# The impact of scaffolded writing instruction on follow-up course assignments

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# The impact of scaffolded writing instruction on follow-up course assignments

The Mechanical Engineering Department at Rose-Hulman Institute of Technology implemented a series of scaffolded assignments across several required courses to improve memo writing instruction. The goal of the scaffolding plan was to encourage students to transfer previous writing instruction to new contexts and write professional documents independently by the time they graduate. Research in engineering education has demonstrated both the importance of writing in the engineering workplace and the extent to which new graduates struggle with the generic and rhetorical features of workplace writing [1], [2], [3]. The ME department established a committee of four engineers and one writing instructor to determine how better to prepare students for writing in the curriculum and in their careers.

As documented in a previous study, the committee first identified all of the courses in the ME curriculum that included technical communication instruction. We then categorized that instruction by genre, including memos, presentations, reports, and technical drawings. Using memos as a starting point, we then identified threshold concepts, or core things students needed to know to compose successful memos [4]. These threshold concepts represent the communication tasks and skills that the department expects students to transfer across courses.

The committee used our original study and scholarship about how students transfer knowledge about writing from one context to another to recommend a memo scaffolding plan to the department [5], [6]. As a result, the department sequenced memo instruction and memo assignments in three courses across two years in the curriculum by aligning instruction and expectations. In addition to the mechanics of including figures and presenting results, scaffolded instruction also includes discussions of generic features of memos and the ways generic and linguistic features can support the needs of a particular audience. We facilitated this alignment of instruction and expectations through face-to-face meetings and online resources for faculty on our campus learning management system.

In the sections that follow, we first describe the details of the scaffolded memo assignments and our research methods for assessing those assignments. We then present the results of our assessment, which compares memos of students who did experience scaffolded instruction with memos of students who did not based on rhetorical and generic features common to technical memos. Our findings did not uncover significant differences in mean ratings of student memos before and after our intervention; however, we did uncover reduced variation in these same ratings. We conclude with a discussion of our results—including what we learned about our scaffolding process and its potential for positive impact—and the changes we plan to make to scaffolded instruction.

## Scaffolded memo instruction

The scaffolding plan for memo writing encompasses three primary courses that occur during the first and second years. Figure 1 shows a visual representation of where memo assignments usually occur in the curriculum (outlined boxes), along with the courses in the scaffolding plan (connected boxes). The solid boxes are courses with significant memo writing instruction. The partial-shaded boxes are courses with memo assignments, but not significant instruction. Effective memo writing should be observed in these courses if the scaffolding plan is successful.

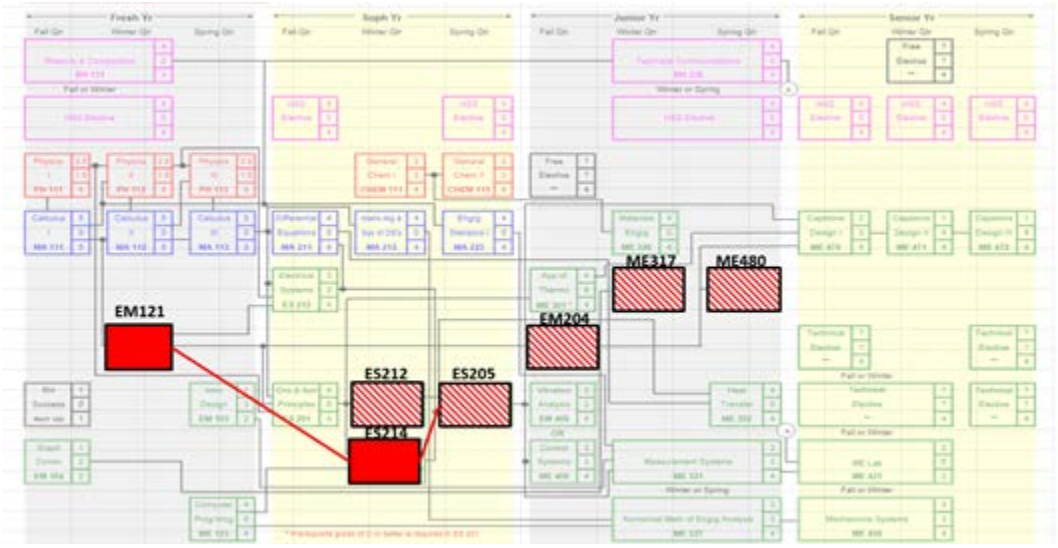


**Figure 1.** A visualization of where memo assignments occur in the ME curriculum. Solid boxes represent courses with significant instruction given; shaded boxes represent courses with a memo assignment but no significant instruction. The solid red lines show the prerequisite chain that orders the three courses most involved in the scaffolding plan

In the first course, the instructor discusses an annotated exemplar memo that students mimic as they report on their own team's minor design project. In the second course, students receive instruction on the mechanics of good memos (strong first sentences, how to present figures, making observations before explanations, and giving evidence to support claims) and write their own memos in a laboratory setting. In the third course, the instructor references what was learned in the previous two but does not give significant instruction about memo writing. Students are expected to write a satisfactory memo in a laboratory setting when asked.

## Methods

In this study we assess the impact of our memo scaffolding plan by assessing a single assignment in a required third-year Mechanics of Materials course (EM204 in Figure 1). The control and treatment groups consist of students taking the course at two separate offerings. We describe here the context of the course, the details of the assignment, development of the assessment rubric, and our assessment process.

The course uses a traditional lecture-based structure where the grade in the course is primarily determined by exam grades. The assignment we target is a team project worth five percent of the course grade, with teams of two to three people. The assignment falls into the category of a minor design problem where teams choose a pipe size and material from a list of choices to satisfy a particular loading case. Teams have approximately two weeks to complete the assignment, mostly outside of scheduled lecture time. Teams are assigned randomly. After the fact, we verified that at least one team member from each team in the treatment group experienced the scaffolded instruction in a previous course.

The assignment explicitly asks for teams to submit a memo to communicate the design itself, assumptions and choices made, the worst-case bending moment and stress state, and the worst-case pipe deflection. Supporting documentation is also required, backing up the claims and results described in the memo. Table 1 shows the grading rubric used for the assignment, split into the categories of memo clarity and supporting documentation persuasiveness. Students received the grading rubric as part of the assignment.

**Table 1.** The assignment grading rubric focuses student efforts on the clarity of the memo and persuasiveness of supporting documentation.

| | **Poor [15]** | **Moderate [30]** | **Excellent [45]** |
|---|---|---|---|
| **Memo clarity** | Memo is inconsistent with supporting work, leaves out important information, or is unclear in some other way, like a rough draft. | Memo has some good qualities and some poor qualities, either in structure, writing, details, or consistency. | Memo is concise without leaving out primary results. Memo is consistent with supporting work and relevant conventions. |
| **Supporting documentation persuasiveness** | Analysis is difficult to follow. You submitted what looks like scratch work that wasn't cleaned up. | Some of your analysis steps are clearly documented, but diagrams or logic are lacking. Overall, not a very convincing analysis. | All of your analysis steps are clearly documented, with sound logic and good diagrams. Any EM204 student would be convinced. |

The assessment rubric used for this study is not the grading rubric for the assignment, but a generic memo rubric developed to support the memo scaffolding plan and ABET data collection. The author team completed an inter-rater-reliability exercise with one sample student memo. As a result of this exercise, we modified the generic memo rubric to better capture the true quality of the sample memo. We found consensus with a four-level assessment (exemplary, good, needs work, and unsatisfactory) of five separate broad objectives. Figure 2 shows the final version of the assessment rubric that we used to assess all of the memo submissions.

| | |
|---|---|
| *Exemplary* | Commendable or deserving imitation because of excellence. |
| *Good* | Expectations are generally met; some specific areas need improvement. |
| *Needs work* | Important expectations are being met marginally or not at all. Multiple significant errors. |

| Broad objectives | Exemplary | Good | Needs work | Unsatisfactory |
|---|---|---|---|---|
| Language and grammar | Subjects and verbs agree, sentences are complete. | Expectations are generally met with minor exceptions. Good effort. | Several errors in mechanics, usage, grammar, or style. | Superficial attempt. |
| Coherence throughout | The structure of the sections, ¶s, sentences, and word choice merit imitation. Graphical elements are explicitly referred to in the text. | Expectations are generally met with minor exceptions. Good effort. | ¶s poorly arranged or in wrong section. Topic sentences need work. Word choice consistently ambiguous or colloquial. | Reads as if it were an unedited first draft or pasted up with insufficient revision. |
| Credibility | Assertions are true, unambiguous, and supported by evidence and reasoning. The reader is convinced by the analysis. | Expectations are generally met with minor exceptions. Good effort. | Important errors or omissions of fact or method. Special knowledge needed to fill gaps in the report. | Lacks signs of sufficient intellectual effort. |
| Graphical elements | Graphical elements are clear and support written content, but good enough to stand alone. Figures and tables have meaningful captions. | Expectations are generally met with minor exceptions. Good effort. | Graphical elements have critical flaw(s). | Minimal effort. |
| Memo Format | Includes appropriate heading, strong first sentence, and elements like bolded text to indicate key findings. Memo is concise and ~1 page. | Recognizable as a memo with minor exceptions. | Missing one or more key elements of memo format. | Does not resemble a memo. |

**Figure 2.** The rubric used for assessing student memo submissions splits the assessment into five broad objectives. Only one broad objective was explicitly tied to memo formatting.

The department implemented the memo scaffolding plan during the treatment group's second-year course sequence. Therefore, the control group consists of students who did not experience the scaffolding and the treatment group consists of students who did experience the scaffolding. A few of the students in the treatment group took the course out of sequence, so had not experienced the scaffolding. However, each of the treatment group teams included at least one student who had experienced the scaffolding.

On the day that the assignment was submitted by students, informed consent forms were collected from the students according to standard Institutional Review Board processes. The collected submissions were scanned digitally, names were redacted, and each submission was given a random number. A conversion table was created to track the treatment and control group submissions. Five of the authors individually considered each submission, rating using the rubric as they went. The individual ratings were collected through a form, then converted into a spreadsheet through an intermediate step in MATLAB. Before the author team looked at the overall ratings, we discussed the holistically "best" and "worst" submissions from the entire set, not knowing if they were from the treatment or control group.

## Results

An examination of performance on the memo assignment before and after scaffolding finds that there is not a significant change in mean score in any single rubric category or in the mean total score. However, a significant decrease in the variation of total scores is found in the group that received scaffolded instruction.

We first examine the memos by performance in each rubric category (Language and grammar, Coherence throughout, Credibility, Graphical elements, and Memo format). The qualitative ratings used in the rubric were mapped to numerical values in the following way: exemplary (4 points), good (3 points), needs work (2 points), and unsatisfactory (1 point). Figure 3 plots the change in mean score and 95% confidence intervals in each rubric category after scaffolding. These confidence intervals are determined using a Welch t-test, which assumes that the scores of both groups are normally distributed but does not assume that both score distributions have equal variance.

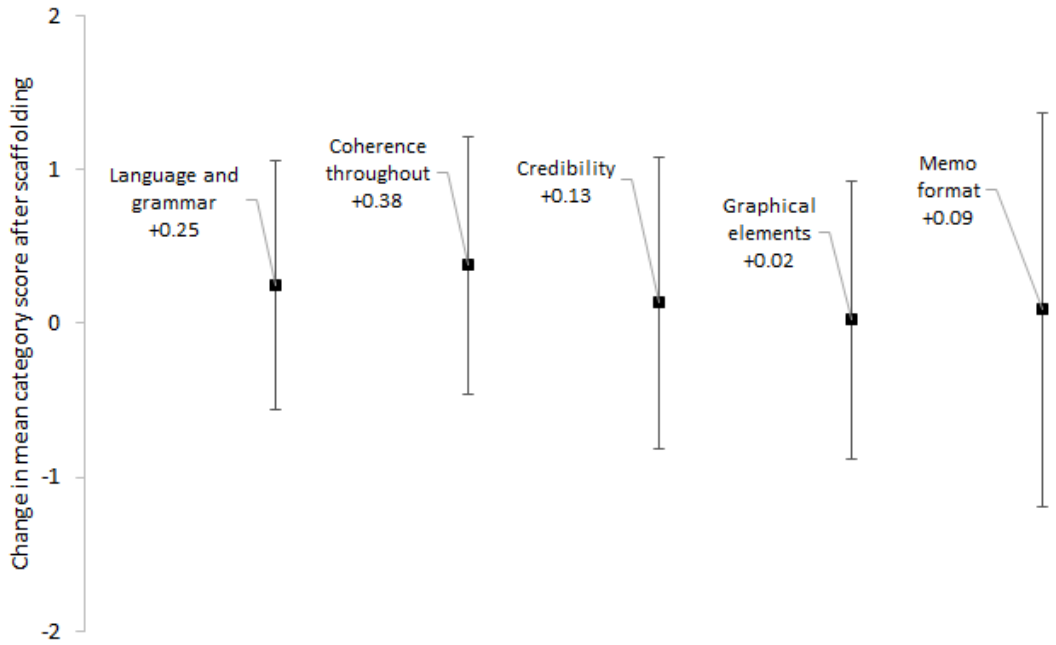


**Figure 3.** Change in mean score in each rubric category after scaffolded instruction is implemented for memo writing. Sample size is n = 9 for memos written without scaffolded instruction and n = 5 for memos written with scaffolded instruction.

A positive change in mean score is seen within each rubric category, with the largest change observed in "Coherence throughout" (+0.38) and the smallest change observed in "Graphical elements" (+0.02). However, these changes are not statistically significant since their 95% confidence intervals include zero. For this reason, we do not have sufficient evidence to conclude that the scaffolding made a significant difference in student performance in any specific rubric category. The large confidence intervals shown in Figure 3 are partially due to the sample sizes, which were necessarily small in this study (n = 5 with scaffolding and n = 9 without scaffolding).

The bubble plot in Figure 4 illustrates the distribution of ratings in each rubric category for students with and without the scaffolding experience. In some categories—specifically, "Coherence throughout" and "Language and grammar"—there appears to be less variance in scores within the sample that received scaffolded instruction. An F-test for equality of variances is performed in each category to test whether the variation in scores is significantly different between the two samples. The result of these tests found that there is not a statistically significant difference in score variance in any specific rubric category.

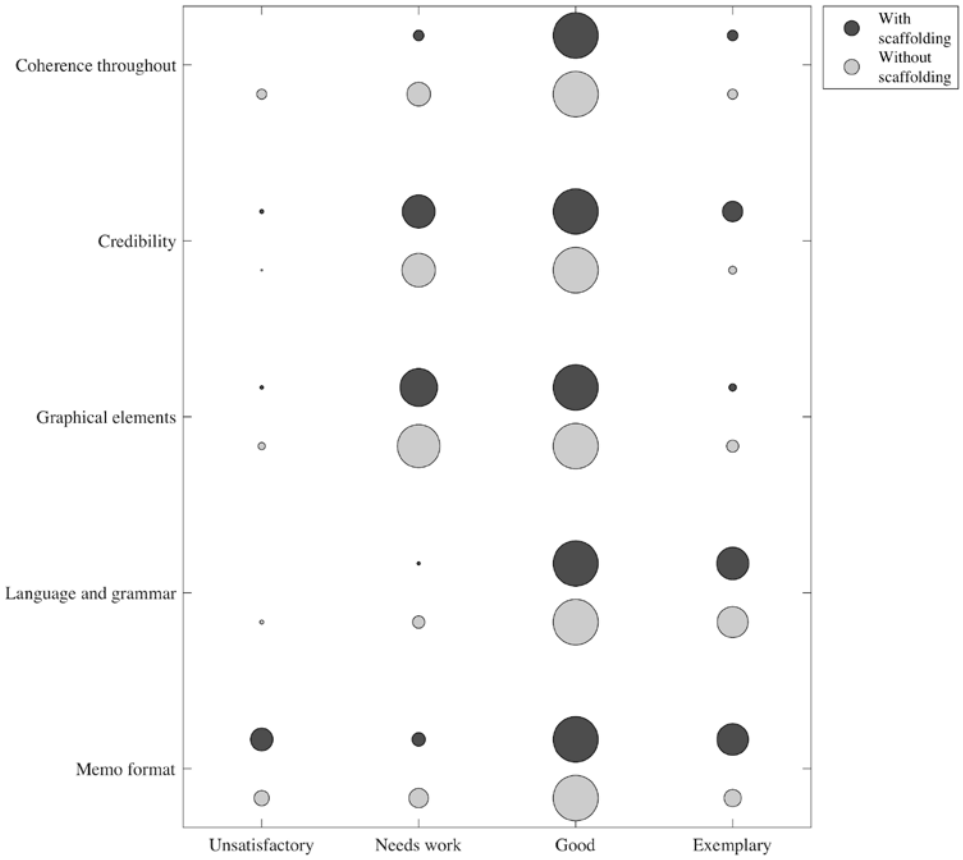


**Figure 4.** Distribution of ratings given to memos in each of the rubric categories for memos written post-scaffolding (dark gray) and pre-scaffolding (light gray). These data are normalized to sample size so that each bubble series illustrates the proportionality of ratings awarded at each level (unsatisfactory, needs work, good, and exemplary).

We now examine the memos individually by calculating the mean of the total scores from all raters. The maximum possible total score is 20 points from the five category scores added together, with non-integer values possible because of averaging. Figure 5 plots the total memo scores for both groups. The mean and standard deviation of total scores for students with and without scaffolding is $14.52 \pm 0.41$ and $13.64 \pm 2.19$, respectively. The samples that received scaffolded instruction have a mean total score that is 0.88 points higher than the sample that did not. We performed a Welch t-test to see whether or not this change is significant. The result of this test is a 95% confidence interval for the change in mean total score between the two

samples, which is [-0.83, 2.59]. Because this confidence interval contains zero, we do not have sufficient evidence to conclude that the scaffolding significantly increased memo scores overall. Once again, the size of this confidence interval is largely affected by the small sample sizes.

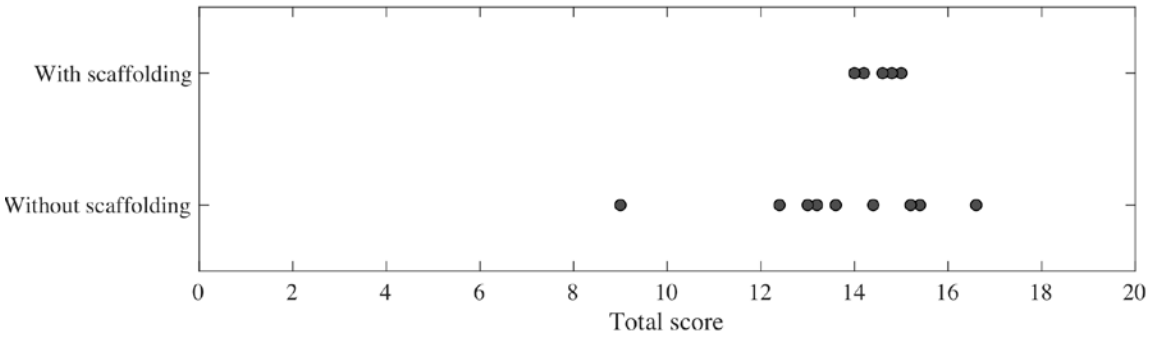


**Figure 5.** Distribution of total scores for memos written with and without scaffolded instruction. Total score is calculated by summing the scores in each of the five rubric categories.

Finally, we performed an F-test for equality of variances between the two samples shown in Figure 5. The calculated F-statistic is 28.01. This is greater than 8.8051, which is the critical value of the F-distribution with a significance level of $\alpha = 0.005$. This means that we may conclude with 99% confidence that the variation in total score is smaller for students that received scaffolded instruction. This suggests that the scaffolding may have produced a perceptible (and potentially positive) effect; student performance on the memo writing assignment became more uniform.

**Discussion**

We expected scores to go up for the treatment group (particularly in the categories of memo format and graphical elements), but they didn't. With a small sample size, the score difference would have to be large to be detectable. Also, the treatment group teams didn't uniformly have the scaffolding experience. Whoever took the lead on the memo drafting may not have been a student with the experience. Team dynamics were beyond our control and beyond the scope of this study. We don't think the effort of creating and implementing a scaffolding plan is wasted, though.

We believe our assessment rubric is doing the job of assessing overall memo quality. Before considering the numerical scores, we discussed the overall best and worst memos from a qualitative perspective. Group consensus was easy to find. We then looked at the numerical scores of the memos. The qualitatively "best" memo was also the memo with the highest numerical score. The qualitatively "worst" memo was also the memo with the lowest numerical score.

Our scaffolding instruction tends to focus on students creating effective laboratory memos that share collected data and explain well-posed experimental results. This study assessed memo writing in a different kind of situation—a minor design problem where choices made play a much larger role. Also, graphical elements played a much larger role in the scaffolding memos

than in the assessment memo. These differences create a more complex writing process; students have to draw on previous genre knowledge but also recognize how to adapt that generic form to a new context. Thus, the lack of a clear improvement in memo score might be explained by the scaffolding instruction not aligning perfectly with the assessment assignment as well as students not yet having practiced the kind of genre adaptation this assignment required. We had hoped that the scaffolding plan would lead to more effective memos in any rhetorical situation. Clearly, we're not able to claim this.

The low impact of the assignment on the student's course grade might also contribute to the absence of significant improvement in student work. Research on the role of students' disposition in their ability to transfer knowledge from one context to another suggests that if students don't value the task—either in terms of a grade or perceived benefit to the student—they're unlikely to make the effort to draw on previous knowledge [7] [8]. Thus, an assignment that is only worth 5% of a student's grade, like the assignment we studied, might not motivate students enough to do the hard intellectual work of drawing on previous writing experiences.

Although our assessment method is not precise enough to uncover significant differences in the average memo score, we did uncover a difference in the variation of memo score. The reduction in variation might have resulted from students being exposed to more uniform training and expectations around memo writing. Their common understanding of a proper memo, even if at a good but not exemplary level, is a possible benefit of scaffolding instruction of this type. On the other hand, our scaffolding might have unintentionally stifled the better memo writers, or the high score in the un-scaffolded group might have been an outlier. The pros and cons of these results depend on the context of the educational situation.

## Conclusion

There are many changes and improvements we might make to our scaffolding plan and assessment process. For example, we could improve our scaffolding plan by being more explicit about the need to transfer memo-writing skills during upcoming classes. Writing studies research about teaching students to transfer writing skills to new contexts argues that instruction needs to be explicit [9] [10]. Students might not realize, for example, that the writing instruction given from one faculty member would be relevant in another faculty member's course. To make scaffolding more explicit, instructors should be explicit when they introduce assignments that students will use those same skills in other courses (forward transfer) and—in later courses—explicitly ask them to draw on previous assignments to complete their work (backward transfer) [10]. Additionally, more chances to see and discuss a range of memos would help students understand the bedrock features of the genre and the surface features that change based on context and purpose of the memo. For example, we could gather and share examples of good and bad memos from different courses in our curriculum so that instructors can discuss effective memo writing with students in all classes.

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