry course during the fall quarter of 2023 according to IRB protocol #23178. Participants were invited to participate in the study via an in-person announcement in class and a Canvas announcement that included a sign-up sheet Google Form. An email was then sent out with the description of the experiment, their role as a participant, and the Google Form that will be used to collect the consent of participants and data. The students who chose to complete surveys received extra credit, however, there was no penalty for not participating in the study. If a student did not wish for their data to be used in the study

they could decline consent, but could still earn extra credit by completing both beginning and end-of-quarter surveys.

Design

The current study is a longitudinal design that spans a single academic quarter. It involved the recruitment of 160 organic chemistry students, with their consent to participate in the study, in the initial week of the quarter. Data collected from student participants included a beginning-of-quarter and an end-of-quarter survey, which assessed students' level of self-efficacy and growth/fixed mindset, demographic information, and course grades. Dr. Casselman's course is designed such that students are assigned regular self-assessment (SA) assignments which consist of a problem set and a grading assignment to be completed by the students. Student participant performance on these problem sets and grading assignments served as the primary source of data for evaluating the correctness and accuracy of students' self-assessment skills. These assignments were analyzed after the quarter concluded and exclusively involved the data of students who had consented to participate.

Materials

Demographics Survey

In the study, Google Forms and Canvas were used for administering the beginning-of-quarter and end-of-quarter surveys to collect data on self-assessment abilities, demographic information, and student perceptions of their self-efficacy and growth mindset. The demographic survey was administered through a Google Form via email to students who signed up through the study sign-up sheet. The demographic survey used in the study consisted of several items designed to gather information about participants' personal characteristics. Participants were asked to respond to the following items:

1. Gender: Participants were provided with response options including Male, Female, Non-binary/third gender, and Prefer not to answer.
2. Age: Participants were asked to indicate their age by providing a numerical value.
3. Race/Ethnicity: Participants were presented with a list of racial and ethnic categories, including American Indian/Native American/Alaska Native, Asian/Asian American, Black/African American, Hispanic/Latinx, Native Hawaiian/Other Pacific Islander, White/European, Bi-/Multi-racial, and Prefer not to say.
4. Undergraduate Major/Concentration: Participants were asked to specify their undergraduate major or concentration, providing an open-ended response field.

General Self-Efficacy Scale

The General Self-Efficacy Scale (GSES) is a 10-item questionnaire designed to measure an individual's belief in their ability to cope with various challenges in life (Schwarzer & Jerusalem, 1995). Developed by Schwarzer and Jerusalem in 1995, the scale assesses individuals' perceived self-efficacy, which refers to their confidence in their capability to overcome obstacles and accomplish goals in different domains of life. The survey utilized in this study incorporates the GSES, with participants asked to rate their agreement with 10 statements on a scale of 1 to 5. A rating of 1 indicates that the statement is 'not true at all,' while a rating of 5 indicates that the statement is 'exactly true.' The items included in the GSES cover a range of situations and scenarios, including problem-solving, goal attainment, coping with unexpected events, and maintaining composure in challenging circumstances. Each item is formulated as a declarative statement reflecting the individual's perceived self-efficacy in that particular situation. Higher scores on the scale indicate greater levels of perceived self-efficacy, reflecting a stronger belief in one's ability to effectively manage and navigate through life's challenges.

Dweck Mindset Quiz

The Growth Mindset Survey utilized in this study is based on the work of psychologist Carol Dweck and is designed to assess individuals' beliefs about intelligence and abilities, specifically whether they hold a fixed or growth mindset (Dweck, 2006). Developed by Dweck and her colleagues, the quiz consists of statements that prompt participants to reflect on their attitudes toward effort, challenges, and success. Participants are instructed to indicate their level of agreement with each statement on a scale of 1 to 4, with 1 representing 'strongly agree' and 4 representing 'strongly disagree.' After completing the survey, participants' scores are categorized into four mindset groups based on their total scores: 21-27 = Strong Growth Mindset, 15-20 = Growth with some Fixed ideas, 8-14 = Fixed with some Growth ideas, and 0-7 = Strong Fixed mindset. The items included in the survey cover various aspects of mindset beliefs, including beliefs about the malleability of intelligence, the importance of effort in achievement, and the value of feedback.

Self-Assessment Assignments

Self-assessments are frequently assigned, short assignments integrated into the course curriculum for students to complete throughout the academic quarter. These assignments cover varying topics of differing complexity throughout the quarter. The assignments are made up of two parts: the problem set and the grading. Students complete the work on the problem set first and then upload that to Gradescope. Students then complete the grading assignment which consists of a check-off list of procedural steps and answers for the worksheet itself. Self-assessment assignments are assigned once or twice weekly after specific lectures. Within the course, these assignments are not scored for correctness, but rather for completion. Self-assessment assignments represent a small portion (15%) of students' final grade.

Procedure

Survey Data

Participants were recruited for this study in the first week of the academic quarter at UCR. Students were given the option to either consent to have their data used in the study or decline to provide consent. Regardless of their choice, all students were invited to complete an initial survey by the end of the first week, which was administered online. This survey included the General Self-Efficacy Scale (GSES) and Mindset Quiz, and students who consented to be part of the study also permitted the disclosure of their demographic information and course grades. In the final week of the quarter (week 10), students completed an end-of-quarter survey, also administered online, which included the GSES and Mindset Quiz, as well as a self-assessment perception survey regarding the self-assessment assignments from the quarter. Following the study's conclusion, a list of students who completed both surveys was prepared by the student researcher, ensuring that only the data of students who provided consent would be included in the study's analysis.

Self Assessment Data

Throughout the quarter, students completed short self-assessment assignments that were mandatory for all students, regardless of their participation in the study. These self-assessment assignments were designed to assess students' understanding of course material and problem-solving skills. Each assignment consisted of problem sets and grading assignments, with students required to complete both components. The problem sets were designed to assess students' comprehension of topics covered in the lectures, while the grading assignments allowed students to self-assess their understanding and performance. The self-assessment assignments were not scored for correctness but rather for completion, representing a small portion (15%) of

students' final grades. After the quarter concluded, two self-assessment assignments were analyzed by the student researcher to assess the correctness and accuracy of students' self-assessment abilities. The self-assessments chosen for analysis were selected based on their varying levels of complexity, with high and low-complexity assignments included. The high-complexity assessment (#3) involved tasks that required deeper understanding, critical thinking, and application of complex concepts, including arrow-pushing, resonance, and electron movement. The low-complexity assessment (#11) consisted of predicting the product questions, which are more straightforward problems with fewer steps. This selection aimed to capture an array of students' self-assessment abilities across different levels of difficulty. The scoring of self-assessment correctness involved comparing students' self-assessed answers to the correct solutions provided by the instructor. The data obtained from the self-assessment assignments were validated through inter-rater reliability analysis, with multiple researchers independently scoring a subset of assignments to ensure accuracy. The accuracy of students' self-assessment abilities was evaluated based on the percentage of agreement between the student and the student-researcher's grading, employing Cohen's kappa statistic. Cohen's kappa provides a chance-corrected index of agreement, with values interpreted on a scale ranging from none (0), slight (0.01–0.20), fair (0.21–0.40), moderate (0.41– 0.60), substantial (0.61–0.80), and almost perfect (0.81–1.00) agreement (McHugh, 2012). The SA data were then subjected to statistical analysis to identify any correlations, and differences between students' self-assessment abilities and their academic performance, mindset beliefs, and self-efficacy levels.

RESULTS

The study was expected to show better correctness and accuracy in self-assessment (SA) assignments, higher levels of self-efficacy, and a more growth-oriented mindset for

higher-performing students (*i.e.* A/B letter grades) compared to lower-performing students (*i.e.* C/D/F letter grades). The analysis of SAs of varying complexities revealed several trends regarding correctness and accuracy among students of varying performance levels. For SA #3 (high complexity), there was a positive trend between correctness and academic performance as seen in Figure 1. There was also a positive trend between accuracy and academic performance in SA #3 as seen in Figure 2. On the other hand, a negative trend between correctness and academic performance for SA #11 (low complexity) was observed as seen in Figure 3. There was also a negative trend between accuracy and academic performance for SA #11 as seen in Figure 4.

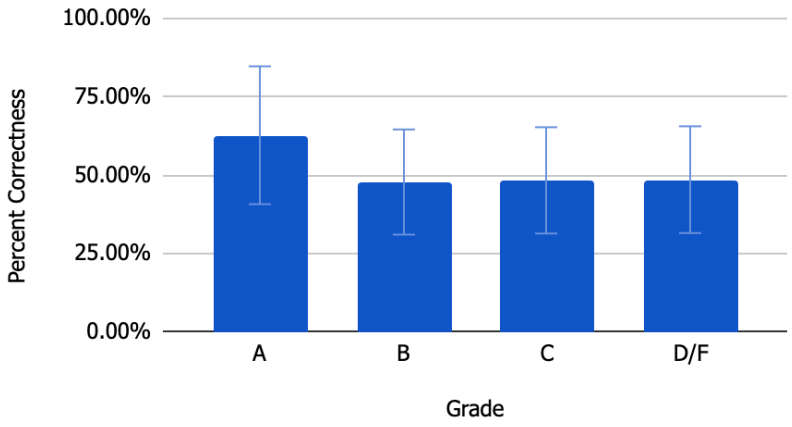


Figure 1. SA #3 correctness vs. letter grade. This figure shows the percent accuracy on SA #3 for each letter grade. Correctness describes the number of right answers compared to the rubric.

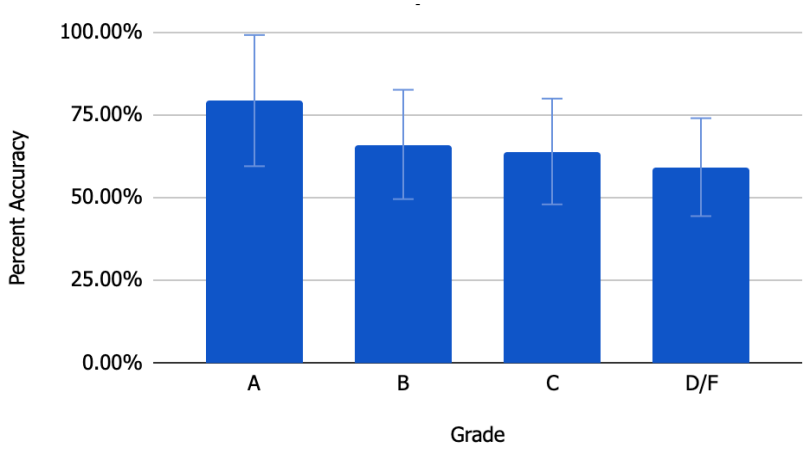


Figure 2. SA #3 accuracy vs. letter grade. This figure shows the percent accuracy on SA #3 for each letter grade. Accuracy describes the number of matching answers from student grading to master grading.

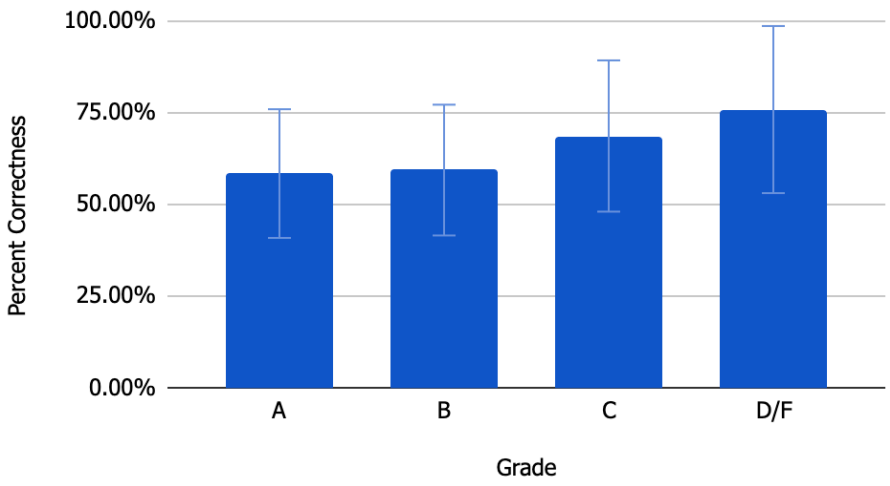


Figure 3. SA #11 correctness vs. letter grade. This figure shows the percent correctness on SA #11 for each letter grade. Correctness describes the number of right answers compared to the rubric.

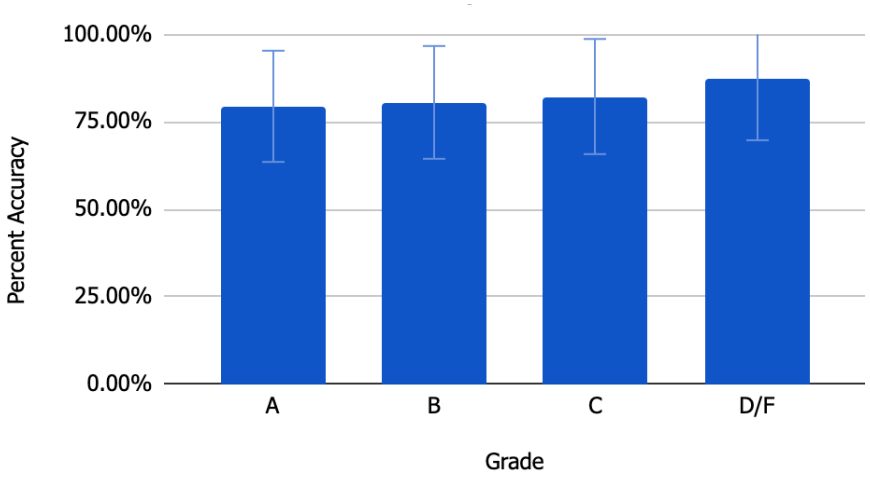


Figure 4. SA #11 accuracy vs. letter grade. This figure shows the percent accuracy on SA #11 for each letter grade. Accuracy describes the number of matching answers from student grading to master grading.

While there appeared to be trends indicating that higher-performing students (A/B) tended to grade more correctly and accurately than lower-performing students (C/D/F) in high-complexity SAs, and vice versa for low-complexity SAs, no significant differences were found in either SA #3 or SA #11. An independent samples t-test indicated that there was no

significant difference between the higher-performing students (M = 56.02%, SD = 35.84%) and lower-performing students (M = 48.45%, SD = 35.79%) for SA #3 correctness; t(124) = 1.13, p = 0.263. There was no significant difference between the higher-performing students (M = 58.99%, SD = 38.02%) and lower-performing students (M = 72.36%%, SD = 36.56%) for SA #11 correctness; t(125) = -1.48, p = 0.141. There was no significant difference between the higher-performing students (M = 72.82%, SD = 29.90%) and lower-performing students (M = 61.68%, SD = 32.12%) for SA #3 accuracy; t(124) = 1.85, p = 0.067. There was no significant difference between the higher-performing students (M = 80.00%, SD = 25.18%) and lower-performing students (M = 85.02%, SD = 20.19%) for SA #11 accuracy; t(125) = -0.858, p = 0.393 (Table 1).

Table 1. Results of Independent Sample T-tests Regarding Self-Assessment Correctness and Accuracy

Logistic parameter	A/B		C/D/F		*t*	*df*	*p*	*MD*
	M	*SD*	*M*	*SD*				
Assessment 3 Correctness	56.0	35.8	48.5	35.8	1.13	124	0.263	0.076
Assessment 3 Accuracy	72.8	29.9	61.7	32.1	1.85	124	0.067	0.107
Assessment 11 Correctness	59.0	38.0	72.4	36.6	-1.48	125	0.141	-0.108
Assessment 11 Accuracy	80.0	25.2	85.0	20.2	-0.858	125	0.393	-0.038

Note. Independent Sample T-tests regarding Self Assessment Correctness and Accuracy between higher-performers and lower-performers.

However, there were significant differences between A grade students and B, C, D and F grade students in SA #3 with a positive correlation between grade and correctness, and grade and accuracy in SA #3. An independent samples t-test indicated that there was a significant difference between the A grade students (M = 62.78%, SD = 35.87%) and all other (B/C/D/F)

students (M = 48.25%, SD = 35.00%) for SA #3 correctness; t(124) = 2.21, p = 0.029 (Table 1). There was also a significant difference between the A students (M = 79.45%, SD = 29.23%) and all other (B/C/D/F) students (M = 64.34%, SD = 30.75%) for SA #3 accuracy; t(124) = 2.69, p = 0.008 (Table 2). There was no significant difference between course achievement and correctness or accuracy for SA #11.

Table 2. Results of Independent Sample T-tests Regarding Self-Assessment Correctness and Accuracy

Logistic parameter	A		B/C/D/F		*t*	*df*	*p*	*MD*
	M	*SD*	*M*	*SD*				
Assessment 3 Correctness	62.8	35.8	48.3	35.0	2.21	124	0.029*	0.145
Assessment 3 Accuracy	79.5	29.2	64.3	30.8	2.69	124	0.008*	0.151
Assessment 11 Correctness	57.5	37.0	65.6	40.3	-1.14	125	0.258	-0.082
Assessment 11 Accuracy	79.4	25.1	82.5	22.7	-0.708	125	0.480	-0.031

Note. Independent Sample T-tests regarding Self Assessment Correctness and Accuracy between A students and B/C/D/F students. Significant differences are visible in Self Assessment 3 in both correctness and accuracy. *Indicates significance, $p < 0.05$.

The results of the Dweck Mindset Quiz are summarized in Table 3. The majority of students predominantly held a fixed mindset, with some inclination towards growth-oriented ideas.. Furthermore, there is a slight positive trend between mindset type and academic performance, with lower-performing students tending to have slightly higher scores indicative of a growth mindset compared to higher-performing students. However, it's essential to note that this correlation is minimal and there is no significant difference between the higher-performers (M = 10.95, SD = 3.74) and lower-performers (M = 11.74, SD = 3.26) between mindset type and academic performance; t(136) = -0.821, p = 0.413.

The General Self-Efficacy Scale results are summarized in Table 3. The range of possible scores for this survey is 10-50. The survey results suggest that students generally possess high levels of confidence in their ability to perform tasks and overcome challenges. While both higher and lower-performing students exhibit high self-efficacy overall, there is a slight difference in average scores between the two groups favoring higher-performing students. However, there is no significant difference between the higher-performers (M = 35.76, SD = 5.51) and lower-performers (M = 34.85, SD = 5.61) regarding self-efficacy levels and academic performance; $t(136) = 0.641$, $p = 0.523$.

Table 3. Self-Efficacy and Mindset Scores

	Full sample	
	n	%
Self Efficacy		
Higher-Performers		
10-20	0	0.00
20-30	17	18.5
30-40	56	60.9
40-50	19	20.7
Lower-Performers		
10-20	0	0.00
20-30	8	17.4
30-40	31	67.4
40-50	7	15.2
Mindset		
Higher-Performers		
0-7 (Strong fixed mindset)	13	14.1
8-14 (Fixed with some growth ideas)	57	62.0
15-20 (Growth with some Fixed ideas)	12	13.0
21-27 (Strong Growth Mindset)	1	1.09
Lower-Performers		
0-7 (Strong fixed mindset)	1	2.17
8-14 (Fixed with some growth ideas)	37	80.4
15-20 (Growth with some Fixed ideas)	8	17.4
21-27 (Strong Growth Mindset)	0	0.00

Note. $N_{total} = 160$. However, only 139 participants provided data for all surveys. $N_{high\ performers} = 92$; $N_{low\ performers} = 46$.

Results of the student perceptions of SAs are reported in Table 4. Higher-performing students expressed that their performance on SAs accurately reflected their graded assessments, unlike lower-performers (63.04% vs 28.95%). This perception was positively correlated, indicating a strong belief in the reliability of SAs among higher-performing students. Additionally, higher-performing students reported favorably on the frequency of SAs, finding them more beneficial compared to their lower-performing counterparts (95.65% vs. 78.94%), and this preference was positively correlated. Moreover, higher-performing students acknowledged spending more time on SAs (71.74% vs. 57.89%), which was also positively correlated with performance. Lastly, higher-performing students felt more confident in their ability to accurately assess their own understanding of course material through SAs compared to lower-performing students (79.35% vs. 60.53%). Overall, most students, irrespective of performance level, found the assessments helpful in identifying areas of weakness in the course. They often revisited the assessments as study tools before the midterm, helping them keep up with the course, regardless of their performance on graded assessments. Furthermore, students generally perceived the assessments to be less difficult than the course material, and they found it useful to grade their own work, independent of their performance on graded assessments as seen in Table 4.

Table 4. Percentage of Students Who Reported High Perceptions

	% High Perception
How useful do you find it to grade your own work?	
High Performers	81.52
Low Performers	76.31
Total	80.43
How helpful do you find the frequency of the self-assessments?	
High Performers	95.65**
Low Performers	78.95**
Total	89.13
I revisit previous assessments throughout the quarter.	
High Performers	73.91*
Low Performers	60.53*
Total	71.01
I revisit previous assessments just before the midterm.	
High Performers	97.83
Low Performers	100.0
Total	97.83
My performance on self-assessments accurately reflects my performance on graded assessments.	
High Performers	
Low Performers	63.04**
Total	28.95**
I spend a generous amount of time on self-assessments in preparation for exams.	51.45
High Performers	
Low Performers	71.74*
Total	57.89*
Self-assessments are helpful when reviewing for the exam.	67.39
High Performers	
Low Performers	91.30
Total	89.47
Self-assessments help me to identify areas of weakness in understanding the course material.	91.30
High Performers	
Low Performers	90.22
Total	92.11
Self-assessments are an effective way for me to monitor my progress throughout the course.	91.30
High Performers	
Low Performers	89.13
Total	81.58
I feel confident in my ability to accurately assess your own understanding of course material through self-assessments.	86.96
High Performers	
Low Performers	79.35*
Total	60.52*
I enjoy using self-assessments as a learning tool.	73.91
High Performers	
Low Performers	86.96
Total	84.21
Self-assessments motivate me to study and engage with the course material.	86.23
High Performers	
Low Performers	82.61
Total	86.84
	84.06

Note. This figure represents student perceptions of self-assessment assignments. It reflects the percentage of students who reported high perceptions, or greater than 2 on the Self-Assessment Perception Survey separated into high performers (A/B), low performers (C/D/F) and total. * $p < 0.05$; ** $p < 0.001$.

DISCUSSION

The findings from this study provide valuable insights into the relationships between self-assessments (SAs) and academic performance, mindset, and self-efficacy among students. Our initial hypothesis predicted that higher-performing students (*i.e.* A/B grades) would demonstrate better correctness in SAs compared to lower-performing students (*i.e.* C/D/F grades). We also hypothesized that higher-performing students would be able to more accurately grade their own work. Additionally, we hypothesized that higher-performing students would exhibit higher levels of self-efficacy and a more growth-oriented mindset over a fixed mindset.

When surveying students' growth versus fixed mindset, the majority of students would be characterized by having a fixed mindset with some growth-oriented ideas, as measured by the Dweck Mindset Quiz. While a slight positive correlation was found between mindset type and academic performance, this correlation was subtle and non-significant (Table 3). Furthermore, when students were surveyed at the end of the quarter, there was no significant change in mindset over the duration of the quarter, highlighting the stability of students' beliefs about their abilities. Similarly, the study revealed high levels of self-efficacy among students, with slightly higher scores observed among higher-performing students. However, this difference was not statistically significant, indicating that self-efficacy alone may not be a decisive factor in predicting academic success in the context of a challenging organic chemistry course.

In terms of SA correctness, trends were noted suggesting that higher-performing students exhibited higher correctness scores in SA #3 (high complexity) than their lower-performing counterparts, although these trends were not significant (Table 1). However, significant differences were found in the correctness scores of SA #3 between 'A' students and all other performing students (B/C/D/F), indicating a potential advantage for higher-performing students

in comprehending complex material (Table 2). Further, no significant differences were observed in the correctness of SA #11 (low complexity) between high and lower-performing students. Higher-performing students may possess a deeper understanding of complex concepts and topics, enabling them to tackle high-complexity SAs more correctly. Conversely, the tendency for higher-performing students to exhibit less correctness on low-complexity SAs could suggest that they perceive these assessments as less challenging or less important compared to high-complexity assessments, leading to lower correctness in their grading. Furthermore, in the context of the Dunning-Kruger effect, higher-performing students' tendency to exhibit less correctness on low-complexity SAs could be attributed to their overestimation of their abilities (Schlösser et al., 2013). This overconfidence in their skills may result in a lower level of correctness in their SAs, as they may not feel the need to thoroughly review their work or may underestimate the importance of these assignments.

Moreover, trends in SA accuracy were noted suggesting that higher-performing students tended to grade SA #3 (high complexity) more accurately than their lower-performing counterparts, although these trends were not significant (Table 1). Significant differences were found in the accuracy of high complexity SAs between ‘A’ grade students and all other performing students, indicating a potential advantage for higher-performing students in accurately assessing their work (Table 2). Moreover, the disparity in accuracy between high and low-complexity assessments suggests that more challenging SA tasks may better cater to the evaluation needs of higher-performing students, particularly in gauging their understanding of complex subject matter. Lower-performing students may struggle with grasping complex material, leading to less accurate responses on high-complexity assessments.

The positive correlations observed between higher-performing students' perceptions of SAs and their academic outcomes highlight the potential value of SA practices in educational settings. The fact that higher-performing students found SAs to be reflective of their graded assessments suggests that these tools can serve as reliable indicators of student understanding and performance (Table 4). Moreover, the positive correlation between higher-performing students' appreciation for the frequency of SAs and their academic outcomes underscores the importance of integrating regular SA practices into educational curricula (Table 4). These findings suggest that higher-performing students find greater benefit from increased opportunities for self-reflection and self-monitoring through frequent SA tasks than lower-performing students. Additionally, the positive correlation between the time spent on SAs and academic performance suggests that investing time in self-evaluation activities may contribute to improved learning outcomes. However, it's essential to note that while higher-performing students generally perceived SAs more favorably, all students, regardless of performance level, found them helpful in identifying areas of weakness and supporting their learning process. Future studies could further investigate the specific mechanisms through which SA practices influence student learning and performance, exploring factors such as self-regulation strategies, metacognitive skills, and the role of feedback in enhancing the effectiveness of SA processes (Andrade et al., 2019). Additionally, investigating how to effectively implement SA practices across diverse educational contexts and disciplines could provide valuable insights for optimizing their impact on student learning and achievement.

CONCLUSIONS

This study has revealed complex findings regarding self-assessment (SA) correctness, accuracy, mindset, and self-efficacy among students of varying academic performance levels. Trends were observed suggesting that higher-performing students were better equipped to grade high-complexity SAs. There was also no significant difference in mindset type or self-efficacy scores. exhibiting higher self-efficacy scores, these differences were not statistically significant. Additionally, no significant correlation was found between mindset type and academic performance, challenging initial predictions. The observed trend of higher-performing students exhibiting better accuracy in grading high-complexity SAs could be linked to their deeper understanding of the subject matter, or having greater confidence and competence in their self-assessment abilities. The lack of significant differences in mindset type and self-efficacy scores among performance groups could suggest that these psychological factors might operate independently of academic achievement in the context of a challenging organic chemistry course.

The study's results also reveal insights into students' mindset and self-efficacy. Despite the lack of significant differences between high and lower-performing students, these findings prompt reflection on the broader implications for fostering growth-oriented attitudes. While SAs may serve as valuable tools for self-reflection and identifying areas for improvement, they alone may not be sufficient to instigate significant shifts in students' beliefs about their abilities and potential for growth. One hypothesis is that mindset type and self-efficacy may have little effect on student achievement in the challenging context of an introductory organic chemistry course. The complexity of the subject matter, coupled with the intensity of coursework and assessments, may overshadow the effects of mindset type and self-efficacy on academic performance. Students may need to devote considerable time and energy to mastering course material and

navigating the intricacies of organic chemistry because students may be more focused on meeting the rigorous academic standards and achieving satisfactory grades rather than on cultivating growth-oriented mindsets or bolstering their self-effective habits. Fostering a growth mindset and enhancing self-efficacy in the context of a challenging introductory organic chemistry course may require a comprehensive approach, incorporating a variety of instructional strategies and interventions tailored to individual student needs.

The lack of significant differences in SA accuracy between high and lower-performing students underscores the complexity of factors influencing student learning and assessment outcomes. These findings highlight the importance of considering individual differences, learning styles, and external factors in understanding student performance. Despite the non-significant results, the study's findings prompt reflection on the implications for SAs as an instructional method.

Higher-performing students likely possess a deeper comprehension of the subject matter, allowing them to provide more accurate evaluations of their own work, and recognize areas for improvement. Additionally, higher-performing students may have cultivated greater confidence and competence in their self-assessment abilities over time from their past academic successes and experiences. Consequently, these students might approach self-assessment tasks with a heightened level of self-assurance, enabling them to engage more critically and discerningly with the assessment criteria. Thus, the observed trend suggests the importance of both subject mastery and self-assessment efficacy in facilitating accurate self-evaluations among higher-performing students.

Overall, the hypotheses that students who consistently, correctly, and accurately complete their SAs would be more strongly associated with higher summative assessment and overall

course grades, as well as being associated with a growth-oriented mindset, were not fully supported by the findings of the study. While trends and patterns were observed in the data, such as higher-performing students demonstrating advantages in grading high complexity SAs and exhibiting higher self-efficacy scores, all of these differences did not reach statistical significance. Additionally, there was no significant correlation found between mindset type and academic performance. Therefore, while the hypothesis provided a theoretical framework for the study and guided the research questions, the results did not provide strong empirical support for all aspects of the hypothesis. This underlies the importance of considering the complexity of factors influencing student learning and assessment outcomes.

In conclusion, while the study provides valuable insights into the relationships between academic performance, mindset, and self-efficacy, further research is needed to elucidate the complex interplay of factors influencing student learning and assessment outcomes. Understanding these dynamics can inform the development of targeted interventions to support student success and foster a growth-oriented learning environment.

REFERENCES

Andrade, H. L. (2019). A Critical Review of Research on Student Self-Assessment. *Frontiers in Education*, *4*, 1-13. https://doi.org/10.3389/feduc.2019.00087

Bandura, A. (1997). Self-efficacy: The exercise of control. W H Freeman/Times Books/ Henry Holt & Co.

Buzzetto-Hollywood, N., Mitchell, B. C., & Hill, A. J. (2019). Introducing a Mindset Intervention to Improve Student Success. *Interdisciplinary Journal of E-Learning & Learning Objects*, *15*, 135–155. https://doi.org/10.28945/4465

Dweck, C. S. (2006). Mindset: The new psychology of success.

McHugh, M. L. (2012). Interrater reliability: The kappa statistic. *Biochemia Medica, 22*(3), 276-282. https://doi.org/10.11613/BM.2012.031

Mo Ching Mok, M., Leung Lung, C., Pui Wah Cheng, D., Hun Ping Cheung, R., & Lee Ng, M., (2006). Self-assessment in higher education: experience in using a metacognitive approach in five case studies. *Assessment & Evaluation in Higher Education, 31*(4), 415-433. https://doi.org/10.1080/02602930600679100

Nieminen, J. H., Asikainen, H., & Rämö, J. (2021). Promoting deep approach to learning and self-efficacy by changing the purpose of self-assessment: a comparison of summative and formative models. *Studies in Higher Education, 46*(7), 1296–1311. https://doi.org/10.1080/03075079.2019.1688282

Pereira, D., Cadime, I., Brown, G., & Assunção Flores, M. (2022) How do undergraduates perceive the use of assessment? A study in higher education. *European Journal of Higher Education, 12*(1), 1-17. https://doi.org/10.1080/21568235.2020.1871393

Schlösser, T., Dunning, D., Johnson, K. L., & Kruger, J. (2013). How unaware are the unskilled? Empirical tests of the "signal extraction" counter explanation for the Dunning–Kruger effect in self-evaluation of performance. *Journal of Economic Psychology, 39*, 85-100. https://doi.org/10.1016/j.joep.2013.07.004

Schwarzer, R., & Jerusalem, M. (1995). Generalized Self-Efficacy scale. Measures in health psychology: A user's portfolio. *Causal and control beliefs*. 35-37.

Shryock, K. (2020). *The Effect of Self-Reflection on Relative Student Success in Undergraduate Calculus 1*. [Masters dissertation, Northern Illinois University]. ProQuest Dissertations Publishing.

Yan, Z., & Carless, D. (2022). Self-assessment is about more than self: the enabling role of feedback literacy. *Assessment & Evaluation in Higher Education, 47*(7), 1116-1128. https://doi.org/10.1080/02602938.2021.2001431

Yeager, D. S., & Dweck, C. S. (2012). Mindsets That Promote Resilience: When Students Believe That Personal Characteristics Can Be Developed. *Educational Psychologist, 47*(4), 302–314. https://doi.org/10.1080/00461520.2012.722805

APPENDICES

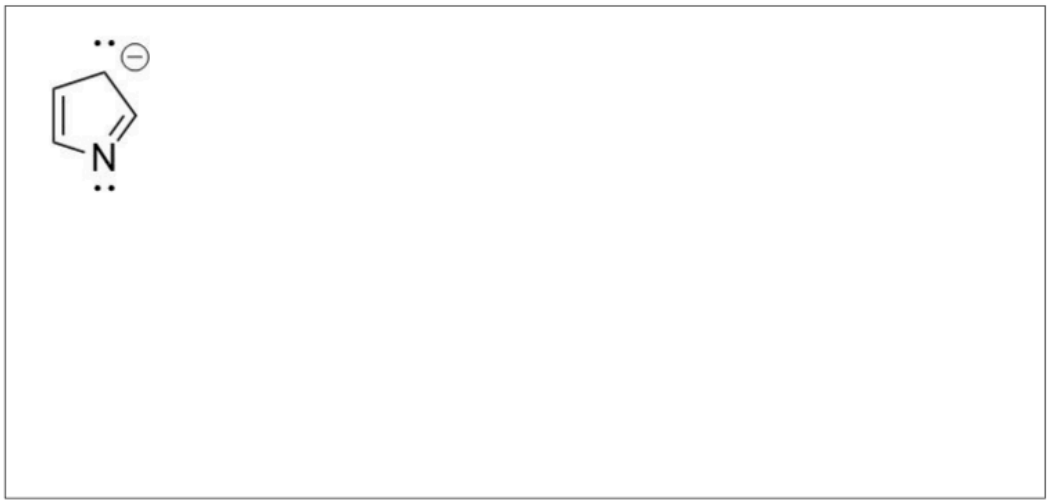
Appendix A

Self-Assessments

CHEM 8A (Casselman) Self Assessment

Name:

Draw all valid resonance structures for the structures shown below:



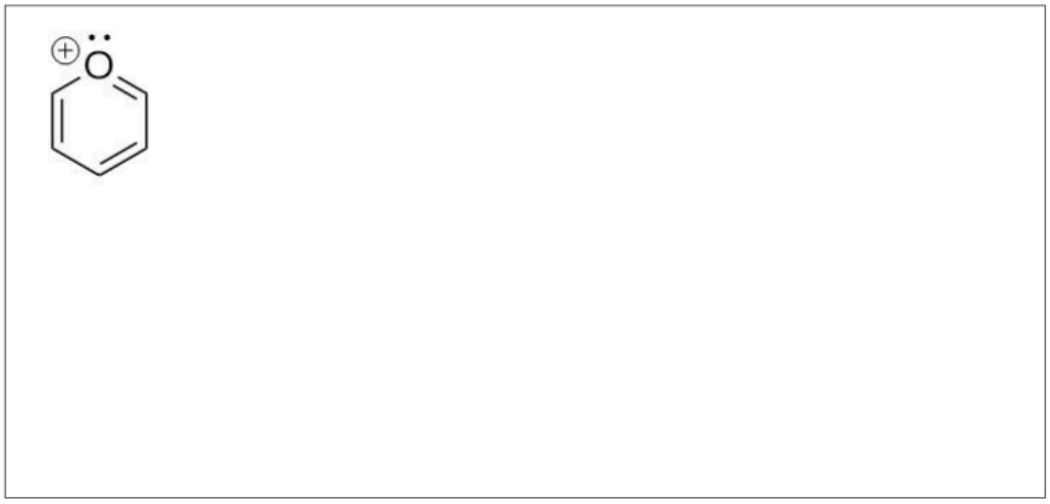


Figure 5. Self Assessment #3. Students worked on the problems, and then used a rubric to grade themselves. Self Assessment #3 was defined to be high complexity.

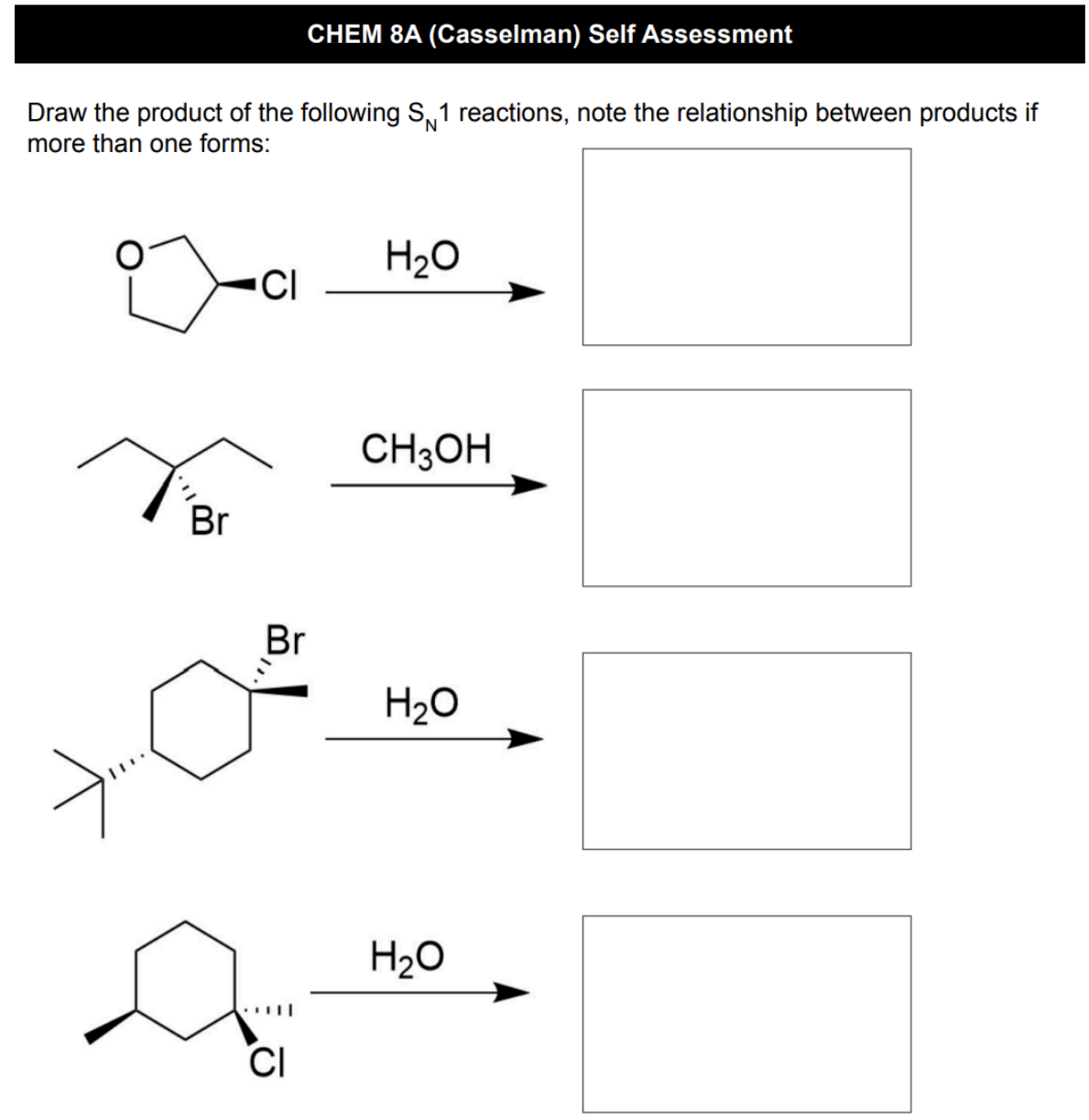


Figure 6. Self Assessment #11. Students worked on the problems, and then used a rubric to grade themselves. Self Assessment #11 was defined to be low complexity.

Appendix B

Demographic Information

Demographic Characteristics of Participants	Full sample	
	n	%
Gender		
Female	94	58.8
Male	64	40.0
Non-binary/third gender	1	0.63
Prefer not to answer	1	0.63
Age		
18	17	10.6
19	96	60.0
20	30	18.8
21+	17	10.6
Race/Ethnicity		
American Indian/Native American/Alaska Native	1	0.63
Asian/Asian American	102	63.8
Bi-/Multi-racial	6	3.75
Black/African American	1	0.63
Hispanic/Latinx	26	16.3
Native Hawaiian/Other Pacific Islander	1	0.63
White/European	17	10.6
Prefer not to say	6	3.75
Undergraduate Major		
Biochemistry	15	9.38
Biology	75	46.9
Cellular, Molecular, and Developmental Biology	18	11.3
Neuroscience	24	15.0
Other (Science)	12	7.50
Other (Engineering)	12	7.50
Other (Non-STEM)	2	1.25
Undeclared	1	0.63

Note. $N = 160$.