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The impact of industrial role-playing scenarios in chemical engineering laboratory courses on students' writerly self-efficacy

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Abstract

Technical communication is highly valued within industry, and engineering educators have long sought to integrate effective writing instruction into engineering curricula. However, many engineering undergraduates consider writing as outside the practice of engineering and resist viewing themselves as competent writers. This study examined whether writerly self-efficacy, which is belief in one's ability to successfully implement writing in a specific context, could be improved by embedding writing assignments into industrially relevant scenarios that reflect professional engineering practice. Scenarios were incorporated into a two-part series of senior-level chemical engineering unit operations laboratory courses with heavy technical writing requirements and to evaluate self-efficacy, the Post-Secondary Writerly Self-Efficacy Scale (PSWSES) was administered. Three separate cohorts of engineering students took the PSWSES at three points of contact across the two semesters of the courses.

The results showed changes across all three factors of the PSWSES. Local and global writing process knowledge, which encapsulates writerly abilities/skills, showed significant and steady increases throughout the three administrations, indicating that the students were growing as writers and were more confident in their writerly abilities. The physical reaction factor, a factor that captures intrapersonal traits dealing with the physical act of writing, also increased, although with a small effect size, indicating that the students may have become more comfortable with the writing process with practice. The final factor, time and effort, which relates to beliefs about time management and motivation, decreased steadily with a small effect size across the administrations, signaling a decrease in willingness and motivation, perhaps due to fatigue, throughout the academic year or perhaps, due to the students being in their senior year.

This study demonstrates that situated technical writing instruction contextualized within authentic, industrially relevant contexts is positively related to chemical engineering students' confidence in the writing process within engineering contexts. Student gains in comfort with the physical aspects of writing were modest but nonetheless suggest a positive shift in their attitudes toward writing as being integral to engineering practice. The decrease in writing willingness and motivation may indicate a need for instructors to consider striking a better balance between the demands of writing with overall workload demands.

Introduction

Technical communication is an integral part of the practice of engineering, with engineers spending significant time communicating using a variety of oral and written genres, including presentations, stakeholder updates, email, and technical reports amongst others, and addressing various audiences[1-3]. Industry highly values communication skills in engineering graduates and communication training is also linked with enhanced career progression[4, 5]. As such, engineering educators have long strived to integrate effective technical communication instruction into engineering curriculums. Some efforts include stand-alone technical writing courses, publication of technical writing texts for engineers[6], and collaboration with communication experts[7, 8], including Writing Across the Curriculum (WAC) or Writing in the Disciplines (WID) programs[6, 9, 10]. Although these efforts incorporate writing into engineering disciplines, a disconnect is that engineering students often do not view themselves as writers.

This disconnect inhibits student learning and engagement and places technical communication as 'outside' the practice of engineering. The identity of an 'engineer' may even clash with the identity of 'writer'. However, as work from sociocultural and situated learning perspectives shows, engineering communication and engineering identity are linked [11]. As engineering educators, we need to help students understand the value of technical communication skills in their career and demonstrate how technical communication skills cannot be separated from the context of engineering practice.

In the present study, we embedded technical communication training into engineering education through an approach that situates the learning within an industrially relevant scenario. The literature on situated learning has shown convincingly that knowledge and skills are best learned in contexts that closely resemble the contexts in which they will be used [12, 13]. The scenario used in this study was implemented at XX University, a land grant institution in the western region of the United States in a two-part series of senior-level chemical engineering unit operations laboratory courses. In addition to the senior-level capstone design, these laboratory courses are the primary sources for technical communication instruction in this institution's chemical engineering curriculum. Previous publications detail the situated course design[14, 15] and describes the Writing Center collaboration[16] and rubric development[3, 17] within these courses. The purpose of this study was to investigate the association between the industrially relevant role-playing scenario and students' writerly self-efficacy. Our hypothesis was that as students engage in situated learning scenarios across two semesters of their engineering training, the greater growth they would realize in how efficacious they view themselves as writers and engineers.

Background

Self-efficacy is a person's belief of being capable of performing necessary tasks successfully[18] and therefore writing self-efficacy is specific to a person's belief of being capable of writing successfully. Writing self-efficacy is an internalized construct that is not a fixed entity but rather is malleable and can be developed through consistent self-monitoring, self-control, coaching, and practice [19]. Writerly self-efficacy on the other hand focuses on the behavioral elements of writing. While *writing* self-efficacy includes qualities such as the cognitive processes involved with inscribing, communicating, composing, and expressing ideas, *writerly* self-efficacy eludes to the behavioral manifestations or characteristics of the writer. Schmidt and Alexander[19] developed the Post-Secondary Writerly Self-Efficacy Scale (PSWSES), a 20-item instrument based on the theoretical and empirical work of Albert Bandura[18], to measure writerly self-efficacy.

Three distinct factors of the PSWSES were identified through principle component analysis: (1) local and global writing process knowledge, (2) physical reaction, and (3) time and effort[19]. Local and global writing process knowledge concerns students' beliefs in writerly abilities of rhetorical awareness, planning and revising, reading as a writer, awareness of strengths and challenges, and a recognition of the values of modeling. Physical reaction concerns intrapersonal traits dealing with the physical act of writing. Time and effort concerns management and motivations that promote writerly behaviors. The PSWSES has been used successfully as a reliable instrument[20] in a variety of writing research projects, including the writing of nurses[21, 22] and Nigerian undergraduate mass communication students[23].

With the PSWSES, we surveyed the senior-level students multiple times across the duration of the two senior-level laboratory courses. Using this survey data, we were able to determine their trends in writerly self-efficacy throughout their senior year.

Methods

Course Descriptions and Context

The courses involved in this work are ECHM 442: Senior Unit Operations Laboratory I and ECHM 443: Senior Unit Operations Laboratory II, a two-part sequential unit operations laboratory course series. These senior level courses are a required part of the curriculum for both chemical and biological engineering majors at [XX University] and are the primary sources of communication training. The two main learning objectives for these courses are to develop technical communication skills and complete hands-on experimental work. The 442 course is a combined chemical and biological engineering section while the 443 course is split into separate chemical and biological engineering sections. This work focuses on the 443 chemical engineering course section which has a larger student enrollment. Further detail regarding the situated course design can be found in [14, 15].

Writerly Self-Efficacy

The design of our study allowed us to investigate longitudinally the changes in students' writerly self-efficacy in three separate cohorts of engineering students at three points of contact across two semesters of their engineering studies (Figure 1). Writerly self-efficacy was measured using the PSWSES, which was administered three times during the students' academic year at the:

- start of the Fall semester 442 course,
- start of the Spring semester 443 course, and
- end of the Spring semester 443 course

to three separate cohorts of 442 and 443:

- Cohort 1: 55 students (AY2021)
- Cohort 2: 41 students (AY2022)
- Cohort 3: 37 students (AY2023)

for a total of 133 students.

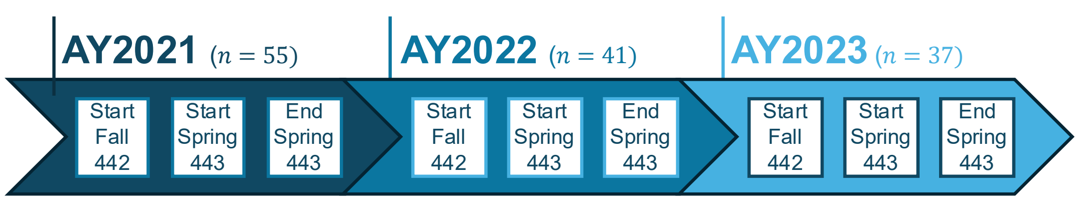

Figure 1. *Number of students per cohort and timeline of the survey administrations.*

Completion of the survey was assigned as an ungraded course assignment. The survey was administered in Qualtrics and responses were deidentified as per IRB approved protocols by a member of the research team who was not a designated instructor for the course. As per Schmidt and Alexander, the writerly self-efficacy was measured for each PSWSES survey administration by calculating a mean score on all items excluding item 19 since it did not load significantly on any of the three factors and therefore, was dropped from further analyses. In addition, a 0-10 response scale was used rather than the 0-100 response scale for ease of survey administration. We measured the three factors[19] at each occasion and students' scores for each of the factors were derived by calculating the mean of items 1, 3-9, 11-13, 15, 16, and 18 for Factor 1, items 8, 14, and 17 for Factor 2, and 2, 10, and 20 for Factor 3. Survey items are shown in the supplementary information. Using the Statistical Package for Social Sciences (SPSS), the means of each factor were analyzed in a multivariate repeated measures analyses of variance (RM-ANOVA) with occasion (fall, early spring, and late spring) the repeated measure, and the three mean factor scores as the multivariate dependent variables.

Results

Initially, data across the three cohorts were analyzed to determine if there were statistical differences between the years/cohorts. Performing three multivariate analyses of variance (ANOVA), one for each of the three administrations of the PSWSES, where the students' scores on the 19 items for each administration served as the dependent variables and the three cohorts served as a between subjects variable, we found that student responses to each item did not differ by cohort (Table 1). Because there were no differences among the cohorts, the data were combined, which increased the population size and strengthened the statistical power of subsequent inferential statistics. With the cohorts combined across each of the three administrations, we checked for reliability of the measurements using Cronbach alpha (Table 1). The values were 0.90, 0.90, and 0.93 for fall, early spring, and late spring, respectively, and therefore, the items produced highly reliable measurements at all three administrations.

Table 1. *Statistical results of the cohorts.*

	Wilks' Lambda	*F (df1, df2)*	*p*-value	Cronbach alpha
Fall	0.77	0.78 (38, 214)	0.82	0.9
Early Spring	0.73	1.01 (38, 224)	0.46	0.9
Late Spring	0.74	0.95 (38, 222)	0.55	0.93

Using the means from the three administrations as a repeated measure, a repeated measures analysis of variance (RM-ANOVA) was conducted with the Greenhouse-Geisser correction. The analysis showed a significant within-subjects effect, $F(2, 264) = 16.73$, $p < 0.001$, $\eta^2_p = 0.11$. Follow-up paired samples T-tests indicated that the overall means (Table 2, overall means) from the late spring were significantly greater than both the early spring means ($p = 0.005$; Cohen's $d = 0.23$) and the fall means ($p < 0.001$; Cohen's $d = 0.62$), and that the early spring means were significantly greater than the fall means, ($p = 0.022$; Cohen's $d = 0.20$). The strength of students' beliefs in their writerly self-efficacy as reflected in the mean scores on the PSWSES showed significant and steady increases from fall to early spring and again from early spring to late spring (Table 2). Although the effect sizes were relatively small between fall and early spring and between early spring to late spring, the increases made from fall to late spring were large.

Table 2 *Means and standard deviations (in parentheses) with an N of 133 from PSWSES*

	Fall	Early Spring	Late Spring
Overall	7.52 (1.14)	7.69 (1.08)	7.90 (1.22)
Factor 1 – writing knowledge	7.51 (1.15)	7.74 (1.08)	7.79 (1.41)
Factor 2 – physical reaction	7.29 (2.00)	7.45 (1.84)	7.70 (1.38)
Factor 3 – time and effort	7.79 (1.41)	7.74 (1.75)	7.43 (1.57)

When considering the three different factors, the means of each factor changed throughout the administrations of the survey (Table 2, rows 3-5). Further analyses using RM-ANOVA on the factors showed there was a significant multivariate within-subjects effect, with a large effect size, Wilks' Lambda = 0.506, $F(6, 127) = 20.688$, $p < 0.001$, $\eta^2_{\mathrm{p}} = 0.49$.

Follow-up univariate tests using the Greenhouse-Geisser correction showed a significant difference on Factor 1 – local and global writing process knowledge with a large effect size, a significant difference on Factor 2 – physical reaction with a small to medium effect size, and a significant difference on Factor 3 – time and effort with a medium effect size (Table 3).

Table 3. *Statistical analysis results using the Greenhouse-Geisser correction for the three different factors of the PSWSES where "df" represents "degrees of freedom" between groups (1) and within groups (2).*

	F (df1, df2)	*p*-value	Effect size (η^2_p)	Effect Size Interpretation
Factor 1 – writing knowledge	36.6 (1.81, 238)	<0.001	0.22	Large
Factor 2 – physical reaction	6.4 (1.83, 242)	0.003	0.05	Small to Medium
Factor 3 – time and effort	5.9 (1.92, 254)	0.004	0.04	Medium

Shown in Table 4 are the paired sample *T*-test results that showed significant differences between two different administrations for a given factor. For Factor 1 all three administrations (fall, early spring, and late spring) had differences that were significant with medium effect sizes. For Factor 2, the difference between Fall and Late Spring was significant and had a small effect size, while Early and Late Spring also had a significant difference, but with a small effects size. For Factor 3, both Fall and Late Spring and Early Spring and Late Spring had significant differences with a small effect size.

Table 4. *Summary of the paired samples T-test results that showed significant differences for the three factors of the PSWSES across the three administrations.*

Factor	Comparison	p-value	Effect Size (Cohen's d)	Effect Size Interpretation
Factor 1 – writing knowledge	All pairs	≤0.001	0.28 to 0.67	Medium
Factor 2 – physical reaction	Fall vs. Late Spring	0.001	0.28	Small
Factor 2 – physical reaction	Early vs. Late Spring	0.008	0.23	Small
Factor 3 – time and effort	Fall vs. Late Spring	0.003	0.26	Small
Factor 3 – time and effort	Early vs. Late Spring	<0.011	0.22	Small

Discussion
The strength of students' beliefs in their writerly abilities of rhetorical awareness, planning and revising, reading as a writer, awareness of strengths and challenges, and recognition of the values of modeling (i.e., Factor 1 - Local and Global Writing Process Knowledge) increased significantly and steadily from fall to early spring and from early spring to late spring. As the students are both learning and practicing technical communication throughout the two courses, these increases indicate that the students are growing as writers and more confident in their writerly abilities. The strength in their beliefs about intrapersonal traits dealing with the physical act of writing (i.e., Factor 2 - Physical Reaction) also increased from fall to spring, indicating perhaps that with practice the students are becoming more comfortable with the writing process. However, the strength in their beliefs about the management and motivations that promote writer behaviors (i.e. Factor 3 – Time and Effort) decreased steadily from fall to late spring. This is perhaps not surprising, given that the course is senior level. Most students plan to graduate at the end of the spring semester and motivation, or willingness to devote time and effort, can decrease throughout the year. In addition, student fatigue could play a role in this decline.

Limitations
This study has several limitations. First, the relatively small sample size limits the generalizability of the findings. Second, potential instructor effects across classrooms may have influenced student outcomes, making it difficult to attribute observed differences solely to the intervention. Additionally, although survey responses were deidentified after submission, they were self-reported which may have introduced response bias. Furthermore, the surveys were not administered prior to the intervention; as a result, changes in the measured factors cannot be definitively attributed to the situated learning experience. The observed shifts are therefore only hypothesized to be associated with the intervention. Further research, such as qualitative interviews, is needed to better understand the mechanisms underlying the observed shifts in writerly self-efficacy.

Conclusions
This study demonstrates that situating technical writing instruction within authentic, industrially relevant contexts can positively impact chemical engineering students' perceptions of their writing abilities. Notably, students showed significant growth in their confidence related to writing processes, suggesting that contextualized assignments effectively support the development of writerly self-efficacy. Although gains in comfort with the physical aspects of writing were modest, they nonetheless indicate a potential shift in students' attitudes toward writing as a skill integral to engineering practice. The observed decline in motivation and time investment, however, highlights a need to balance writing demands with workload to sustain engagement. Overall, these findings support the value of embedding writing in disciplinary contexts and suggest further attention to motivation and workload management could enhance outcomes. However, it is noted that no interviews or focus groups were conducted to determine if the disciplinary context was the reason for the increase or if it was just doing more writing. In future studies, it is recommended to request further information from the students to determine what aspects of writing improved their writerly self-efficacy.

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References

1. Darling, A. and D. Dannels, *Practicing Engineers Talk about the Importance of Talk: A Report on the Role of Oral Communication in the Workplace.* Communication Education, 2003. **52**: p. 1-16.
2. Donnell, J., A. , B. Aller, M. , M. Alley, and A. Kedrowicz, A. , *Why Industry Says That Engineering Graduates Have Poor Communication Skills: What the Literature Says*. 2011, ASEE Conferences: Vancouver, BC.
3. Wettstein, S.G., D.J. Hacker, and J.R. Brown, *Validation of a Senior-Level Chemical Engineering Laboratory Course Technical Report Rubric that Aligns with Industry Expectations.* International Journal of Engineering Education, 2024. **40**(1): p. 108-115.
4. Sahudin, S., *Literature Review on the Factors Affecting Teaching Effectiveness of Undergraduate Engineering Programmes.* Asean Journal of Engineering Education, 2021.
5. Sageev, P. and C.J. Romanowski, *A Message from Recent Engineering Graduates in the Workplace: Results of a Survey on Technical Communication Skills.* Journal of Engineering Education, 2001. **90**(4): p. 685-693.
6. Russell, D.R. and E.P. Maimon, *Writing in the Academic Disciplines: A Curricular History*. 2002: Southern Illinois University Press.
7. Williams, J.M., *Transformations in Technical Communicat ion Pedagogy: Engineering, Writing, and the ABET Engineering Criteria 2000.* Technical Communication Quarterly, 2001. **10**(2): p. 149-167.
8. Harran, M., *Engineering and Language Discourse Collaboration: Practice Realities.* Across the Disciplines, 2011. **8**(3).
9. Catherine Anne, H., et al., *A Writing in the Disciplines Approach to Technical Report Writing in Chemical Engineering Laboratory Courses*. 2019 ASEE Conferences: Tampa, Florida.
10. Ryan, W., et al., *Writing Across Engineering: A Collaborative Approach to Support STEM Faculty's Integration of Writing Instruction in their Classes*. 2019 ASEE Conferences: Tampa, Florida.
11. Paretti, M.C., L.D. McNair, and J.A. Leydens, *Engineering Communication*, in *Cambridge Handbook of Engineering Education Research*, A. Johri and B.M. Olds, Editors. 2014, Cambridge University Press: Cambridge. p. 601-632.
12. Brown, J.S., A. Collins, and P. Duguid, *Situated Cognition and the Culture of Learning.* Educational Researcher, 1989. **18**(1): p. 32-42.
13. Lave, J. and E. Wenger, *Situated learning: Legitimate peripheral participation*. 1991, Cambridge: Cambridge University Press.
14. Brown, J.R. and S.G. Wettstein. *Integrating Industrial Feedback into Role-Playing Scenarios in Laboratory Classes for Improved Technical Communication Skills*

Transferable to the Workplace. in *2024 ASEE Annual Conference & Exposition*. 2024. Portland Oregon.
15. Brown, J.R. and S.G. Wettstein, *Strengthening engineering identity and communication skills through industrial role-playing in a senior chemical engineering laboratory course.* Education for Chemical Engineers, 2025. **52**: p. 69-76.
16. Wettstein, S.G. and J.R. Brown, *Using Existing University Resources: Integration of the University Writing Center into a Senior-level Laboratory Series for Improved Learning Outcomes*, in *ASEE Annual Conference*. 2021, ASEE Conferences: Virtual Conference.
17. Brown, J.R. and S.G. Wettstein. *Rubric Development for Technical Reports in Chemical Engineering Unit Operations Laboratory Courses*. in *2023 ASEE Annual Conference & Exposition*. 2024. Baltimore, Maryland.
18. Bandura, A., *Guide for creating self-efficacy scales*, in *Self-efficacy beliefs of adolescents*, F. Pajares and T. Urdan, Editors. 2006, Information Age Publishing: Greenwich. p. 307-337.
19. Schmidt, K.M. and J.E. Alexander, *The Empirical Development of an Instrument to Measure Writerly Self-Efficacy in Writing Centers.* The Journal of Writing Assessment, 2012. **5**(1).
20. Mitchell, K.M., S. Zumbrunn, D.N. Berry, and L. Demczuk, *Writing self-efficacy in postsecondary students: A scoping review.* Educational Psychology Review, 2023. **35**(3).
21. Miller, L.C., C.L. Russell, A.-L. Cheng, and A.J. Skarbek, *Evaluating undergraduate nursing students' self-efficacy and competence in writing: Effects of a writing intensive intervention.* Nurse Education in Practice, 2015. **15**(3): p. 174-180.
22. Miller, L.C., C.L. Russell, A.L. Cheng, and S. Zembles, *Testing the efficacy of a scaffolded writing intervention with online degree-completion nursing students: A quasi-experimental design.* Nurse Educ Pract, 2018. **32**: p. 115-121.
23. Adeyemi, A.S.O. and R. Mohammed, *Examining Mass Communication Final Year Undergraduates Writing Self-Efficacy For Employability.* Asian Journal of Multidisciplinary Studies, 2016. **4**: p. 139-148.

Supplementary Material

Items of the Post-Secondary Writerly Self-Efficacy Scale (PSWSES):

1. I can identify incomplete, or fragment, sentences.
2. I can invest a great deal of effort and time in writing a report or memo when I know the paper will earn a grade.
3. I can articulate my strengths and challenges as a writer.
4. I can find and incorporate appropriate evidence to support important points in my reports important points in my reports.
5. I can be recognized by others as a strong writer.
6. When I read a rough draft, I can identify gaps when they are present in the report.
7. I can maintain a sense of who my audience is as I am writing a report.
8. I can write a report without feeling physical discomfort (e.g. headaches, stomachaches, backaches, insomnia, muscle tension, nausea, and/or crying).
9. When I read drafts written by classmates, I can provide them with valuable feedback.
10. When I have a pressing deadline for a report, I can manage my time efficiently.

11. I can attribute my success on writing projects to my writing abilities more than to luck or external forces.
12. When a student who is similar to me receives praise and/or a good grade on a report, I know I can write a report worthy of praise and/or a good grade.
13. Once I have completed a draft, I can eliminate both small and large sections that are no longer necessary.
14. I can write a report without experiencing overwhelming feelings of fear or distress.
15. When writing reports for different courses (engineering, chemistry, elective core courses), I can adjust my writing to meet the expectations of each discipline.
16. I can map out the structure and main sections of a report before writing the first draft.
17. I can find ways to concentrate when I am writing, even when there are many distractions around me.
18. I can find and correct my grammatical errors.
19. I can invest a great deal of effort and time in writing a report when I know the report will not be graded.
20. When I work with a writing tutor, I can learn new strategies that promote my development and success as a writer.