CHAPTER 9.

STEM COURSES AS SITES OF WRITING: STUDENTS' DISCIPLINARY EXPERIENCES WITH WRITING-TO-LEARN ASSIGNMENTS

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As described by Mike Palmquist (Chapter 8, this collection), the practices of writing and writing to learn (WTL) broadly have been utilized to support conceptual learning and critical thinking across disciplines. In alignment with this broad use, many studies have characterized outcomes related to participation in WTL broadly and in STEM courses specifically. Prior syntheses indicate that the effectiveness of WTL can be tied to certain features of the assignments. Namely, assignments should include meaning-making tasks, incorporate interactive writing processes, support metacognition, and provide clear writing expectations (Anderson et al.; Gere et al.; Klein). For a discussion of these aspects of writing assignments, see in this collection Chapter 15 by Jathan Day, Naitnaphit Limlamai, and Emily Wilson. The efficacy of WTL is well established; reviews of the literature have shown that WTL fosters conceptual learning, supports development of scientific reasoning, and encourages argumentation from data, among other benefits (Bangert-Drowns et al.; Reynolds et al.; Rivard). However, despite the known benefits of WTL and characteristics that support its effective use, the implementation of writing, let alone WTL, in STEM courses can be challenging for instructors due to systematic barriers such as class size, which restrict their ability to provide detailed feedback to students and established

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norms in STEM fields (Finkenstaedt-Quinn et al., "Postsecondary"; Moon et al.). Consideration of both the benefits of WTL, and research thereof, and the barriers to implementing writing led to the development of MWrite at the University of Michigan.

The MWrite Program: Propagation of WTL at the University of Michigan

Anne Ruggles Gere and Ginger Shultz, a faculty member in the chemistry department at the University of Michigan, were first introduced to each other by a colleague who knew that Anne was interested in increasing the use of writing in STEM disciplines on campus. They found a common goal: addressing disparities in the teaching practices traditionally used in STEM courses that might exclude certain students while also supporting rote learning—e.g., an overreliance on problem sets that allow students to utilize memorization rather than requiring problem-solving skills (Dood and Watts). Together Gere and Shultz developed the idea of the MWrite program—a program that would work with instructors to develop and implement scaffolded WTL assignments in their classrooms. As they considered what the program should look like, they decided on a target of large, introductory courses with an emphasis on STEM disciplines. The program and assignment design are described in detail in Finkenstaedt-Quinn et al.'s "Praxis of Writing-to-Learn: A Model for the Design and Propagation of Writing-to-Learn in STEM."

In their design, Gere and Shultz considered the barriers that might inhibit instructors' ability to implement writing into their courses. Through MWrite they aimed to provide instructors with a faculty learning community and to better facilitate feedback on student writing by engaging writing fellows (i.e., undergraduate students who were previously successful in the course returning to guide current students) and students' own peers via a tool facilitating anonymous, scaffolded peer review. Before instructors participating in MWrite implement WTL for the first time, they take part in the MWrite faculty seminar where they work closely with a lecturer from the Sweetland Center for Writing and one another to develop their goals for using WTL and to develop their assignments. The Sweetland Center for Writing also trains the undergraduate writing fellows. In alignment with the role of writing fellows described in the literature (Cairns and Anderson; Gladstein), these students serve as near-peers who can work with students enrolled in WTL courses as they respond to the writing assignments as well as grade and provide feedback on students' responses to the assignments. However, the MWrite writing fellows are distinguished by their focus on content as opposed to writing mechanics when working with students and during the grading process.

Additionally, drawing on Gere's expertise with the writing research literature, Gere and Shultz developed a specific form of WTL. The MWrite WTL assignments were designed considering the features of effective WTL practices (Anderson et al.; Gere et al.; Klein). As Figure 9.1 illustrates, students write a response to a prompt, go through the process of peer review, and then revise their response. The prompt presents students with a context and rhetorical features that they must critically consider and to which they apply their content knowledge, creating a meaning-making task. The processes of peer review and revision incorporate interactive writing processes into the assignment and support metacognition. Lastly, at each step the MWrite model aims to present students with clear writing expectations (e.g., by providing criteria for review and revision).

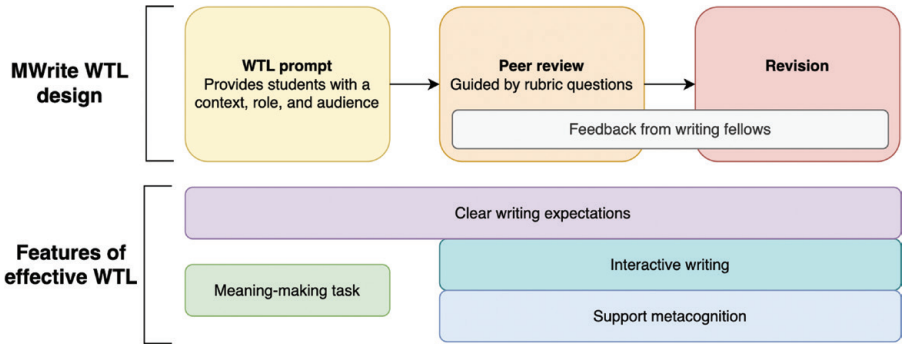

Figure 9.1. Alignment between the MWrite WTL assignment design and features of effective WTL.

Overview of MWrite Research

Beyond the practical considerations, Gere and Shultz wanted to ensure that the evidence-based design of the assignments actually translated into positive outcomes for students. Thus, they developed a research component to the MWrite program. Members of the MWrite research team, including two of this essay's co-authors, recently reviewed the existing research on student learning from and experiences with the MWrite WTL assignments using an engagement framework (Finkenstaedt-Quinn et al., "Portrait"). Briefly, the research team identified that 1) the assignments supported students to describe and learn disciplinary content, 2) the assignments engaged students in critical and disciplinary thinking, 3) the design of the assignments supported the learning process and influenced students' affective experiences, and 4) peer review and revision supported students' engagement with the assignments. While MWrite research is still ongoing, most pertinent for this chapter is students' perceptions of the WTL assignments. Students have primarily expressed how the context and rhetorical features provided

in the WTL prompts and the processes of peer review and revision are tied to positive learning experiences with the WTL assignments as a whole (Gupte et al.; Marks et al.; Petterson et al.). Further research on how students perceive these features and their influence on students' affective experiences is ongoing, with some findings about students' experiences reported herein.

In the spirit of engaging in dialogue and considering what writing means to students outside of English courses, we felt that writing this chapter presented a prime opportunity to further explore the themes of how students experience writing and WTL in STEM courses. Furthermore, in this chapter, we provide an initial exploration of a few areas of interest that have emerged from past data collection but that have not yet been the primary focus of a study, and we examine interviews with students across assignments and courses, situated within the context of undergraduate chemistry courses.

DEVELOPMENT AND EXPLORATION OF THEMES

Faculty members teaching several different chemistry courses have implemented WTL through the MWrite program at the University of Michigan. For this study, we analyzed interviews with students who were currently participating in chemistry courses that implemented MWrite. Interviews took place from the Winter 2019 semester through the Winter 2023 semester in two chemistry courses: organic chemistry (18 students) and introductory biochemistry (21 students). The interviews were conducted with varying research purposes, but across these contexts students discussed their writing experiences, how they perceived writing and WTL, and their affectivity when writing. Students were not always directly asked about these experiences, but across several course contexts, students' affective experiences with WTL in STEM courses surfaced.

The co-authors engaged in an iterative process of discussing themes we noticed across interviews and returning to interviews to further explore those themes. Through this process, we refined the themes to two: students' perceptions of writing in STEM courses and affective experiences related to engaging with scientific practices through WTL.

FINDINGS

While not directly related to the questions of interest in our previous studies, the recurring themes of how students perceive writing and their affectivity about MWrite assignments led us to think about the difference between how we conceptualize writing and WTL and how students perceive and value them. We thought to use this Festschrift's celebration of the career of Anne Ruggles Gere

as an opportunity to explore how students experience writing and WTL in the context of a STEM classroom.

Student Perceptions of Writing in STEM Courses

As part of two sets of interviews targeting students' experiences with WTL in chemistry, we asked students about their past experiences with writing in academic contexts and what disciplines they associated with writing. While primarily intended as questions to contextualize students' experiences, we found the responses intriguing. In both sets of interviews, students initially or exclusively described experiences with writing in non-STEM courses, despite the fact that they were mostly STEM or pre-health majors and ranged from first-year students to seniors. Of the 32 students, only about half of them mentioned without prompting a STEM course or engaging in scientific writing. After prompting, about a third of the remaining students identified writing in their STEM courses. Given the various ways writing can be and is used in STEM courses (e.g., lab reports, short answer questions), the prevalence of students connecting writing experiences to their academic experiences in STEM courses was lower than we expected. Cheri,[1] a second-year student enrolled in the organic chemistry course, captured the dissonance between their experiences with writing as an undergraduate and the disciplines they associate with writing, saying,

> For me [disciplines with writing are] more English, History. Even language. I had to write a lot of essays in Spanish in high school for AP Spanish. But it's funny because the last thing I kind of think of would be science, but I guess now, because to me the word writing kind of means a formal essay, not really a lab report, but lab reports is all the writing I've done in college basically, probably 80 percent of it. So I guess I should start counting science. But, my first thought is humanities.

Additionally, when asked about writing in courses, most students first described their English courses, and the first-year writing requirement course at the University of Michigan in particular. This is of note as it shows another way outside of MWrite that Gere has influenced these students' academic careers: it is due to Gere's efforts while director of the Sweetland Center for Writing that more STEM students do writing in both upper- and lower-level classes.

Of the students who without prompting identified writing in STEM courses, many were either in or had taken a writing requirement course for their

1 Pseudonyms have been used for all student participants.

discipline or had done writing as part of their research experiences. For example, Fern, a first-year student enrolled in the organic chemistry course, recognized writing as a scientific practice, but their primary association with writing in STEM disciplines was due to their research experience, rather than writing in their STEM courses:

> Yeah. In high school, I had a lot of writing experience, because that's something that they do a lot in English and reading classes. Scientific writing especially, I didn't really do anything with that until I got to college, especially in my research group. We do a lot of literature review, so I've had a lot of experience at least my freshman year with scientific writing. But yeah, I never really had too much experience.

As a first-year student, Fern might have had less exposure with writing in their STEM courses, a limitation which may have skewed how they thought about writing in STEM disciplines. In contrast, Laurel, a second-year student also enrolled in the organic chemistry course, discussed experiences with both the classic genre of laboratory reports in STEM courses and writing affiliated with their research position:

> Okay. I think starting in high school, it was just with a lot of English stuff. We didn't do a lot of writing in my other classes. Then coming to college, definitely took a first-year writing class, and that's where most of that happened. But then after that, after my first semester of freshman year, I've definitely done most of my writing actually in science classes and lab classes, doing lab report type stuff or … I work in a research lab, so I've helped with some of the papers and analysis we've done there. It's definitely been more academic writing and analysis, so it's weird when I have to write something that's not for a science lab … but yeah, since I have had a bit more experience with lab reports and stuff like that, now that's kind of what comes to mind in terms of writing for the sciences.

The greater recognition of writing in STEM courses Laurel expressed may be related to the breadth of their academic experiences. Similarly Rose, a second-year student enrolled in the organic chemistry course, said, "[My association of disciplines with writing has] expanded since coming to college."

Fern, Laurel, and Rose all described how their academic experiences with writing expanded as they moved from high school to college. This transition translates when comparing students in the organic chemistry course and the

biochemistry course (where students take the organic chemistry course prior to the biochemistry course). About half of the students interviewed from the biochemistry course discussed writing in STEM courses compared to only a third from the organic chemistry course.

With the weaker association between students mentioning writing and STEM courses than we expected, we considered that students may have a narrower conception of "writing" than we do. For example, Piper, a third-year student enrolled in the biochemistry course, said, "So I don't have a ton of prior experience in writing. Like, especially not scientific, I've done a lot of scientific writing in like biology classes, and for labs and things like that. But just in general, not a ton." There appears to be a disconnect for Piper between their experiences with writing broadly and the scientific writing they did in their STEM courses. This is seen more explicitly in a statement by Heron, a second-year student in the biochemistry course, who, after prompting about their experiences with writing in STEM courses, said, "I've had to do like post-labs, but those are not, I would not call those writing. I would say, just saying what happened and why."

The potential disconnect between the writing students do in their STEM courses and how they conceptualize "writing" is interesting, as laboratory reports, pre/post-lab writing exercises, and short answer response questions are often used in STEM courses. Comparatively, Aderyn, a second-year student enrolled in the biochemistry course, recognized the traditional forms of writing in their STEM courses and discussed the difference between the MWrite WTL biochemistry course and what they normally associated with chemistry courses:

> I was a little bit confused in the beginning, just because I think it's not often in a chemistry class that like you write papers, a lot of it is like, diagram based, or a lot of it is like answering short and like short answer questions and drawing out mechanisms. But none of it is just like paragraph on paragraph on paragraph writing.

While Aderyn did recognize the writing they experienced in their chemistry courses as writing, they described how they were not used to longer writing in the context of their chemistry courses. Furthermore, as seen with Fern and Laurel, whose primary association with writing in STEM courses was the writing they had done as part of their research positions, scientific writing may not be a practice students recognize experiencing at the undergraduate level. From our interviews, even when students recognized writing as something they did in STEM courses, they did not necessarily describe experiences with writing practices that aligned with scientific writing. This may mean that students are not developing scientific practices related to writing or just do not recognize how

the writing incorporated into their STEM courses serves to do so. As most of the students in our study planned to pursue STEM or STEM-adjacent careers, it is important not only to ensure students have opportunities to write in their STEM courses, but also to ensure they recognize that what they are doing is scientific writing, as this can support their affectivity towards the assignments.

Affectivity

A major theme that arose from students' interviews was the affectivity surrounding participation in MWrite assignments and the venue the assignments provided to better engage with scientific practices as compared to traditional assignments. For example, one assignment in the organic chemistry course asked students to take on the role of a scientist writing a grant proposal. This scientist was working on a newly discovered reaction (which we refer to as the "base-free Wittig reaction") and wanted to acquire funding to further study this reaction. The reaction itself was taken from the primary scientific literature and was a direct derivative of one of the reactions the students completed as part of their laboratory course (which we refer to as the "Wittig reaction"). This new reaction was presented in the context of two different real-world applications: use as an anti-cancer agent and use as an insecticide. We noted students expressing positive affectivity toward completing this MWrite assignment in the context of engaging with several scientific practices. Particularly, students engaged with the scientific practices of constructing explanations and communicating information in a more authentic scientific context (National Research Council). The MWrite assignments created a scientific context relevant to students' lives that they found to be interesting, meaningful, and engaging. Students also found that constructing explanations in the provided format (i.e., a grant proposal) allowed them a venue to better learn chemistry concepts by explaining them.

Students perceived the Wittig scenario as more enjoyable than an assignment without context and felt the genre was instrumental in bridging what they were learning in organic chemistry to how it applies to our understanding of the world scientifically. One student, Winter, a second-year student enrolled in the organic chemistry course, said,

> I would say definitely what I do like the most is, like you said, this is from actual research, and so it's nice to have something in the real world to connect like what we're learning to, because a lot of times it does feel a bit disconnected just like organic chemistry in general … it kind of feels like you're doing something that pertains exactly to what you want to do later

> in life. And so I feel like it's a little bit more motivating of an assignment to do when you have like a real world application in something that you're actually interested in.

Winter perceived the assignment as more interesting due to the real-world application provided in the prompt and therefore was more motivated to complete the assignment. They were able to connect what they were doing in class to the authentic practices of scientists. Another student, Autumn, a second-year student in the organic chemistry course, explained that the assignment context reinforced that organic chemistry is relevant to their life:

> I like the actual, like, prompt or like the discussing, like, the significance of it. I felt like, you know, I thought it was pretty cool. It's nice to have some context for like what it is that we're doing … so this is like a treatment, like a drug for a treatment. And I guess it kind of like reinforces that, like, organic chemistry is being used in a context that matters to me and that, like, I can't avoid it, it's gonna come back.

Like Winter, Autumn perceived the assignment as more enjoyable due to the context. Another student, Night, a first-year student in the organic chemistry course, noted that in addition to increased enjoyment in completing the assignment, the provided context for why the reaction was important made the assignment easier to complete and encouraged them to think deeply about their explanation of the reaction because they understood why it is important to learn these concepts:

> Giving it a context versus, you know, just saying explain the differences between the Wittig reaction and a base-free Wittig reaction, giving it that context kind of, you know, makes it a little bit easier to explain why we're focused on the differences instead of just like what the differences are. So it kind of like makes you think a little bit more about why we care about what the changes are.

Night reported more easily engaging in the scientific practice of constructing explanations because of the context provided by the MWrite assignment. Similarly, Spring, a third-year student in the organic chemistry course, felt the features of the MWrite assignment allowed them to better explain the chemistry topics: "I think that environment like created more like – and helped me to – like, explain better about certain topics because like the topic itself is very formal, and, yeah very academic. So I think it was helpful."

While Night and Spring felt constructing explanations was easier in the MWrite context, Summer, a second-year student in the organic chemistry course, praised the assignment for making them think about things differently and noted that being asked to engage in constructing an explanation was not normal for laboratory writing: "And so this made you think about things differently. Because in the lab write-up, I believe it's just claim, evidence, reasoning, or you think not in lab, and here, you're actually trying to, you know, explain a concept and prove a point." Summer felt the MWrite assignment allowed them to *explain* concepts rather than just report their results as they would in a lab report and that this was helpful for their mastery of the topic. Similarly, Day, another second-year student in the organic chemistry course, connected their engagement with the scientific practice of constructing explanations to their understanding of the course material:

> I definitely didn't quite understand the reaction as much like before I did [the MWrite] assignment. That being said, like in lab, I feel like you just kind of mix things and go with it. And I mean, we do write the mechanism in our lab books and everything like that, but this definitely was a better understanding of like, oh, like the reason why I mixed this with this is because of like this is a good leaving group and stuff.

Day, along with Night and Summer, noted they were given an outlet to engage in the scientific practice of constructing explanations and to engage with the material in a way that was different from standard chemistry assignments.

Despite not liking the WTL assignments, Bruce, a fourth-year student in the organic chemistry course, understood the importance of practicing scientific writing in STEM courses beyond just engaging in constructing explanations because students do not have many opportunities to practice writing in this context:

> Yeah, I understand why it's there, and I think I get that it is important. Not just from "explaining things helps you learn" perspective, but also from a, I think, a lot of scientists get into science and don't have a great writing background necessarily. And so it's good to get all the practice you can. So I know it's important and I know why it's in the class, but it doesn't make me like it any more.

Like Bruce, other students also found that the role they were asked to take on (e.g., a scientist requesting funding through a grant proposal) and the audience they were asked to write to (e.g., reviewers at the National Institutes of Health) were helpful for completing the task at hand. These features were designed to help students engage in the scientific practice of communicating information more

authentically. Winter explained that the task of writing a grant proposal helped develop their scientific writing in a way that a standard lab report would not:

> I would say it definitely has helped my scientific writing especially … I think that, you know, formatting an answer in terms of like the how, what, and why is really helpful in like, kind of, just because in grant proposals, you want it to be pretty transparent, I would assume. And so like focusing on how to write in that aspect has been really helpful.

In addition to improving scientific writing, Day felt the MWrite assignment provided a more concrete way to communicate and explain science than a lab report:

> No, yeah, the lab reports definitely like, I guess, also too with the lab reports is still pretty open ended with just like the claim, the lab, [inaudible]. Whereas with this it was like let's write the mechanisms, let's like look at the properties, which I think compare very like explicit, like mechanisms where the lab reports, it's like, the data that we have from our lab, which is usually like 99 percent of the time really messed up, and so I felt like this was definitely like a more concrete way of writing scientific papers.

Finally, Summer explained that the real-world context, alongside things learned in their lecture course, provided an outlet to improve their scientific writing and pull together multiple concepts to develop an explanation. Like Day, Summer explained that this assignment was much different from other types of assignments they had been asked to do and allowed them to think in a different way than they were required to think during exams:

> Sometimes people do assignments just to do assignments, it's not for like the real world meaning … I was able to improve my scientific writing, you know, I was able to prove a point using evidence from stuff I've learned in class, like, you know, going to lecture you don't really know how much you know until you're forced to do something like this. And I think this is very different from like let's say an exam. Like an exam, they're meant they want you to think a specific way, but here, you have to use everything you've learned and not just, you know, specific things you've learned.

Bruce, Winter, Day, and Summer all appreciated the importance of communicating about science through writing, and the grant proposal allowed them to practice this skill.

Altogether, our findings indicate that the MWrite assignments encourage students to engage in the scientific practices of constructing explanations and communicating information in a way that students appreciate and even enjoy, for the most part. We were pleased to see evidence of most of the students viewing MWrite in a positive way; students explained to us the many perceived benefits from participating in the program. This pattern in students' views of their writing could not have occurred without Gere championing the MWrite program. We found that our chemistry MWrite assignments met the goals of the MWrite program, as students were more interested in engaging with the content specifically because of the MWrite assignments. Students also felt the assignments increased their conceptual understanding of organic chemistry through constructing explanations. They were provided with a writing outlet which allowed them to think and communicate about chemistry in a different way than traditional examinations and laboratory reports, and most had positive affectivity toward the assignments as a whole.

DISCUSSION AND FUTURE DIRECTIONS

From our results, it is clear that students have mixed experiences with writing in STEM. While most students included in this study did indeed write in their STEM courses, many did not identify the tasks they were completing as writing. Students described primary writing experiences, especially before college, as being in English courses; several students mentioned that before college they had not written in a STEM course at all. While some students did recall some writing experiences in STEM courses, the students we interviewed reported a lack of formal writing experiences in STEM courses in general, aside from MWrite. As the interviews included herein were not part of a study targeting writing in STEM courses, they may not have fully captured students' experiences. Future research should be directed specifically toward better understanding student conceptions of writing in STEM courses and how these conceptions change as they move through the STEM curriculum.

Writing is a central part of professional science communication, and future scientists should be trained in how to communicate and explain their work through writing. However, it can take some time for students to acclimate to writing in a new genre (Bazerman). Thus, it is important to provide students with opportunities to write in STEM genres and to engage students with scientific writing practices (Keys). WTL can engage students in STEM genres and scientific practices such as constructing explanations and communicating information. The specific contexts provided by our MWrite assignments in chemistry (e.g., the grant proposal) provide a more authentic venue for students to engage in these practices.

Providing students an opportunity to write in and engage in STEM genres through the MWrite assignments also encouraged positive affectivity. Furthermore, incorporating authentic contexts that encourage student engagement in scientific practices could increase not only competency with scientific practices but also meaningful learning. Additional research should explore how students engage in specifically scientific practices through MWrite and how participation in MWrite impacts students' scientific skills (e.g., research, argument, or peer review skills).

Our findings indicate that MWrite WTL can serve its main pedagogical purpose of supporting conceptual learning and disciplinary thinking while also affording students opportunities to write in STEM courses and supporting their engagement in scientific practices. Considered in context with past MWrite WTL research, the findings described herein demonstrate the diverse ways in which the MWrite program, and through it Anne Ruggles Gere, have positively impacted students in STEM at the University of Michigan.

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WORKS CITED

Aderyn. Interview. 21 Feb. 2023.

Anderson, Paul, et al. "The Contributions of Writing to Learning and Development: Results from a Large-Scale Multi-Institutional Study." *Research in the Teaching of English*, vol. 50, no. 2, 2015, pp. 199–235, https://doi.org/10.58680/rte201527602.

Autumn. Interview. 1 Apr. 2022.

Bangert-Drowns, Robert L., et al. "The Effects of School-Based Writing-to-Learn Interventions on Academic Achievement: A Meta-Analysis." *Review of Educational Research*, vol. 74, no. 1, 2004, pp. 29–58, https://doi.org/10.3102/00346543074001029.

Bazerman, Charles. "Genre and Cognitive Development: Beyond Writing to Learn." *Genre in a Changing World*, edited by Charles Bazerman et al., The WAC Clearninghouse / Parlor Press, 2009, pp. 283–98, https://doi.org/10.37514/PER-B.2009.2324.2.14.

Bruce. Interview. 16 Apr. 2020.

Cairns, Rhoda, and Paul V. Anderson. "The Protean Shape of the Writing Associate's Role: An Empirical Study and Conceptual Model." *Across the Disciplines*, vol. 5, no. 2, 2008, https://doi.org/10.37514/ATD-J.2008.5.2.07.

Cheri. Interview. 20 Apr. 2020.

Day. Interview. 31 Mar. 2022.

Dood, Amber J., and Field M. Watts. "Students' Strategies, Struggles, and Successes with Mechanism Problem Solving in Organic Chemistry: A Scoping Review of the Research Literature." *Journal of Chemical Education*, vol. 100, no. 1, 2023, pp. 53–68, https://doi.org/10.1021/acs.jchemed.2c00572.

Fern. Interview. 21 Apr. 2020.

Finkenstaedt-Quinn, Solaire A., et al. "A Portrait of MWrite as a Research Program: A Review of Research on Writing-to-Learn in STEM through the MWrite Program." *International Journal for the Scholarship of Teaching and Learning*, vol. 17, no. 1, 2023, https://doi.org/10.20429/ijsotl.2023.17118.

Finkenstaedt-Quinn, Solaire A., et al. "Postsecondary Faculty Attitudes and Beliefs About Writing-Based Pedagogies in the STEM Classroom." *CBE - Life Sciences Education*, vol. 21, no. 3, 2022, https://doi.org/10.1187/cbe.21-09-0285.

Finkenstaedt-Quinn, Solaire A., et al. "Praxis of Writing-to-Learn: A Model for the Design and Propagation of Writing-to-Learn in STEM." *Journal of Chemical Education*, vol. 98, no. 5, 2021, pp. 1548–55, https://doi.org/10.1021/acs.jchemed.0c01482.

Gere, Anne Ruggles, et al. "Writing and Conceptual Learning in Science: An Analysis of Assignments." *Written Communication*, vol. 36, no. 1, 2019, pp. 99–135, https://doi.org/10.1177/0741088318804820.

Gladstein, Jill M. "Conducting Research in the Gray Space: How Writing Associates Negotiate between WAC and WID in an Introductory Biology Course." *Across the Disciplines*, vol. 5, no. 2, 2008, https://doi.org/10.37514/ATD-J.2008.5.2.02.

Gupte, Trisha, et al. "Students' Meaningful Learning Experiences from Participating in Organic Chemistry Writing-to-Learn Activities." *Chemistry Education Research and Practice*, vol. 22, 2021, pp. 396–414, https://doi.org/10.1039/d0rp00266f.

Heron. Interview. 07 Mar. 2023.

Keys, Carolyn W. "Revitalizing Instruction in Scientific Genres: Connecting Knowledge Production with Writing to Learn in Science." *Science Education*, vol. 83, no. 2, 1999, pp. 115–30, https://tinyurl.com/zjr9b5b9.

Klein, Perry D. "Mediators and Moderators in Individual and Collaborative Writing to Learn." *Journal of Writing Research*, vol. 7, no. 1, 2015, pp. 201–14, https://doi.org/10.17239/jowr-2015.07.01.08.

Laurel. Interview. 27 Apr. 2020.
Marks, L, et al. "Writing-to-Learn in Introductory Materials Science and Engineering." *MRS Communications*, vol. 12, 2022, pp. 1–11, https://doi.org/10.1557/s43579-021-00114-z.
Moon, Alena, et al. "Writing in the STEM Classroom: Faculty Conceptions of Writing and Its Role in the Undergraduate Classroom." *Science Education*, vol. 102, no. 5, 2018, pp. 1007–28, https://doi.org/10.1002/sce.21454.
National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* The National Academies P, 2012, https://doi.org/10.17226/13165.
Night. Interview. 20 Mar. 2022.
Petterson, Michael N., et al. "The Role of Authentic Contexts and Social Elements in Supporting Organic Chemistry Students' Interactions with Writing-to-Learn Assignments." *Chemistry Education Research and Practice*, vol. 23, no. 1, 2022, pp. 189–205, https://doi.org/10.1039/D1RP00181G.
Piper. Interview. 20 Feb. 2023.
Reynolds, Julie A., et al. "Writing-to-Learn in Undergraduate Science Education: A Community-Based, Conceptually Driven Approach." *CBE Life Sciences Education*, vol. 11, no. 1, 2012, pp. 17–25, https://doi.org/10.1187/cbe.11-08-0064.
Rivard, Lé Onard P. "A Review of Writing to Learn in Science: Implications for Practice and Research." *Journal of Research in Science Teaching*, vol. 31, no. 9, 1994, pp. 969–83, https://doi.org/10.1002/tea.3660310910.
Rose. Interview. 30 Apr. 2020.
Spring. Interview. 29 Mar. 2022.
Summer. Interview. 23 Mar. 2022.
Winter. Interview. 31 Mar. 2022.