Students' Self-Reported Self-Regulated Learning Skills Across a First-Year Engineering Program (Full Paper)

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Introduction & Background

The first year in a college undergraduate program is a significant transition in students' lives. For many students this transition includes elements such as relocating to a new living space, adjusting to a new social setting, acquiring new levels of independence, and sometimes needing to learn new skills to be more self-sufficient in day-to-day living. Students struggling with the transition from high school to college is a concern student affairs teams and academic advisors are knowledgeable of and has thus been a topic of research and focus of interventions documented in literature as higher education works to better support student success and retention (e.g., [1], [2], [3], [4]). Not only do these transition processes take time, but how students navigate moving from the familiar to the unfamiliar varies significantly from student to student [3]. Nonetheless, while first-year college students navigate these many transitions, their coursework simultaneously progresses apace.

In most undergraduate engineering programs across the United States, first-year engineering (FYE) students are likely to be enrolled in one or more foundational engineering courses such as mathematics, physics, chemistry, etc. [5] and in some programs, students take these courses in parallel with major-specific or general engineering introductory courses [6], [7]. In many instances students experience a misalignment between their previous education experiences, what they anticipated their undergraduate education to be like, and the realities of the challenges and stressors involved in their first-year courses and experiences. This phenomenon is well-documented among STEM students by Seymour and Hewitt [8] and Seymour and Hunter [9]. Part of first-year engineering students' transition into college is the academic transition from a high school learning environment to a college learning environment that is more demanding, but simultaneously gives them significantly more independence as a learner.

Many students who are accepted into engineering programs are considered smart or academically high achievers in their previous educational contexts [10]; however, the combination of fast-paced and challenging coursework coupled with students having more independence and autonomy in their courses sometimes results in students' first assessment grade being significantly lower than the grades they earned in high school. In some cases, students react productively to this lower grade, acknowledging the need for them to adjust their learning and study strategies. On the other hand, in some cases, students' reactions to these lower grades include stress, frustration, weaker engineering identities, lower self-efficacy, and sometimes even leaving engineering programs [8], [9], [10], [11], [12].

Research Context

First-Year Engineering Course

The context of this study is a First-Year, General Engineering (GE) program at a large, public, land-grant university that serves an average of 2,300 students each semester. The GE program can be taken as a one-semester 4-credit hour course (if specific pre-requisite credits are transferred in) or as a two-semester course sequence of 2-credit hours across the first academic year. The GE program courses expose students to the various engineering disciplines offered at the university, and teach engineering problem scoping and problem solving, data collection and visualization, the engineering design process, programming, CAD, and professional skills.

First-Year Engineering Advising

This GE program also has a team of nine academic advisors responsible for advising first-year general engineering students. The GE instructors and advisors have engaged in strategic collaboration to provide students with comprehensive learning and support experiences. As a part of the College of Engineering's student success initiatives, the GE program set out to more intentionally bring the academic success knowledge, experience, and lessons possessed by the advising team to the GE classroom. It is important to note that *academic success*, in the scope of this initiative, encompasses not only academic skills (e.g., study skills, campus resource seeking, etc.) to successfully navigate college, but also transferable skills that are necessary in professional contexts (e.g., time management, goal setting, planning, reflection, etc.).

First-Year Engineering Course & Advising Programmatic Integration

In Summer 2023, a team of advisors, instructors, and graduate students explored ways of supporting student success and implementing strategies for helping students in FYE classrooms develop academic success skills. Through collaborative discussions between team members and an exploration of educational literature, self-regulation and self-regulated learning (SRL) habits, skills, and behaviors emerged as a suitable framework to guide our efforts. Self-regulation refers to someone's ability to manage emotions, thoughts, and behaviors effectively in pursuit of long-term goals [13]. Self-regulated learning involves students' active control over cognitive, behavioral, and emotional processes in their learning journey [14]. The transition first-year college students face as they transition from the structured learning environments of high school to the more autonomous university settings often reveals a gap in their self-regulation and self-regulated learning abilities, particularly in larger class settings typical of many first-year courses, where individual attention from instructors is limited, and opportunities for interactive learning are reduced [16]. To gain a broader understanding of FYE students' beliefs about their own habits, skills, and behaviors that are associated with self-regulated learning beyond our team's anecdotal observations of students, we decided to ask students to self-report on aspects of their self-regulated learning in surveys throughout their experience.

Methods

Data Collection

Required surveys were administered to all students enrolled in GE courses at the beginning and end of the Fall 2023 Semester and the end of the Spring 2024 semester (3 total surveys). As course assignments, these surveys are called “Beginning of Semester” (BOS) and “End of Semester” (EOS) surveys. Twelve questions on the BOS and EOS surveys asked students to self-report aspects of self-regulated learning using a Likert-style questions. These twelve questions were pulled from Toering et al.’s (2012) Self-Regulation of Learning Self-Report Scale (SRL-SRS), which has been previously validated in the context of secondary-school students ages 11 to 17 years old. Toering et al.’s (2012) complete SRL-SRS instrument is 50 questions that mapped to 6 different sub-scales that were based on previous self-regulated learning inventories and literature. Because we didn’t want the assignment to take more than 15 minutes, our team of instructors and advisors collaborated to select a subset of 12 questions from Toering et al.’s original that included at least one question from each of the 6 sub-scales and are most relevant to our undergraduate GE students’ experiences and challenges.

Data Analysis

For the population of students whose GE experience was only the Fall 2023 semester we considered their BOS survey results as their ‘beginning’ self-reported SRL levels and their Fall 2023 EOS survey results as their ‘end’ self-reported SRL levels. We looked across each of the SRL questions and mapped the distribution of how many students responded at each of the 1-6 levels of “strongly disagree” to “strongly agree” for each survey. We also tested for statistically significant changes from the beginning to the end of the Fall 2023 semester in each question’s average rating to identify the ways in which students self-report significant change in their SRL skills and behaviors in one semester’s time utilizing a two-sample, two-tailed t-test.

For the population of students whose GE experience spanned both the Fall 2023 and Spring 2024 semester we considered the Fall 2023 BOS survey results as their beginning self-reported SRL levels, the Fall 2023 EOS survey results as their ‘middle’ self-reported SRL levels, and the Spring 2024 EOS survey results as their ‘end’ self-reported SRL levels. We did not ask SRL questions on the Spring 2024 BOS survey, as there was only about 5 weeks separating the Fall 2023 EOS and Spring 2024 BOS, and that time was spent for most of our students off-campus for the break between semesters. Similarly to the analysis described above, we looked across each of the SRL questions and mapped the distribution of how many students responded at each of the 1-6 levels of “strongly disagree” to “strongly agree” for each survey. We also tested for statistically significant changes from the beginning to the end of the Fall 2023 semester (‘beginning’ SRL levels to ‘middle’ SRL levels) and the end of Fall 2023 semester to the end of Spring 2024 semester (‘middle’ SRL level to ‘end’ SRL levels) utilizing a two-sample, two-tailed t-test.

Limitations

One limitation of the data collection and analysis was the fact that we only used a sub-set of questions from a validated instrument. We acknowledge this limitation by ensuring that we don't make any claims in this paper that we accurately and completely measured students self-reported SRL, as we did not validate our subset of questions in our GE context. An additional limitation of our analysis is the use of t-tests on the Likert-style data collected for this study. Although parametric tests (such as a t-test) assume continuous data that is normally distributed (two assumptions that are not typically true for data collected from Likert-style questions), studies have shown that using t-tests on Likert-style data can result in minimal additional Type I error compared to non-parametric tests [13]. However, there may still be a small increase in false positive significant results found using parametric tests. Another limitation to this analysis is the accumulation of Type I errors by using multiple t-tests. To help mitigate this issue, we considered three sets of tests (two semester sequence beginning to middle, middle to end, and one semester course beginning to end), and used a Bonferroni correction for each set by dividing the typical $\alpha=0.05$ by the number of t-tests in each set, leading to a new $\alpha=0.05/12 \approx 0.004$. This choice reduces the likelihood of a false positive to the same likelihood of only using three total t-tests, however there is still a chance that a false positive occurs.

Results

We begin by sharing each of the 12 questions asked about SRL skills and behaviors and sharing students' average self-reported rating. Figure 1 shows the 'beginning', 'middle', and 'end' results for students with the two-semester GE course experience. The data for the population of students in the one semester course is included in the Appendix of this paper (Figure 2).

Next, Table 1 shows the distribution of students' self-reported SRL survey responses. Table 1 is the 'beginning' data for the population of students whose GE course experience was two semesters long. Tables for the complete data set for both populations of student that break down each questions' response distribution are included in the Appendix of this paper (Tables 2, 3, 4, and 5).

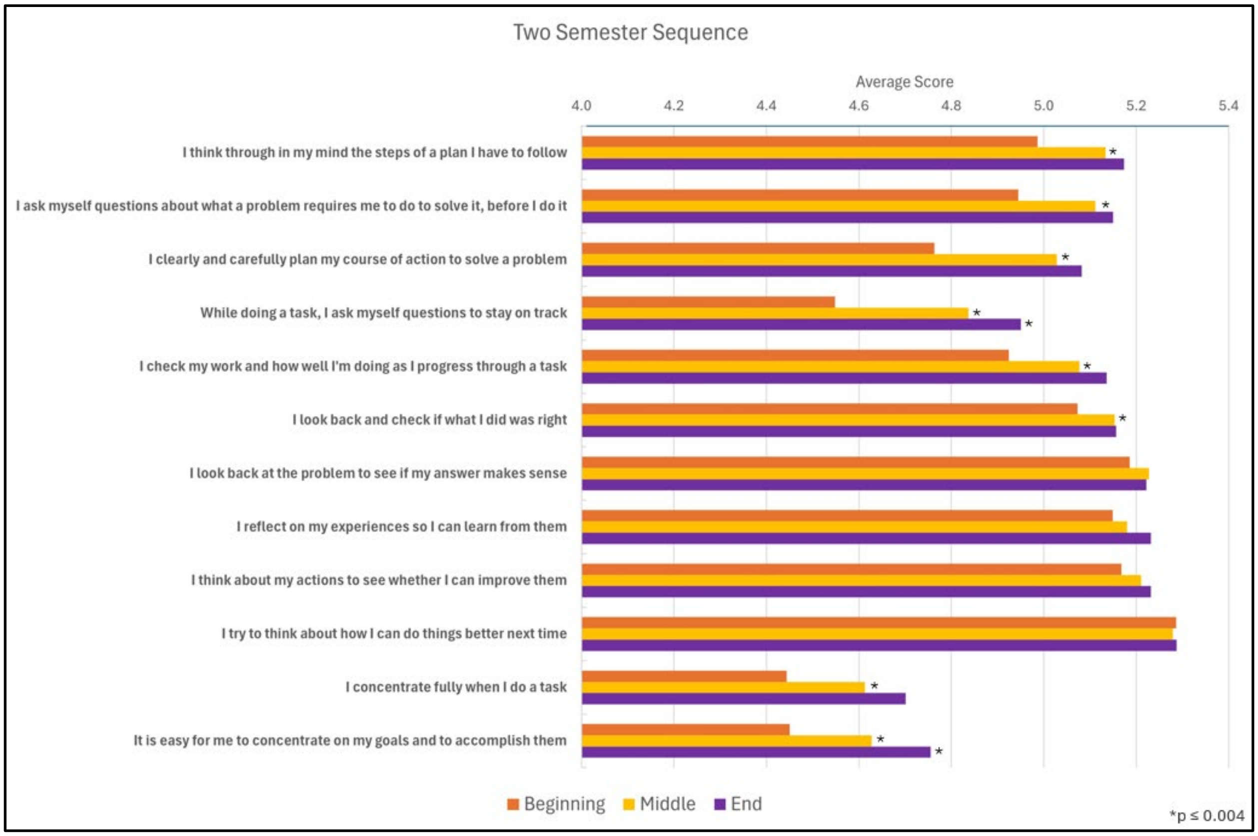

Figure 1: The 'beginning', 'middle', and 'end' average scores for each SRL question for the two-semester first-year engineering course sequence

Table 1: 'Beginning' student response distributions for the two-semester sequence of first-year engineering (N=1930)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I think through in my mind the steps of a plan I have to follow	0.26%	0.52%	2.44%	18.81%	53.06%	24.92%
I ask myself questions about what a problem requires me to do to solve it, before I do it	0.31%	0.47%	2.90%	21.24%	50.88%	24.20%
I clearly and carefully plan my course of action to solve a problem	0.31%	1.35%	5.23%	26.99%	46.99%	19.12%
While doing a task, I ask myself questions to stay on track	0.41%	3.32%	10.21%	30.00%	39.17%	16.89%
I check my work and how well I'm doing as I progress through a task	0.10%	1.14%	3.94%	20.57%	49.53%	24.72%
I look back and check if what I did was right	0.16%	0.73%	2.69%	17.05%	46.84%	32.54%
I look back at the problem to see if my answer makes sense	0.05%	0.41%	1.66%	12.02%	50.47%	35.39%
I reflect on my experiences so I can learn from them	0.10%	0.41%	2.12%	15.03%	46.48%	35.85%
I think about my actions to see whether I can improve them	0.05%	0.21%	1.55%	13.78%	49.90%	34.51%
I try to think about how I can do things better next time	0.05%	0.16%	0.83%	10.47%	47.05%	41.45%
I concentrate fully when I do a task	0.57%	3.68%	9.48%	35.60%	38.39%	12.28%
It is easy for me to concentrate on my goals and to accomplish them	0.93%	3.68%	9.64%	34.72%	37.25%	13.78%

Take Aways & Implications for Future Work

After the collection of first-year GE students' self-reported data related to their self-regulated learning habits, skills, and behaviors we identified three key takeaways:

1. Students are self-reporting less agreement with statements related to planning (Q3), staying on task (Q4), and concentration (Q11 and Q12). The increased use of technology in learning coupled with the rise in social media has led to a significant amount of multitasking and concerns have arisen with regards to the impact on students' learning and academic performance [14]. What we found interesting is that our results are self-reported, so students expressed an awareness that staying on task and maintaining concentration as areas in which they didn't strongly associate their own behaviors with.

2. The self-reported SRL scores at the 'beginning' of the one-semester course are similar to the scores at the 'beginning' of the two-semester course sequence. At our institution, specific prerequisites must be completed for students to enroll in the one-semester course. While these students have often been referred to as higher achievers, these results indicate that GE students being academically more advanced compared to their incoming peers does not translate to them feeling or being more 'college ready' with regards to their self-reported SRL levels.

3. Students self-reported statistically significant increases in agreement that they exhibit over half of the SRL habits, skills, or behaviors across one semester's time. The questions that didn't indicate statistically significant increases were questions in which students scores started higher compared to the other questions – and most of these questions were related to the reflection dimension of self-regulated learning (Q7, Q8, Q9, and Q10).

These survey results and the takeaways outlined above will certainly inform both the instruction of our GE courses, the advising of GE students, and how our program will continue to develop our course-advising integration to more efficiently deliver academic success tools, resources, and strategies to students in both GE courses and advising appointments simultaneously. By knowing that being academically ahead with regards to credit hours doesn't directly translate to being 'ahead' of their peer when it comes to the regulations of their actions, behaviors, and learning experiences we can begin to work on dispelling the assumptions that many of us hold about academically advanced students and what they should or should not be capable of with regards to navigating their new learning context as we teach and advise these students. Additionally, these results provide us with a lens into students' beliefs about their own SRL habits, skills, behaviors – both their self-identified strengths and weaknesses. Students report higher levels of agreement in engaging in reflection, and less agreement with their planning, staying on task, and concentration. As our program aims to support students continued SRL growth and development we will plan to offer more activities and scaffolded assignments in our GE courses to practice planning and goal setting and advisors will be able to offer more targeted resources and strategies related to these dimensions of self-regulated learning to students who come to them seeking guidance when they encounter academic questions or difficulties.

References

[1] A. Venezia and L. Jaeger, "Transitions from high school to college," *The future of children*, pp. 117–136, 2013.

[2] D. T. Mellor, W. R. Brooks, S. A. Gray, and R. C. Jordan, "Troubled transitions into college and the effects of a small intervention course," *Journal of College Student Retention: Research, Theory & Practice*, vol. 17, no. 1, pp. 44–63, 2015.

[3] L. A. Schreiner, M. C. Louis, and D. D. Nelson, *Thriving in transitions: A research-based approach to college student success*. The National Resource Center for The First-Year Experience, 2020.

[4] J. R. Ricks and J. M. Warren, "Transitioning to College: Experiences of Successful First-Generation College Students.," *Journal of Educational Research and Practice*, vol. 11, no. 1, pp. 1–15, 2021.

[5] K. M. Whitcomb, Z. Y. Kalender, T. J. Nokes-Malach, C. D. Schunn, and C. Singh, "Engineering students' performance in foundational courses as a predictor of future academic success," *International Journal of Engineering Education*, vol. 36, no. 4, pp. 1340–1355, 2020.

[6] K. Reid, D. Reeping, and E. Spingola, "A taxonomy for introduction to engineering courses," *The International journal of engineering education*, vol. 34, no. 1, pp. 2–19, 2018.

[7] K. Reid and D. Reeping, "A Classification Scheme for 'Introduction to Engineering' Courses: Defining First-Year Courses Based on Descriptions, Outcomes and Assessment," in *121st ASEE Annual Conference & Exposition*, Indianapolis, IN, 2014, pp. 1–11.

[8] E. Seymour and N. M. Hewitt, *Talking about Leaving: Why Undergraduates Leave the Sciences*. Boulder, CO: Westview Press, 1997.

[9] E. Seymour and A.-B. Hunter, Eds., *Talking about Leaving Revisited: Persistence, Relocation, and Loss in Undergraduate STEM Education*. Springer International Publishing, 2019. doi: 10.1007/978-3-030-25304-2.

[10] A. Kramer, C. Wallwey, G. Thanh, E. Dringenberg, and R. Kajfez, "A Narrative-Style Exploration of Undergraduate Engineering Students' Beliefs about Smartness and Identity," in *2019 IEEE Frontiers in Education Conference (FIE)*, Covington, KY, USA: IEEE, Oct. 2019, pp. 1–9. doi: 10.1109/FIE43999.2019.9028388.

[11] M. Morris, R. Hensel, and J. Dygert, "Why do students leave? An investigation into why well-supported students leave a first-year engineering program," presented at the ASEE annual conference & exposition proceedings, 2019.

[12] M. Meyer and S. Marx, "Engineering Dropouts: A Qualitative Examination of Why Undergraduates Leave Engineering," *Journal of Engineering Education*, vol. 103, no. 4, pp. 525–548, 2014, doi: https://doi.org/10.1002/jee.20054.

[13] J. C. De Winter and D. Dodou, "Five-point Likert items: t test versus Mann-Whitney-Wilcoxon," *Practical assessment, research & evaluation*, vol. 15, pp. 1–12, 2010.

[14] A. J. Dontre, "The influence of technology on academic distraction: A review," *Human Behavior and Emerging Technologies*, vol. 3, no. 3, pp. 379–390, 2021.

Appendix

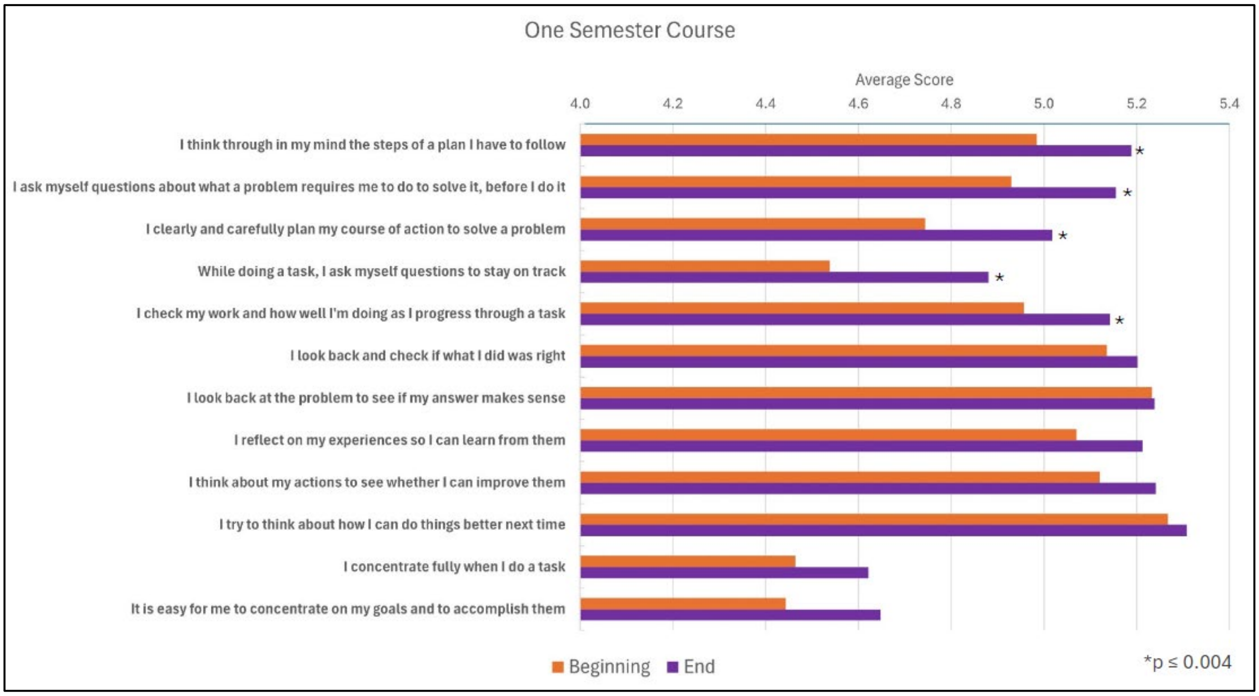

Figure 2: The 'beginning' and 'end' average scores for each SRL question for the one-semester first-year engineering course.

Table 2: 'Middle' student response distributions for the two-semester sequence of first-year engineering (N=1718)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I think through in my mind the steps of a plan I have to follow	0.17%	0.41%	1.28%	12.92%	54.42%	30.79%
I ask myself questions about what a problem requires me to do to solve it, before I do it	0.17%	0.35%	1.75%	14.03%	53.26%	30.44%
I clearly and carefully plan my course of action to solve a problem	0.12%	0.70%	2.62%	18.10%	49.77%	28.70%
While doing a task, I ask myself questions to stay on track	0.41%	1.86%	6.29%	21.25%	45.46%	24.74%
I check my work and how well I'm doing as I progress through a task	0.17%	0.70%	2.79%	14.96%	50.35%	31.02%
I look back and check if what I did was right	0.29%	0.47%	1.98%	14.20%	47.03%	36.03%
I look back at the problem to see if my answer makes sense	0.12%	0.23%	1.11%	10.36%	51.69%	36.50%
I reflect on my experiences so I can learn from them	0.06%	0.35%	1.40%	13.45%	49.24%	35.51%
I think about my actions to see whether I can improve them	0.06%	0.29%	0.87%	11.76%	51.40%	35.62%
I try to think about how I can do things better next time	0.06%	0.17%	0.70%	9.08%	50.81%	39.17%
I concentrate fully when I do a task	0.99%	3.08%	7.28%	30.85%	37.89%	19.91%
It is easy for me to concentrate on my goals and to accomplish them	0.70%	3.20%	9.02%	26.48%	40.86%	19.73%

Table 3: 'End' student response distributions for the two-semester sequence of first-year engineering (N=1772)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I think through in my mind the steps of a plan I have to follow	0.00%	0.06%	1.30%	11.51%	55.47%	31.66%
I ask myself questions about what a problem requires me to do to solve it, before I do it	0.00%	0.45%	0.90%	12.47%	55.59%	30.59%
I clearly and carefully plan my course of action to solve a problem	0.00%	0.45%	1.98%	16.08%	51.86%	29.63%
While doing a task, I ask myself questions to stay on track	0.17%	1.52%	4.40%	18.06%	48.70%	27.14%
I check my work and how well I'm doing as I progress through a task	0.06%	0.51%	1.52%	13.21%	53.10%	31.60%
I look back and check if what I did was right	0.00%	0.51%	1.81%	13.09%	50.68%	33.92%
I look back at the problem to see if my answer makes sense	0.00%	0.28%	0.62%	10.89%	53.05%	35.16%
I reflect on my experiences so I can learn from them	0.00%	0.11%	1.30%	10.61%	51.30%	36.68%
I think about my actions to see whether I can improve them	0.00%	0.11%	0.90%	9.93%	53.84%	35.21%
I try to think about how I can do things better next time	0.00%	0.11%	0.28%	10.10%	49.77%	39.73%
I concentrate fully when I do a task	0.62%	3.05%	5.59%	26.98%	43.91%	19.86%
It is easy for me to concentrate on my goals and to accomplish them	0.68%	2.26%	6.49%	23.48%	45.65%	21.44%

Table 4: 'Beginning' student response distributions for the one-semester course of first-year engineering (N=442)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I think through in my mind the steps of a plan I have to follow	0.45%	0.68%	2.49%	19.00%	51.13%	26.24%
I ask myself questions about what a problem requires me to do to solve it, before I do it	0.45%	0.90%	3.62%	18.55%	53.17%	23.30%
I clearly and carefully plan my course of action to solve a problem	0.68%	0.68%	6.33%	26.70%	47.06%	18.55%
While doing a task, I ask myself questions to stay on track	1.13%	2.04%	11.99%	28.28%	39.82%	16.74%
I check my work and how well I'm doing as I progress through a task	0.45%	1.13%	4.52%	17.42%	49.10%	27.38%
I look back and check if what I did was right	0.23%	0.45%	2.49%	13.35%	49.32%	34.16%
I look back at the problem to see if my answer makes sense	0.23%	0.00%	1.13%	9.50%	53.17%	35.97%
I reflect on my experiences so I can learn from them	0.45%	0.68%	2.71%	18.10%	43.67%	34.39%
I think about my actions to see whether I can improve them	0.23%	0.45%	1.36%	15.38%	50.23%	32.35%
I try to think about how I can do things better next time	0.23%	0.00%	0.68%	10.18%	49.77%	39.14%
I concentrate fully when I do a task	0.45%	4.98%	8.37%	34.62%	37.10%	14.48%
It is easy for me to concentrate on my goals and to accomplish them	0.90%	3.39%	11.54%	31.45%	40.05%	12.67%

Table 5: 'End' student response distributions for the one-semester course of first-year engineering (N=386)

Question	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
I think through in my mind the steps of a plan I have to follow	0.00%	0.00%	2.33%	11.14%	51.81%	34.72%
I ask myself questions about what a problem requires me to do to solve it, before I do it	0.00%	0.52%	2.33%	11.14%	53.11%	32.90%
I clearly and carefully plan my course of action to solve a problem	0.00%	0.78%	3.11%	18.65%	48.45%	29.02%
While doing a task, I ask myself questions to stay on track	0.26%	1.30%	4.66%	23.83%	43.78%	26.17%
I check my work and how well I'm doing as I progress through a task	0.00%	0.78%	1.81%	13.73%	49.74%	33.94%
I look back and check if what I did was right	0.00%	0.52%	1.55%	13.21%	46.63%	38.08%
I look back at the problem to see if my answer makes sense	0.00%	0.52%	1.04%	10.62%	49.74%	38.08%
I reflect on my experiences so I can learn from them	0.00%	0.26%	0.78%	13.21%	48.96%	36.79%
I think about my actions to see whether I can improve them	0.00%	0.00%	0.78%	11.14%	51.30%	36.79%
I try to think about how I can do things better next time	0.00%	0.00%	0.78%	10.36%	46.11%	42.75%
I concentrate fully when I do a task	0.00%	3.37%	8.55%	30.83%	37.05%	20.21%
It is easy for me to concentrate on my goals and to accomplish them	0.26%	3.89%	8.29%	25.65%	42.23%	19.69%